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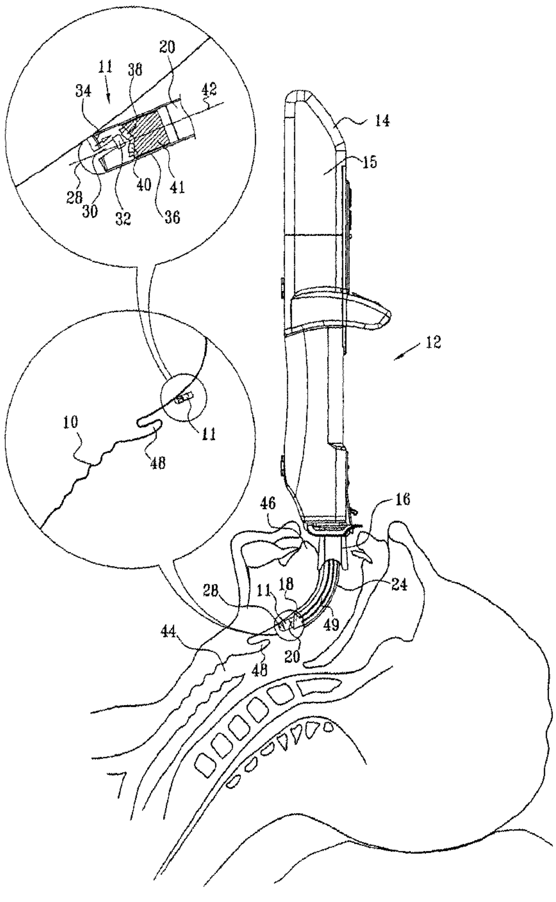
(54) Title: EXTENDABLE TUBE



(57) Abstract: An automatically operative medical insertion device (12) and method including an insertable element (18) which is adapted to be inserted within a living organism in vivo, a surface following element (20), physically associated with the insertable element and being arranged to follow a physical surface within the living organism in vivo, a driving subsystem (15) operative to at least partially automatically direct the insertable element along the physical surface and a navigation subsystem (274) operative to control the driving subsystem based at least partially on a perceived location of the surface following element along a reference pathway stored in the navigation subsystem.

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EXTENDABLE TUBE

FIELD OF THE INVENTION

The present invention relates to systems and methods for automatic insertion of an element into a living organism in vivo and to an extendable insertable element and a method of insertion thereof.

REFERENCE TO CO-PENDING APPLICATION

Applicants hereby claim priority of PCT Application No. PCT/IL01/01121 filed December 5, 2001, entitled "Apparatus For Self-Guided Intubation".

BACKGROUND OF THE INVENTION

The following U.S. Patents are believed to represent the current state of the art:

6,248,112; 6,236,875; 6,235,038; 6,226,548; 6,211,904; 6,203,497; 6,202,646; 6,196,225; 6,190,395; 6,190,382; 6,189,533; 6,174,281; 6,173,199; 6,167,145; 6,164,277; 6,161,537; 6,152,909; 6,146,402; 6,142,144; 6,135,948; 6,132,372; 6,129,683; 6,096,050; 6,096,050; 6,090,040; 6,083,213; 6,079,731; 6,079,409; 6,053,166; 5,993,424; 5,976,072; 5,971,997; 5,957,844; 5,951,571; 5,951,461; 5,885,248; 5,720,275; 5,704,987; 5,592,939; 5,584,795; 5,506,912; 5,445,161; 5,400,771; 5,347,987; 5,331,967; 5,307,804; 5,257,636; 5,235,970; 5,203,320; 5,188,111; 5,184,603; 5,172,225; 5,109,830; 5,018,509; 4,910,590; 4,672,960; 4,651,746

Reference is also made to: http://www.airwaycam.com/system.html

SUMMARY OF THE INVENTION

The present invention seeks to provide improved systems and methods for automatic insertion of an element into a living organism in vivo.

There is thus provided in accordance with a preferred embodiment of the present invention an automatically operative medical insertion device including an insertable element which is adapted to be inserted within a living organism in vivo, a surface following element, physically associated with the insertable element and being arranged to follow a physical surface within the living organism in vivo, a driving subsystem operative to at least partially automatically direct the insertable element along the physical surface and a navigation subsystem operative to control the driving subsystem based at least partially on a perceived location of the surface following element along a reference pathway stored in the navigation subsystem.

There is also provided in accordance with a preferred embodiment of the present invention an automatically operative medical insertion method, which includes inserting an insertable element within a living organism in vivo, physically associating a surface following element with the insertable element and causing the surface following element to follow a physical surface within the living organism in vivo, directing the insertable element along the physical surface using a driving subsystem and controlling direction of the insertable element based at least partially on a perceived location of the surface following element along a reference pathway stored in a navigation subsystem.

Further in accordance with a preferred embodiment of the present invention the driving subsystem is operative to fully automatically direct the insertable element along the physical surface. Alternatively, the driving subsystem is operative to automatically and selectably direct the insertable element along the physical surface.

Additionally in accordance with a preferred embodiment of the present invention the navigation subsystem receives surface characteristic information relating to the physical surface from the surface following element and employs the surface characteristic information to perceive the location of the surface following element along the reference pathway.

Preferably, the surface characteristic information includes surface contour information. Additionally, the surface characteristic information includes surface hardness information. Preferably, the surface contour information is three-dimensional. Alternatively, the surface contour information is two-dimensional.

In accordance with a further preferred embodiment of the present invention, the insertable element is an endotracheal tube and the physical surface includes surfaces of the larynx and trachea. Alternatively, the insertable element is a gastroscope and the physical surface includes surfaces of the intestine. In accordance with another preferred embodiment, the insertable element is a catheter and the physical surface includes interior surfaces of the circulatory system.

Further in accordance with a preferred embodiment of the present invention the insertion device also includes a reference pathway generator operative to image at least a portion of the living organism and to generate the reference pathway based at least partially on an image generated thereby.

Preferably, the reference pathway includes a standard contour map of a portion of the human anatomy. Additionally, the standard contour map is precisely adapted to a specific patient. Alternatively, the standard contour map is automatically precisely adapted to a specific patient.

Further in accordance with a preferred embodiment of the present invention the reference pathway is operator adaptable to designate at least one impediment.

Additionally in accordance with a preferred embodiment of the present invention the insertable element includes a housing in which is disposed the driving subsystem, a mouthpiece, a tube inserted through the mouthpiece and a flexible guide inserted through the tube, the surface following element being mounted at a front end of the guide.

Preferably, the mouthpiece includes a curved pipe through which the tube is inserted. Additionally, the driving subsystem is operative to move the guide in and out of the housing, through the curved pipe and through the tube. Preferably, the driving subsystem also operates to selectably bend a front end of the guide. Additionally or alternatively, the driving subsystem is operative to move the insertable element in and out of the living organism. Additionally, the driving subsystem is also operative to selectably bend a front end of the insertable element.

Further in accordance with a preferred embodiment of the present invention the surface following element includes a tactile sensing element.

Preferably, the surface following element includes a tip sensor including a tip integrally formed at one end of a short rod having a magnet on its other end, the rod extends through the center of a spring disk and is firmly connected thereto, the spring disk being mounted on one end of a cylinder whose other end is mounted on a front end of the insertable element.

Further in accordance with a preferred embodiment of the present invention the tip sensor also includes two Hall effect sensors, which are mounted inside the cylinder on a support and in close proximity to the magnet, the Hall effect sensors being spaced in the plane of the curvature of the curved pipe. Each Hall effect sensor includes electrical terminals operative to provide electric current representing the distance of the magnet therefrom. The tip sensor operates such that when a force is exerted on the tip along an axis of symmetry of the cylinder, the tip is pushed against the spring disk, causing the magnet to approach the Hall effect sensors and when a force is exerted on the tip sideways in the plane of the Hall effect sensors, the tip rotates around a location where the rod engages the spring disk, causing the magnet to rotate away from one of the Hall effect sensors and closer to the other of the Hall effect sensors.

Still further in accordance with a preferred embodiment of the present invention the driving subsystem operates, following partial insertion of the insertable element into the oral cavity, to cause the guide to extend in the direction of the trachea and bend the guide clockwise until the surface following element engages a surface of the tongue, whereby this engagement applies a force to the surface following element.

Additionally in accordance with a preferred embodiment of the present invention the navigation subsystem is operative to measure the changes in the electrical outputs produced by the Hall effect sensors indicating the direction in which the tip is bent.

Moreover in accordance with a preferred embodiment of the present invention the navigation subsystem operates to sense the position of the tip and the past history of tip positions and to determine the location of the tip in the living organism and relative to the reference pathway.

In accordance with yet another preferred embodiment, the navigation subsystem operates to navigate the tip according to the reference pathway. Additionally, the navigation subsystem operates to sense that the tip touches the end of the trough beneath the epiglottis. Additionally or alternatively, the navigation subsystem is operative to sense that the tip reaches the tip of the epiglottis. In accordance with another preferred embodiment, the navigation subsystem operates to sense that the tip reached the first cartilage of the trachea. Additionally, the navigation subsystem operates to sense that the tip reached the second cartilage of the trachea. Additionally or alternatively, the navigation subsystem is operative to sense that the tip reached the third cartilage of the trachea. Preferably, the navigation subsystem operates to load the reference pathway from a memory.

Further in accordance with a preferred embodiment of the present invention the driving subsystem is operative to push the tube forward.

Still further in accordance with a preferred embodiment of the present invention the driving subsystem includes a first motor which operates to selectably move the insertable element forward or backward, a second motor which operates to selectably bend the insertable element and electronic circuitry operative to control the first motor, the second motor and the surface following element.

Preferably, the electronic circuitry includes a microprocessor operative to execute a program, the program operative to control the first and second motors and the surface following element and to insert and bend the insertable element inside the living organism along the reference pathway.

Further in accordance with a preferred embodiment of the present invention the driving subsystem is operative to measure the electric current drawn by at least one of the first and second motors to evaluate the position of the surface following element.

Still further in accordance with a preferred embodiment of the present invention the reference pathway is operative to be at least partially prepared before the insertion process is activated. Preferably, the medical insertion device includes a medical imaging system and wherein the medical imaging system is operative to at least partially prepare the reference pathway. Preferably, the medical imaging subsystem includes at least one of an ultrasound scanner, an X-ray imager, a CAT scan system and an MRI system.

Further in accordance with a preferred embodiment of the present invention the medical imaging system operates to prepare the reference pathway by marking at least one contour of at least one organ of the living organism.

In accordance with another preferred embodiment, the medical imaging system operates to prepare the reference pathway by creating an insertion instruction table including at least one insertion instruction. Preferably, the insertion instruction includes instruction to at least one of extend, retract and bend the insertable element.

Further in accordance with a preferred embodiment of the present invention the navigation subsystem is operative to control the driving subsystem based at least partially on a perceived location of the surface following element and according to the insertion instruction table stored in the navigation subsystem.

Additionally in accordance with a preferred embodiment of the present invention the operative medical insertion device operates to at least partially store a log of a process of insertion of the insertable element. Additionally, the operative medical insertion device transmits the log of a process of insertion of the insertable element.

Further in accordance with a preferred embodiment of the present invention the computer operates to aggregate the logs of a process of insertion of the insertable element. Additionally, the computer prepares the reference pathway based at least partially on the aggregate.

Still further in accordance with a preferred embodiment of the present invention the computer transmits the reference pathway to the medical insertion device.

Further in accordance with a preferred embodiment of the present invention the insertable element includes a guiding element and a guided element. Additionally, the driving subsystem operates to direct the guiding element and the guided element at least partially together. Additionally or alternatively, the driving subsystem is operative to at least partially automatically direct the guide in a combined motion comprising a longitudinal motion and lateral motion.

In accordance with yet another preferred embodiment, the mouthpiece includes a disposable mouthpiece.

In accordance with still another preferred embodiment of the present invention, the insertable element is extendable. In accordance with yet another preferred embodiment, the insertable element includes a mounting element which is arranged to be removably engaged with an intubator assembly and an extendable tube operatively associated with the mounting element. Preferably, the extendable tube is arranged to be pulled by a flexible guide operated by the intubator assembly.

In accordance with yet another preferred embodiment of the present invention, the extendable tube includes a coil spring. Additionally or alternatively, the extendable tube also includes a forward end member, on a distal end thereof.

Preferably, the forward end member includes a diagonally cut pointed forward facing tube end surface. Additionally or alternatively, the medical insertion device also includes a forward end member mounted inflatable and radially outwardly expandable circumferential balloon.

Preferably, the forward end member mounted inflatable and radially outwardly expandable circumferential balloon receives inflation gas through a conduit formed in a wall of the forward end member and continuing through the tube to a one way valve.

In accordance with another preferred embodiment, the medical insertion device also includes a flexible guide having mounted at a distal end thereof a tip sensor. Preferably, the flexible guide is formed with an inflatable and radially outwardly expandable guide mounted balloon. Additionally, the inflatable and radially outwardly expandable guide mounted balloon receives inflation gas through a conduit formed in the flexible guide and extending therealong. Preferably, the conduit is connected to a source of pressurized inflation gas. Additionally or alternatively, the source of pressurized inflation gas is located within the intubator assembly. Preferably, the inflation gas comprises pressurized air.

It is appreciated that the distances and angles referenced in the specification and claims are typical values and should not be construed in any way as limiting values.

BRIEF DESCRIPTION OF THE DRAWINGS AND APPENDICES

The present invention will be understood and appreciated more fully from the following detailed description, taken in conjunction with the drawings and appendices in which:

Figs. 1A to 1L are a series of simplified pictorial illustrations of a process of employing a preferred embodiment of the present invention for the intubation of a human;

Figs. 2A to 2F taken together are a flowchart illustrating a preferred implementation of the present invention, operative for an intubation process as shown in Figs. 1A to 1L;

Fig. 3 is a simplified illustration of the internal structure of a preferred embodiment of the present invention for intubation of a human;

Fig. 4 is a simplified block diagram of a preferred embodiment of the present invention;

Figs. 5A to 5H are electrical schematics of a preferred embodiment of the present invention for intubation of a human;

Figs. 6A to 6K are a series of simplified pictorial illustrations of a process of employing a preferred embodiment of the present invention for insertion of an element into the intestine of a human;

Fig. 7 is a preferred embodiment of a table comprising instruction, operative in accordance with a preferred embodiment of the present invention, for insertion of an element into the intestine of a human as shown in Figs. 5A to 5K;

Fig. 8 is a flowchart illustrating a preferred implementation of the present invention, operative for a process of insertion of an element into the intestine of a human as shown in Figs. 6A to 6K;

Figs. 9A to 9F are a series of simplified pictorial illustrations of an extendable endotracheal tube assembly constructed and operative in accordance with a preferred embodiment of the present invention in various operative orientations;

Figs. 10A to 10G are a series of simplified pictorial illustrations of the extendable endotracheal tube assembly of Figs. 9A - 9F employed with the medical insertion device of Figs. 1A - 8 for the intubation of a human;

Figs. 11A to 11F are a series of simplified pictorial illustrations of an extendable endotracheal tube assembly constructed and operative in accordance with another preferred embodiment of the present invention in various operative orientations; and

Figs. 12A to 12G are a series of simplified pictorial illustrations of the extendable endotracheal tube assembly of Figs. 9A - 9F employed with the medical insertion device of Figs. 1A - 8 for the intubation of a human.

LIST OF APPENDICES

Appendices 1 to 3 are computer listings which, taken together, form a preferred software embodiment of the present invention.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

Reference is now made to Figs. 1A to 1L, which are a series of simplified pictorial illustrations of a system and methodology for the intubation of a human in accordance with a preferred embodiment of the present invention.

It is appreciated that the general configuration of the mouth and trachea is generally the same for all humans except for differences in scale, such as between an infant, a child and an adult. In a preferred implementation of the present invention, a standard contour map 10 of the human mouth and trachea is employed. The scale of the map 10 may be further precisely adapted to the specific patient, preferably automatically. Alternatively, the scale of the map 10 is adapted to the specific patient semi-automatically. In this alternative the operator can select the scale of the map 10, for example by selecting between a child and an adult. Thereafter the scale of the map 10 is automatically adapted to size of the specific patient as a part of the intubation process. As a further alternative or in addition the operator is enabled to designate one or more typical impediments such as: a tumor, a swelling, an infection and an injury. Selecting an impediment preferably creates a suitable variation of the general map 10.

Fig. 1A shows the map 10 and the location therein where a tip sensor 11 of an intubator engages the mouth and trachea of the patient. It is a particular feature of the present invention that intubation is at least partially automatically effected by utilizing the contour map 10 to monitor the progress of tip sensor 11 and thus to navigate the intubator accordingly.

As seen in Fig. 1A, an intubator assembly 12, suitable for the intubation of a human, is partially inserted into an oral cavity of a patient. The intubator assembly 12 preferably comprises a housing 14 in which is disposed a guide driver 15, a mouthpiece 16, a tube 18 inserted through the mouthpiece 16, a flexible guide 20 inserted through the tube 18, and tip sensor 11 mounted at the distal end of the guide 20. The mouthpiece 16 preferably comprises a rigid curved pipe 24 through which the tube 18 is inserted. Preferably the curved pipe 24 comprises a slit 49 on each side. Alternatively, the curved pipe 24 is eliminated.

It is appreciated that some of the components comprising the intubator assembly 12 may be disposable, for example, the tube 18 and the mouthpiece 16.

The guide driver 15 is operative to move the guide 20 in and out of the housing 14, through the curved pipe 24 and through the tube 18. The guide driver 15 is also operative to selectably bend the distal end of the guide 20 clockwise and counterclockwise in the plane of the curvature of the curved pipe 24 in the sense of Fig. 1A.

Referring now to an enlargement of the tip sensor 11, it is seen that tip sensor 11 preferably comprises a tip 28 preferably integrally formed at one end of a short rod 30 having a magnet 32 on its other end. The rod 30 preferably extends through the center of a spring disk 34 and is firmly connected thereto. The spring disk 34 is preferably mounted on one end of a cylinder 36 whose other end is mounted on the distal end of the guide 20. Preferably, the tip sensor 11 also comprises two Hall effect sensors, 38 and 40, which are mounted inside the cylinder 36 on a support 41 and in close proximity to the magnet 32. The Hall effect sensors 38 and 40 are preferably spaced in the plane of the curvature of the curved pipe 24. Typically, each Hall effect sensor has electrical terminals operative to provide electric current representing the distance of the magnet 32 therefrom.

When a force is exerted on the tip 28 along the axis of symmetry 42 of cylinder 36, the tip 28 is pushed against the spring disk 34, causing the magnet 32 to approach the Hall effect sensors 38 and 40. Since the distance between the magnet 32 and each of the Hall effect sensors 38 and 40 decreases, both Hall effect sensors 38 and 40 produce an increase in their output electric current. When a force is exerted on the tip 28 sideways in the plane of the Hall effect sensors 38 and 40, the tip 28 rotates around the location where the rod 30 engages the spring disk 34, as is shown in Fig. 1A. This causes the magnet 32 to rotate away from the Hall effect sensor 40 and closer to the Hall effect sensor 38. The output electric current of the Hall effect sensor 40 typically decreases and the output electric current of the Hall effect sensor 38 typically correspondingly increases. Thus, it may be appreciated that the tip sensor 11 enables electronic circuitry (not shown) to measure the amplitude and the direction of force exerted on the tip 28 in the plane of the Hall effect sensors 38 and 40 and to compute the orientation of a surface of a tissue against which the sensor tip 28 is depressed, relative to the axis of symmetry 42.

It is appreciated that sensors other than Hall effect sensors can be used to measure the direction and the amplitude of the force exerted on the tip 28, or otherwise to measure the proximity and the orientation of the adjacent surface.

During automatic operation of the system, following partial insertion of the intubator assembly 12 into the oral cavity, as shown in Fig. 1A, the guide driver 15 typically causes the guide 20 to extend in the direction of the trachea 44 and bends the guide 20 clockwise until the tip 28 engages a surface of the tongue 46. This engagement applies a force to tip 28, which causes the tip to rotate counterclockwise wherein the magnet 32 approaches the Hall effect sensor 38. Electronic circuitry (not shown) inside the housing 14, which measures the changes in the electrical outputs produced by the Hall effect sensors 38 and 40, indicates that the tip 28 is bent clockwise.

By sensing the position of the tip and employing the past history of tip positions, the system of the present invention determines the location of the tip sensor 11 in the oral cavity and relative to the map 10. This location is employed in order to navigate the intubator correctly, as described hereinbelow.

Reference is now made to Fig. 1B, which illustrates a further step in the intubation in accordance with the present invention. Fig. 1B shows the guide 20 extended further and reaching an area between the base of the tongue 46 and the epiglottis 48 of the patient.

As seen in Fig. 1C, the guide 20 extends further forward until the tip 28 touches the end of the trough beneath the epiglottis 48.

As seen in Fig. 1D, the guide 20 bends counterclockwise and touches the bottom surface of the epiglottis 48. Then the guide 20 retracts a little, while preserving continuous tactile contact between the tip 28 with the bottom surface of the epiglottis 48.

As seen in Fig. 1E, the guide 20 retracts further until the tip 28 of the tip sensor 11 reaches the tip 165 of the epiglottis 48 and then the tip 28 loses tactile contact with the surface of the tip 165 of the epiglottis 48.

As seen in Fig. 1F, the guide 20 bends further counterclockwise, then extends forward and then bends clockwise until the tip 28 touches the upper surface of the epiglottis 48.

As seen in Fig. 1G, the guide 20 extends forward, preserving continuous tactile contact with the epiglottis 48, until the tip 28 senses the first trough of the trachea 44.

As seen in Figs. 1H and 1I, the guide 20 extends further forward until the tip 28 senses the second trough of the trachea 44.

As seen in Figs. 1J and 1K, the guide 20 extends further forward until the tip 28 senses the trough of the third cartilage of the trachea 44. Then the guide 20 further extends, typically for adults by 5 centimeters, to ensure that the tube 16 reaches to the third cartilage.

As seen in Fig. 1L, the guide driver 15 is pulled out with the guide 20 leaving the mouthpiece 16 and the tube 18 inside the patient's mouth and trachea 44.

Reference is now made to Figs. 2A to 2F, which, taken together, are a flowchart of the process of the intubation of a human shown in Figs. 1A to 1K.

Fig. 2A and 2B, taken together, correspond to the step of the intubation process shown in Fig. 1A.

In step 100 of Fig. 2A the intubator assembly 12 is set to perform intubation.

In step 102 the intubator loads an intubation pattern map 10 from its memory.

In steps 104, 106 and 108 the intubator enables the operator to set the scale of the intubation pattern map to the corresponding size of the patient by selecting between an infant, a child and an adult.

In steps 110, 112 and 114 the intubator enables the operator to adapt the intubation pattern map 10 to a type of intubation impediment, preferably by selecting from a menu. As seen in Fig. 2A the menu typically provides the operator with four optional impediments: an infection, a swelling, a tumor and an injury, and a fifth option not to select any impediment. It is appreciated that various types of impediments can be defined as is typical for a specific organ.

As seen in Fig. 2B, steps 120, 122, 124, 126, 128 and 130 cause the guide 20 to extend in the direction of the throat and simultaneously bend clockwise until the tip sensor is depressed against the surface of the tongue or until extension and bending limits are reached. As seen in step 128, the bending limit is preferably 50 degrees and the extension limit is preferably 2 centimeters. If the tip sensor is depressed, the scale of the intubation pattern map 10 is preferably updated (step 132) to match the particular scale or size of the intubated patient. If at least one of the extension limit and the bending limit is reached an error message is displayed (step 134) and the intubation process is stopped.

Reference is now made to Fig. 2C, which corresponds to Figs. 1B and 1C. As illustrated in Fig. 2C, the guide driver 15 performs sequential steps 140, 142, 144 and 146 in a loop, extending (step 140) guide 20 further into the patient's throat and along the throat surface, following the intubation pattern map 10 and keeping the tip in contact with the surface (steps 144, 146). When the output electric currents from both Hall effect sensors 38 and 40 increase, the intubator assumes (step 142) that the tip 28 has reached the end of the trough beneath the epiglottis 48. The point of engagement between the tip 28 and the body is designated in Fig. 1C by reference numeral 147. The scale of the intubation pattern map 10 is then preferably updated to match the patient's organ structure (step 148).

Reference is now made to Fig. 2D, which corresponds to Figs. 1D and 1E. As seen in Fig. 2D the guide driver 15 performs steps 150, 152 and 154 in a loop, bending the distal end of the guide 20 counterclockwise until the tip 28 touches the epiglottis 48, or until a bending limit, preferably of 45 degrees is reached (step 154) and the intubation stops (step 156). The preferred point of engagement between the tip 28 and the surface of the epiglottis is designated in Fig. 1D by reference numeral 155. After sensing an engagement between the tip 28 and the surface of the epiglottis, the guide driver 15 performs steps 158, 160, 162, and 164 in a loop, retracting the guide 20 further (step 158), and increasing the bending of the guide 20 (step 164), until the tip of the guide reaches the tip of the epiglottis 48, designated in Fig. 1E by reference numeral 165. When the tip 28 reaches the tip of the epiglottis 48, the tip 28 is released and the output electric currents from both Hall effect sensors decrease to a minimum. Preferably the intubation pattern map 10 is updated (step 166) to match the patient's organ structure.

Reference is now made to Fig. 2E, which corresponds to Figs. 1E and 1F. As seen in Fig. 2E, the guide driver 15 causes the guide 20 to move above and around the tip of the epiglottis 48 by causing the guide 20 to bend counterclockwise, preferably by 45 degrees, then to move forward down the throat by 5 millimeters and then to bend clockwise, preferably by 10 degrees (Step 170). Then the guide driver 15 performs steps 172, 174 and 176 in a loop, bending and extending (step 174) until the tip 28 of the guide touches the upper surface of the epiglottis 48 or until an extension limit, preferably of 1 centimeter, or a bending limit, preferably of 50 degrees, is reached, and the intubation is stopped (step 178). A preferred point of engagement between the tip 28 and the epiglottis is designated in Fig. 1F by reference numeral 177.

Reference is now made to Fig. 2F, which corresponds to Figs. 1G to 1K. As seen in Fig. 2F, a "cartilage crest counter N" is first zeroed (step 180). Then the guide driver 15, performing steps 182 to 198 in a loop, causes the guide 20 to move the sensor tip 11 forward (step 182) along the surface of the trachea 44, preserving contact between the tip 28 and the surface of the trachea (steps 186 and 188) by increasing the bend (step 188) as needed. Each time a crest (189 in Figs. 1H, 1I, 1J) of a cartilage of the trachea 44 is located the "cartilage crest counter" is incremented (step 190), the tip 28 is moved about the crest (steps 192, 194, 196 and 198) and the loop process repeats until the third cartilage is located. Then the guide 20 further extends, typically for adults by 5 centimeters, to ensure that the tube 16 reaches to the third cartilage. The guide driver 15 then signals to the operator that the insertion is completed successfully (step 200).

Reference is now made to Fig. 3, which is a simplified illustration of the internal structure of a preferred embodiment of the present invention useful for intubation of a human. The intubator assembly 12 preferably comprises the housing 14, the guide driver 15, the mouthpiece 16, the tube 18, the flexible guide 20 inserted inside the tube 18 and the tip sensor 11 mounted at the distal end of the guide 20. Preferably the mouthpiece comprises a curved pipe 24.

Preferably, the guide driver 15 comprises a first motor 210 that drives a gearbox 212 that rotates a threaded rod 214. A floating nut 216 is mounted on the threaded rod 214. As the motor 210 rotates the threaded rod 214, the floating nut 216 is moved forward or backward according to the direction of the rotation. The floating nut 216 is operative to move a carriage 218 along a bar 220 and thus to push or pull the guide 20. When the carriage 218 touches a stopper 222 the stopper 222 moves with the carriage 218 along the bar 220 and pushes the tube 18 forward.

A second motor 224 is connected to a disk 226 to which two guide angulation wires 228 are attached at first end thereof. The guide angulation wires 228 are threaded inside the guide 20 and their other ends are connected to the distal end of the guide just short of the tip sensor 11. When the motor 224 rotates the disk 226 clockwise one of the wires 228 is pulled and the second wire is loosened. The wire that is pulled pulls and bends the distal end of the guide 20 counterclockwise in the sense of Fig. 3. Accordingly, when the motor 224 rotates counter-clockwise the second wire of the two wires 228 is pulled and the first wire is loosened. The wire that is pulled pulls and bends the distal end of the guide 20 clockwise in the sense of Fig. 3.

Electronic circuitry 229 is provided within the housing 14 and is preferably electrically connected to operating switches 230, a display 232, the motors 210 and 224 and to the Hall effect sensors 38 and 40 (Fig. 1A) in the tip sensor 11. Preferably, the electronic circuitry 229 also comprises a microprocessor, operative to execute a program. The program is preferably adapted to control the switches 230, the display 232, motors 210 and 224 and the Hall effect sensors 38 and 40 and to insert and bend the guide inside a living organism, according to a predefined map until the tip of the guide reaches a destination point inside the living organism. Preferably the program is operative to cause the tip 28 of the guide 20 to follow a predefined internal contour of an organ of the living organism. Preferably program is operative employ tactile sensing to measure the position of the tip of the guide relative to the surface organ of the living organism.

It is appreciated that the term “microprocessor” also includes inter alia a “microcontroller”.

Electrical batteries (not shown) are preferably provided within the housing 14 to supply electric power to the electronic circuitry, the tip sensor 11, the motors 210 and 224, the display 232 and all other elements of the present invention that consume electricity. It is appreciated that external sources of electricity can also be employed to provide power to the intubator assembly 12.

Communication interface (not shown), preferably employing infra-red communication technology, is provided to enable communication with external data processing equipment.

Preferably, a balloon 234 is provided at the distal end of the tube 18 and a thin pipe (not shown) is inserted through the pipe 18 and is connected, through the side of the pipe, to the balloon. The thin pipe enables an operator to inflate the balloon when the distal end of the pipe 18 reaches the appropriate place in the trachea, thus securing the distal end of the pipe to the trachea.

Reference is now made to Fig. 4, which is a simplified functional block diagram of a preferred embodiment of the guide driver 15 described hereinabove. In Fig. 4 the guide 20 is driven by two drivers. A longitudinal driver 240 preferably comprises a motor 210, the gear 212, the threaded rod 214, the floating nut 146 and the carriage 218 of Fig. 3. A bending guide driver 242 preferably comprises the motor 224, the disk 226 and wires 228 (Fig. 3). The longitudinal driver 240 and the bending guide driver 242 are controlled by two software driver modules. A longitudinal software driver module 244 controls the longitudinal driver 240 and comprises two functions: an extend function 246 and a retract function 248. A bending software driver 250 controls the bending guide driver 242 and comprises two functions: a bend counterclockwise function 252 and a bend clockwise function 254. The functions 246, 248, 252 and 254 are operated by a propagation control software module 256.

At the other end of the guide 20, the tip sensor 11 measures the proximity and orientation of an adjacent surface. In a preferred embodiment of the present invention the tip sensor 11 performs the proximity and orientation measurements by measuring the force applied to a tactile tip by a surface of an adjacent tissue. A tip sensor software driver module 260, operative to receive input signals from the tip sensor 11, provides two input functions: a counterclockwise tip rotation function 262 and a clockwise tip rotation function 264. The measurements of the tip positions as provided by the tip sensor software driver module 260 are collected and stored by a sensor log module 266.

The map 10 is loaded into memory and serves as an updatable map 268. A comparator 270 compares the accumulated measurements from the tip sensor 11 with the updated reference map 268. The results of the comparisons are calculated by an update scale module 272 to provide a scaling factor that is applied to update the updated map 268. Consequently a navigation module 274 employs the updated map information to instruct the propagation control 256 to execute the next step of the insertion program.

It is appreciated that a measurement of the electric current drawn by at least one of the longitudinal guide drive and the bending guide drive can also serve as an input to the comparator 270 to evaluate the position of the tip sensor.

Reference is now made to Figs. 5A to 5H, which are, taken together, an electrical schematic of a preferred embodiment of the present invention useful for intubation of a human. Reference is especially made to microprocessor 278, which is preferably operative to operate a program to control the elements of the intubator assembly 12, such as the operating switches 230, the display 232, the motors 210 and 224 (Fig. 3), and the Hall effect sensors 38 and 40 in the tip sensor 11 (Fig. 1A), and to perform the intubation process, such as the process shown and described hereinabove with reference to Figs. 2A to 2F.

Reference is now made to Figs. 6A to 6K, which are a series of simplified pictorial illustrations of ten typical steps in a process of employing a preferred embodiment of the present invention useful for insertion of an element into the intestine of a human.

It is appreciated that some of the organ systems of a living organism are generally similar up to a scale factor, such as the mouth and trachea system. Other organs, such as the intestine system, are generally different from one human body to the other. Therefore, in order to employ the present invention to insert a medical device or apply a medicine to a specific location within a generally variable organ, a map of the organ, at least from the entry point and until the required location, is prepared before the insertion process is activated. The required map is preferably prepared by employing an appropriate medical imaging system, such as an ultrasound scanner, an X-ray imager, a CAT scan system or a MRI system. The map can be a two dimensional map or a three-dimensional map as appropriate for the specific organ. Typically for the intestine system a three dimensional map is required.

It is appreciated that an inserter according to a preferred embodiment of the present invention for use in organs that are variable in three dimensions is similar to the intubator assembly 12, preferably with the following modifications:

(1) The tube 18 may be replaced with a different insertable device;

(2) An additional guide bending system employing elements similar to motor 222, disk 224 and wires 226 is added and mounted perpendicularly to the first

system of motor 222, disk 224 and wires 26, so that it is possible to bend the end of the guide in three dimensions. It is appreciated that three-dimensional manipulation is possible also by employing three or more motors; and

(3) The tip sensor 11 preferably comprises four Hall effect sensors to sense the motion of the tip 28 in three dimensions. It is appreciated that it is possible to operate the tip sensor in a three-dimensional space also by employing three Hall effect sensors. It is also appreciated that other types of sensors can be employed to measure the proximity and orientation of an adjacent surface in three dimensions.

In a preferred embodiment of the present invention, when the guide 20 performs longitudinal motion, such as insertion or retraction, the guide 20 also performs a small and relatively fast lateral motion. The combined longitudinal and lateral motions are useful for sensing the surface of the organ in three dimensions and hence to better determine the location of the tip sensor 11 in the organ and relative to the map 10.

Due to limitations of the graphical representation, a two-dimensional imaging and map is shown in Figs. 6A to 6K.

As seen in Fig. 6A, a human organ, the intestine in this example, is imaged, typically by a CAT scan system 280, and an image 282 of the internal structure of the organ is produced.

In Fig. 6B the image 282 of the organ is used to create an insertion map 284. Typically the image 282 is displayed on a computer screen (not shown) and a pointing device, such as a computer mouse or a light pen, is used to draw a preferred path 286 that the tip of the guide is to follow. The path is typically drawn by marking a contour of the organ, and optionally marking the guide bending points, as is shown and described with reference to Figs. 1A to 1 K. Alternatively, a preferred path is created, such as path 286, not necessarily continuously following the contours of the organ. As a further alternative, the map 10 or the path 286 is converted into a set of insertion steps as is shown and described hereinbelow with reference to Fig. 7.

Reference is now made to Fig. 7 together with Fig. 8 and with Figs. 6C to 6K. As shown in Fig. 7, a table 290 is provided for storage in a computer memory and for processing by a computer processor. The table 290 contains rows 292, wherein each row 292, preferably comprises an instruction to perform one step in the process of insertion of a medical insertion device into a living organism such as shown and described with reference to Figs. 6C to 6K. Preferably each row 292 contains the expected values or the maximal values for the extension of an insertion guide such as guide 20, the bending of the insertion guide and the electrical outputs from the Hall effect sensors 38 and 40 (Fig. 1A). In a preferred embodiment of the present invention the row 292 contains five sets of values:

(a) Initial bend 294 contains two values for bending the guide from a straight position, in two perpendicular planes.

(b) Initial insertion 295 contains a longitudinal value for extending or retracting the guide in centimeters.

(c) Initial sensor measurements 296 contains expected output values of four sensors such as four Hall effect sensors, for example, Hall effect sensors 38 and 40 of Fig. 1A. The initial sensors measurements 296 are expected to be measured by the time the guide reaches the value of the initial insertion 295.

(d) Insert distance 297 contains a longitudinal value for further extending or retracting the guide in centimeters. Typically the initial sensor measurements 296 are expected to be preserved, while the guide is extended or retracted, by adapting the bending of the guide.

(e) Final sensor measurements 298 contain expected output values of the four sensors of step (c). The initial sensor measurements 298 are expected to be measured by the time the guide reaches the value of the insert distance 297.

It is appreciated that the path drawn in Fig. 6B can be employed to prepare a table of instructions, such as table 290 of Fig. 7.

Referring to Fig. 8, which is a flowchart illustrating a preferred implementation of the present invention, operative for a process of insertion of an element into the intestine of a human as shown in Figs. 6A to 6K. The flowchart of Fig. 8 is a preferred embodiment of a program, operative to be executed by a processor, such as microprocessor 278 of Fig. 5A, comprised in a preferred embodiment of the present invention, for insertion of an element into a living organism, preferably by employing a table 290 shown and described with reference to Fig. 7.

The preferred flowchart shown in Fig. 8 starts by loading the table (step 300) such as the map shown in Fig. 7. The program then reads a first row 292 from the map (step 302) and causes the distal end of the guide 20 to bend according to the initial bending values 294. Then the program causes the guide 20 to extend or retract according to the initial insertion distance 295 of the first row in the map. The program continues to bend and insert the guide 20 until output values of the sensors match the expected initial sensor measurement 296 of the row (steps 304, 306 and 308), or until a limit is surpassed, an error message is displayed and the program is stopped (step 310).

Preferably, the initial values of the sensors are measured and then the program continues to extend or retract the guide 20 (step 312) until the sensors produce the final sensors measurements 298 values (step 314), while keeping in contact with the surface (steps 316 and 318) or until at least one of predefined limits is surpassed (step 320) where the program is stopped (step 310). If the final sensor measurements 298 values are measured the program proceeds to step 320 and loops through steps 302 and 320 until all the rows 292 of the table are processed. Then the program displays an insertion success message on the display 232 and halts (step 322).

As indicated by row No. 1 of Fig. 7 and Fig. 6C the guide is bent, preferably by up to 45 degrees, to the left in the plane of Fig. 6C and, while preserving contact with the left side of the intestine, is extended up to 5 centimeters or until the sensor tip engages the internal surface of the intestine head on at a point in the map 284 designated by reference numeral 330.

As indicated by row No.2 of Fig. 7 and Fig. 6D the guide is bent by up to 45 degrees to the right in the plane of Fig. 6D and, while preserving contact with the left side of the intestine, is extended up to 2.5 centimeters or until the sensor tip does not sense the internal surface of the intestine at a point in the map 284 designated by reference numeral 332.

As indicated by row No.3 of Fig. 7 and Fig. 6E the guide is bent by up to 110 degrees to the left in the plane of Fig. 6E and, while preserving contact with the left side of the intestine, is extended by 1 centimeter to a point in the map 284 designated by reference numeral 334.

In accordance with row 4 of Fig. 7 and Fig. 6F the guide is bent by up to 45 degrees to the right in the plane of Fig. 6F and is extended by 6 centimeter to a point in the map 284 designated by reference numeral 336.

As indicated by row No.5 of Fig. 7 and Fig. 6G the guide is bent by up to 20 degrees to the right in the plane of Fig. 5G and, while preserving contact with the right side of the intestine, is extended by 4 centimeters to a point in the map 284 designated by reference numeral 338.

As indicated by row No.6 of Fig. 7 and Fig. 6H the guide is bent by up to -60 degrees to the left in the plane of Fig. 6H and is extended by up to 3 centimeters or until the sensor tip engages the internal surface of the intestine head on at a point in the map 284 designated by reference numeral 340.

As indicated by row No.7 of Fig. 7 and Fig. 6I the guide is bent by up to 45 degrees to the right in the plane of Fig. 6I and is extended by up to 1 centimeter or until the sensor tip engages the internal surface of the intestine with its right side in a point in the map 284 designated by reference numeral 342.

As indicated by row No.8 of Fig. 7 and Fig. 6J the guide is extended by up to 1 centimeters or until the sensor tip engages the internal surface of the intestine with its left side at a point in the map 284 designated by reference numeral 344.

As indicated by row No.9 of Fig. 7 and Fig. 6K the guide is bent by up to 45 degrees to the right in the plane of Fig. 6K and is extended by up to 1 centimeter or until the sensor tip engages the internal surface of the intestine head on at a point in the map 284 designated by reference numeral 346.

In a preferred embodiment of the present invention the system and the method are operative for automatic operation. Alternatively the present invention can be operated manually, by providing to the operator the information collected by the sensor log 266 form the tip sensor 11 and enabling the operator to control manually the guide 20. In another alternative part of the procedure is performed automatically and another part is performed manually. For example, the guide 20 may be inserted automatically and a medical device, such as the tube 18 may be inserted manually.

It is appreciated that a log of the process of insertion of an insertable element into a living organism such as a human body is preferably stored in an internal memory of the present invention and that this log can be transmitted to a host computer. It is appreciated that the host computer can aggregate insertion process logs and thereby continuously improve relevant insertion pattern maps such as the standard contour map 10. Thereafter, from time to time or before starting an insertion process, the present invention is capable of loading an updated map such as standard contour map 10.

It is also appreciated that the accumulated logs of processes of insertions can be employed to improve the algorithm for processing the maps, such as the algorithms shown and described with reference to Figs. 2A – 2F and Fig. 8. The improved algorithm can be transmitted to the present invention as necessary.

Reference is now made to Figs. 9A to 9F, which are a series of simplified pictorial illustrations of an extendable endotracheal tube assembly constructed and operative in accordance with a preferred embodiment of the present invention, in various operative orientations.

Turning to Fig. 9A, it is seen that the extendable endotracheal tube assembly, designated generally by reference numeral 400, preferably comprises a mounting element 402 which is arranged to be removably engaged with an intubator assembly (not shown) such as intubator assembly 12 (Figs. 1A - 1L). Fixed to or integrally formed with mounting element 402 is a mouthpiece 404, which is preferably integrally formed with a rigid curved pipe 406. Fixedly mounted onto mounting element 402, interiorly of rigid curved pipe 406, is a mounting base 408 onto which is, in turn, mounted, an extendable tube 410, preferably including a coil spring 411, typically formed of metal. Fixedly mounted onto a distal end of extendable tube 410 there is preferably provided a forward end member 412, preferably presenting a diagonally cut pointed forward facing tube end surface 414.

Upstream of end surface 414, forward end member 412 is preferably provided with an inflatable and radially outwardly expandable circumferential balloon 416, which receives inflation gas, preferably pressurized air, preferably through a conduit 418 embedded in a wall of forward end member 412 and continuing through tube 410 to a one way valve 419.

It is noted that the extendable endotracheal tube assembly 400 may comprise an integrally formed mouthpiece assembly and an integrally formed insertable extendable tube assembly. The integrally formed mouthpiece assembly may comprise the mouthpiece 404 and the rigid curved pipe 406. The integrally formed extendable tube assembly may comprise the extendable tube 410, the mounting element 402, the mounting base 408, the coil spring 411, the forward end member 412 with the end surface 414 and the circumferential balloon 416, the conduit 418 and the one way valve 419.

Extending slidably through forward end member 412, tube 410, mounting base 408 and mounting element 402 is a flexible guide 420, which preferably corresponds in function inter alia to guide 20 in the embodiment of Figs. 1A - 1L and preferably has mounted at a distal end thereof a tip 421, which preferably corresponds in structure and function inter alia to the tip 28 in the embodiment of Figs. 1A - 1L. Tip 421 forms part of a tip sensor, preferably enclosed in guide 420, which preferably corresponds in structure and function inter alia to the tip sensor 11 in the embodiment of Figs. 1A - 1L.

As distinct from that described hereinabove with reference to Figs. 1A - 8, the flexible guide is preferably formed with an inflatable and radially outwardly expandable balloon 422, which receives inflation gas, preferably pressurized air, preferably through a conduit 424 formed in flexible guide 420 and extending therealong, preferably to a source of pressurized inflation gas, preferably located within the intubator assembly (not shown).

Fig. 9B shows inflation of balloon 422 by means of pressurized air supplied via conduit 424, causing balloon 422 to tightly engage the interior of forward end member 412.

Fig. 9C illustrates extension of tube 410, which is preferably achieved by forward driven movement of flexible guide 420 in tight engagement with forward end member 412, thus pulling forward end member 412 and the distal end of tube 410 forwardly therewith.

Fig. 9D illustrates inflation of balloon 416 by means of pressurized air through one way valve 419 and conduit 418. As will be described hereinbelow, this inflation is employed for sealing the tube 410 within a patient's trachea.

Fig. 9E illustrates deflation of balloon 422 following inflation of balloon 416, corresponding to desired placement and sealing of tube 410 within the patient's trachea. Fig. 9F illustrates removal of the flexible guide 420 from the tube 410.

Reference is now made to Figs. 10A to 10G, which are a series of simplified pictorial illustrations of the extendable endotracheal tube assembly of Figs. 9A - 9F employed with the medical insertion device of Figs. 1A - 8 for the intubation of a human.

Turning to Fig. 10A, it is seen that the extendable endotracheal tube assembly, designated generally by reference numeral 500, preferably comprises a mounting element (not shown) which is arranged to be removably engaged with an intubator assembly 503 which is preferably similar to intubator assembly 12 (Figs. 1A - 1L) or any other intubator assembly described hereinabove but may alternatively be any other suitable intubator assembly. Fixed to or integrally formed with the mounting element is a mouthpiece 504, which is preferably integrally formed with a rigid curved pipe 506. The extendable entotracheal tube assembly 500 is shown inserted into a patient's oral cavity, similar to the placement shown in Fig. 1A.

Fixedly mounted onto the mounting element, interiorly of rigid curved pipe 506, is a mounting base 508 onto which is, in turn, mounted, an extendable tube 510, preferably including a coil spring 511 (Fig. 10C), typically formed of metal. Fixedly mounted onto a distal end of extendable tube 510 there is preferably provided a forward end member 512, preferably presenting a diagonally cut pointed forward facing tube end surface 514.

Upstream of end surface 514, forward end member 512 is preferably provided with an inflatable and radially outwardly expandable circumferential balloon 516, which receives inflation gas, preferably pressurized air, preferably through a conduit 518 embedded in a wall of forward end member 512 and continuing through tube 510 to a one way valve 519.

It is noted that the extendable endotracheal tube assembly 500 may comprise a mouthpiece assembly and an extendable tube assembly, which is inserted therein. The mouthpiece assembly comprises the mouthpiece 504, which is integrally formed with the rigid curved pipe 506. The extendable tube assembly comprises the extendable tube 510, which is integrally formed together with the mounting element, the mounting base 508, the coil spring 511, the forward end member 512 with the end surface 514 and the circumferential balloon 516, the conduit 518 and the one way valve 519.

Extending slidably through forward end member 512, tube 510, mounting base 508 and the mounting element is a flexible guide 520, which preferably corresponds in function inter alia to guide 20 in the embodiment of Figs. 1A - 1L and preferably has mounted at a distal end thereof a tip, which preferably corresponds in structure and function inter alia to the tip 28 in the embodiment of Figs. 1A - 1L. The tip forms part of a tip sensor, preferably enclosed in guide 520, which preferably corresponds in structure and function inter alia to the tip sensor 11 in the embodiment of Figs. 1A - 1L.

As distinct from that described hereinabove with reference to Figs. 1A - 8, the flexible guide is preferably formed with an inflatable and radially outwardly expandable balloon 522, which receives inflation gas, preferably pressurized air, preferably through a conduit 524 formed in flexible guide 520 and extending therealong, preferably to a source of pressurized inflation gas preferably located within the intubator assembly 503.

The source of pressurized inflation gas may be an automatic inflator/deflator 526. Additionally or alternatively, a one way valve 528 may be provided for manual inflation. The automatic inflator/deflator 526 may be fixed within intubator assembly 503 or alternatively may be mounted therewithin for motion together with flexible guide 520.

Fig. 10B shows inflation of balloon 522 by means of pressurized air supplied via conduit 524, causing balloon 522 to tightly engage the interior of forward end member 512.

Fig. 10C illustrates extension of tube 510, which is preferably achieved by forward driven movement of flexible guide 520 in tight engagement with forward end member 512, thus pulling forward end member 512 and the distal end of tube 510 forwardly therewith.

Fig. 10D illustrates further extension of tube 510, by forward driven movement of flexible guide 520 in tight engagement with forward end member 512, thus pulling forward end member 512 and the distal end of tube 510 forwardly therewith. This further motion is preferably provided based on the navigation functionality described hereinabove with reference to Figs. 1A - 8. It is appreciated that the forward driven movement of tube 510 as described hereinabove with reference to Figs. 1A - 8, may be provided by driven forward motion of the flexible guide 520.

Fig. 10E illustrates inflation of balloon 516 by means of pressurized air through conduit 518 and one way valve 519. As will be described hereinbelow, this inflation is employed for sealing the tube 510 within a patient's trachea.

Fig. 10F illustrates deflation of balloon 522 following inflation of balloon 516, corresponding to desired placement and sealing of tube 510 within the patient's trachea. Fig. 10G illustrates removal of the flexible guide 520 from the tube 510.

Reference is now made to Figs. 11A to 11F, which are a series of simplified pictorial illustrations of an extendable endotracheal tube assembly constructed and operative in accordance with another preferred embodiment of the present invention in various operative orientations.

Turning to Fig. 11A, it is seen that the extendable endotracheal tube assembly, designated generally by reference numeral 600, preferably comprises a mounting element 602 which is arranged to be removably engaged with an intubator assembly (not shown) such as intubator assembly 12 (Figs. 1A - 1L). Fixed to or integrally formed with mounting element 602 is a mouthpiece 604.

Fixedly mounted onto mounting element 602 is a mounting base 608 onto which is, in turn, mounted, an extendable tube 610, preferably including a coil spring 611, typically formed of metal. Fixedly mounted onto a distal end of extendable tube 610 there is preferably provided a forward end member 612, preferably presenting a diagonally cut pointed forward facing tube end surface 614.

Upstream of end surface 614, forward end member 612 is preferably provided with an inflatable and radially outwardly expandable circumferential balloon 616, which receives inflation gas, preferably pressurized air, preferably through a conduit 618 embedded in a wall of forward end member 612 and continuing through tube 610 to a one way valve 619.

It is noted that the extendable endotracheal tube assembly 600, comprising at least one of mounting element 602, mouthpiece 604, mounting base 608, tube 610, coil spring 611, forward end member 612, end surface 614, circumferential balloon 616, conduit 618 and one way valve 619, may also be integrally formed as a unified structure.

Extending slidably through forward end member 612, tube 610, mounting base 608 and mounting element 602 is a flexible guide 620, which preferably corresponds in function inter alia to guide 20 in the embodiment of Figs. 1A - 1L and preferably has mounted at a distal end thereof a tip 621, which preferably corresponds in structure and function inter alia to the tip 28 in the embodiment of Figs. 1A - 1L. Tip 621 forms part of a tip sensor (not shown), preferably enclosed in guide 620, which preferably corresponds in structure and function inter alia to the tip sensor 11 in the embodiment of Figs. 1A - 1L.

As distinct from that described hereinabove with reference to Figs. 1A - 8, the flexible guide is preferably formed with an inflatable and radially outwardly expandable balloon 622, which receives inflation gas, preferably pressurized air, preferably through a conduit 624 formed in flexible guide 620 and extending therealong, preferably to a source of pressurized inflation gas preferably located within the intubator assembly (not shown).

Fig. 11B shows inflation of balloon 622 by means of pressurized air supplied via conduit 624, causing balloon 622 to tightly engage the interior of forward end member 612.

Fig. 11C illustrates extension of tube 610, which is preferably achieved by forward driven movement of flexible guide 620 in tight engagement with forward end member 612, thus pulling forward end member 612 and the distal end of tube 610 forwardly therewith.

Fig. 11D illustrates inflation of balloon 616 by means of pressurized air through conduit 618 and one way valve 619. As will be described hereinbelow, this inflation is employed for sealing the tube 610 within a patient's trachea.

Fig. 11E illustrates deflation of balloon 622 following inflation of balloon 616, corresponding to desired placement and sealing of tube 610 within the patient's trachea. Fig. 11F illustrates removal of the flexible guide 620 from the tube 610.

Reference is now made to Figs. 12A to 12G, which are a series of simplified pictorial illustrations of the extendable endotracheal tube assembly of Figs. 11A - 11F employed with the medical insertion device of Figs. 1A - 8 for the intubation of a human.

Turning to Fig. 12A, it is seen that the extendable endotracheal tube assembly, designated generally by reference numeral 700, preferably comprises a mounting element (not shown) which is arranged to be removably engaged with an intubator assembly 703 which is preferably similar to intubator assembly 12 (Figs. 1A - 1L) or any other intubator assembly described hereinabove but may alternatively be any other suitable intubator assembly. Fixed to or integrally formed with the mounting element is a mouthpiece 704. The extendable entotracheal tube assembly 700 is shown inserted into a patient's oral cavity, similar to the placement shown in Fig. 1A.

Fixedly mounted onto the mounting element is a mounting base 708 onto which is, in turn, mounted, an extendable tube 710, preferably including a coil spring 711 (Fig. 12C), typically formed of metal. Fixedly mounted onto a distal end of extendable tube 710 there is preferably provided a forward end member 712, preferably presenting a diagonally cut pointed forward facing tube end surface 714.

Upstream of end surface 714, forward end member 712 is preferably provided with an inflatable and radially outwardly expandable circumferential balloon 716, which receives inflation gas, preferably pressurized air, preferably through a conduit 718 embedded in a wall of forward end member 712 and continuing through tube 710 to a one way valve 719.

It is noted that the extendable endotracheal tube assembly 700, comprising at least one of mounting element, mouthpiece 704, mounting base 708, tube 710, coil spring 711 (Fig. 12C), forward end member 712, end surface 714, circumferential balloon 716, conduit 718 and one way valve 719, may also be integrally formed as a unified structure.

Extending slidably through forward end member 712, tube 710, mounting base 708 and the mounting element is a flexible guide 720, which preferably corresponds in function inter alia to guide 20 in the embodiment of Figs. 1A - 1L and preferably has mounted at a distal end thereof a tip, which preferably corresponds in structure and function inter alia to the tip 28 in the embodiment of Figs. 1A - 1L. The tip forms part of a tip sensor, preferably enclosed in guide 720, which preferably corresponds in structure and function inter alia to the tip sensor 11 in the embodiment of Figs. 1A - 1L.

As distinct from that described hereinabove with reference to Figs. 1A - 8, the flexible guide is preferably formed with an inflatable and radially outwardly expandable balloon 722, which receives inflation gas, preferably pressurized air, preferably through a conduit 724 formed in flexible guide 720 and extending therealong, preferably to a source of pressurized inflation gas preferably located within the intubator assembly 703.

The source of pressurized inflation gas may be an automatic inflator/deflator 726. Additionally or alternatively, a one way valve 728 may be provided for manual inflation. The automatic inflator/deflator 726 may be fixed within intubator assembly 703 or alternatively may be mounted therewithin for motion together with flexible guide 720.

Fig. 12B shows inflation of balloon 722 by means of pressurized air supplied via conduit 724, causing balloon 722 to tightly engage the interior of forward end member 712.

Fig. 12C illustrates extension of tube 710, which is preferably achieved by forward driven movement of flexible guide 720 in tight engagement with forward end member 712, thus pulling forward end member 712 and the distal end of tube 710 forwardly therewith.

Fig. 12D illustrates further extension of tube 710, by forward driven movement of flexible guide 720 in tight engagement with forward end member 712, thus pulling forward end member 712 and the distal end of tube 710 forwardly therewith. This further motion is preferably provided based on the navigation functionality described hereinabove with reference to Figs. 1A - 8. It is appreciated that the forward driven movement of tube 710 as described hereinabove with reference to Figs. 1A - 8, may be provided by driven forward motion of the flexible guide 720.

Fig. 12E illustrates inflation of balloon 716 by means of pressurized air through conduit 718 and one way valve 719. As will be described hereinbelow, this inflation is employed for sealing the tube 710 within a patient's trachea.

Fig. 12F illustrates deflation of balloon 722 following inflation of balloon 716, corresponding to desired placement and sealing of tube 710 within the patient's trachea. Fig. 12G illustrates removal of the flexible guide 720 from the tube 710.

Appendices 1 to 3 are software listings of the following computer files:

Appendix 1: containing file intumed.asm.

Appendix 2: containing file c8cdr.inc.

Appendix 3: containing file ram.inc.

The method for providing the software functionality of the microprocessor 278, in accordance with a preferred embodiment of the present invention, includes the following steps:

1. Provide an Intel compatible computer with a Pentium II CPU or higher, 128MB RAM, a Super VGA monitor and an available serial port.

2. Install Microsoft Windows 95 or Microsoft Windows 98 Operating System.

3. Install the Testpoint Development kit version 40 available from Capital Equipment Corporation, 900 Middlesex Turnpike, Building 2, Billereca, MA 0821, USA.

4. Connect a flash processor loading device COP8EM Flash, COP8 In Circuit Emulator for Flash Based Families to the serial port of the Intel compatible computer. The COP8EM flash processor loading device is available from National Semiconductors Corp. 2900 Semiconductor Dr., P.O.Box 58090, Santa Clara, CA 95052-8090, USA

5. Place a COP8CDR9HVA8 microcontroller available from National Semiconductors Corp., 2900 Semiconductor Dr., P.O.Box 58090, Santa Clara, CA 95052-8090, USA in the COP8EM Flash.

6. Copy the files intumed.asm, c8cdr.inc, and ram.inc, respectively labeled Appendix 1, Appendix 2 and Appendix 3 to a temporary directory.

7. Load the file intumed.asm by using the operating software available with the COP8EM Flash device from National Semiconductors.

8. To run the intumed.asm; Install the COP8CDR9HVA8 microcontroller in its socket in the electrical circuit, which detailed electronic schematics are provided in Figs. 5A to 5H, where the microcontroller is designated by reference numeral 278.

It is appreciated that the software components of the present invention may, if desired, be implemented in ROM (read-only memory) form. The software components may, generally, be implemented in hardware, if desired, using conventional techniques.

It is appreciated that the particular embodiment implemented by the Appendix is intended only to provide an extremely detailed disclosure of the present invention and is not intended to be limiting.

It is appreciated that various features of the invention which are, for clarity, described in the contexts of separate embodiments may also be provided in combination in a single embodiment. Conversely, various features of the invention which are, for brevity, described in the context of a single embodiment may also be provided separately or in any suitable subcombination.

It will be appreciated by persons skilled in the art that the present invention is not limited by what has been particularly shown and described hereinabove. Rather the scope of the present invention includes both combinations and subcombinations of the various features described hereinabove as well as variations and modifications which would occur to persons skilled in the art upon reading the specification and which are not in the prior art.

Appendices 1 through 3 are as follows:

Appendix 1

```
; Files:          intumed.asm, ram.inc and c8cdr.inc.

#UPPERCASE
                ; verify
                .TITLE  intumed
                .LIST   0ff     ;complete listing.    ; X'040
                .CONTRL 3           ; 0- disable all code alteration, 3- re-enable code
alteration.

                .incld c8cdr.inc   ; File that include all the definitions of cop8cdr.
                .incld ram.inc     ; File that include all the variables, constants, registers
and
                                   ; bits definitions.

;-----------------CONFIGURATION----------------------
.sect option,conf

                .db 01   ; 5=0 security dis, 2=0 wdog dis, 1=0 halt dis, 0=1 flex.
                        ; flex=1 -execution following reset will be from flash memory.
                        ; flex=0 -flash memory is erased. execution following reset will be
from
                        ;       boot rom with the mictowire plus isp routines.

;---------------------------------------------
.sect begin_rst,rom,abs=0
reset:          rpnd

;------------ Clear memory -------------------
                ld s,#0        ; Clean segment0 0-6fH.
                ld b,#0        ;
                ld a,#06f        ; Cleans the memory between
st00:           ld [b+],#0     ; b to a
                ifgt a,b       ;
                jmp st00       ;

                LD SP,#01e    ; Stack Pointer in Memory 1eH. The stack works in LIFO
(last
                ld 01e,#0ff ; in first out) with "push a" and "pop a" instructions.
                ld 01f,#0ff ;  The stack starts from 1eH until 0H.

                ld s,#1        ; Clean s1 0-7fH.
                ld b,#0        ;
                ld a,#07f        ; Cleans the memory between
st01:           ld [b+],#0     ; b to a
                ifgt a,b       ;
```

```
        jmp st01    ;

        ld s,#2     ; Clean s2 0-7fh.
        ld b,#0     ;
        ld a,#07f       ; Cleans the memory between
st02:   ld [b+],#0  ; b to a
        ifgt a,b    ;
        jmp st02    ;


        ld 05c,#'E'  ; when the pc send moving command, the cop8 transmit
packets of
        ld 05d,#'D' ; information every 160 msec. in every packet We have 10
blockes of
                ; 9 bytes in s1 and 10 in s2. At the end of the packet there is 1
                ; byte of check sum and then the 2 bytes of 'E','D' to signal
                ; end of transmition.
        ld s,#0
; ---  port   definitions  ---    see ram.inc for bits definitions.
        ld pgc,#033; clkdly enabled   ; g2=t1b=cha2,g3=t1a=cha1 - inputs
        ld pg,#0     ; sk idle phase=0
        ld plc,#057
        ld pl,#0af
        ld pbc,#010; b0-3 = a2d(in), b5-7 = limit switches(in)
        ld pb,#0f0
        ld pac,#0ff
        ld pa,#03

; ----- UART initialization -------------
        ld enu,#0           ; no parity, 8 bit data
        ld enur,#0
        ld enui,#022        ; 1 stop bit, Asynch. mode,psr+baud clock
                ; enable receive int.,disable trans. int.
        ld baud,#4      ; 38400 baud rate.
        ld psr,#060     ; 10MHz*2 /(16*(4+1)*6.5)

; ----- LCD initialization -------------
        jsr init_lcd
        ld temp,#low(wordmm); type in line 1 of lcd "   mm   ", in the left side
there is
        jsr type_string0   ; space for 3 digits of mm, and in the right side 3 spaces
for
                ; direction (+/-  up/down) and 2 digits of movement.
        ld temp,#low(wordpoweron)
        jsr type_string1

; ----- PWM,T0,interupts initialization  -----------
```

```
                ld cntrl,#080       ; timer 1 - pwm mode - stopped.
                ld a,#0ff       ; timer 1 would be used in capture mode, meaning that
pulse
                x a,tmr1lo      ; received from linear motor will capture the value of
timer1
                ld a,#0ff       ; in timer 1 auto reload A (t1rahi/lo) and pulse from
angular
                x a,tmr1hi      ; motor in B (t1rbhi/lo).

                ld t2cntrl,#0a0; timer 2 - pwm toggle mode stopped.
                ld t3cntrl,#0a0; timer 3 - pwm toggle mode stopped.
                sbit t2a,pl     ; enable linear motor and lock it by putting 0 in control1,2.
                sbit t3a,pl     ; enable angular motor and lock it by putting 0 in
control3,4.

                sbit t2hs,hstcr
                sbit t3hs,hstcr
                ld cntrl,#060       ; timer 1 - capture mode.

                rbit t1pndb,icntrl
                sbit t1enb,icntrl  ; timer 1 - capture mode, t2enB=1
                rbit t1pnda,psw
                sbit t1ena,psw     ; timer 1 - capture mode, t2enA=1
                sbit itsel0,itmr ; 8,192 inst. cycles - 4,096 m. sec timer 0 interrupts.
                rbit t0pnd,icntrl
                sbit t0en,icntrl ; start timer0.

; ----- Program initialization -----------

                sbit 7,pls_y1       ; pls_y=08000H
                            ; over 80 is positive angle and under 80 is negative angel.
                ld data_cntr,#21
                sbit stop2,aflags
                sbit direction,lflags
                sbit stop1,lflags
                sbit en_calc,lflags
                ld pls_x1,#068
                sbit limits_c_en,limits_flags
                sbit home_command,buttons_flags
                sbit gie,psw        ; enable interupts.
                jmp main

;***********************************************
.sect pc_module,rom
main:           ifbit limits_c_en,limits_flags
                jsr limits_check

                ifbit start_stop,buttons_flags
```

```
                jsr autorun_states

                ifbit stop_command,buttons_flags
                jsr stop_operation

                ifbit buttons_t_en,buttons_flags
                jsr buttons_test

                ifbit home_command,buttons_flags
                jsr home_p_states
                ifbit self_t_command,buttons_flags
                jmp self_t_states

main0:          jmp linear_states     ; linear_states + angular_states.

main1:          jsr updatelcd

                ifbit a2den,flags2    ; a2d check.
                jsr a2d00

                ld a,#0
                add a,linear_stat
                add a,ang_stat
                add a,autorun_stat
                add a,selft_stat
                add a,home_stat
                ifeq a,#0
                sbit enddata,flags1        ; if 2 motors are stopped, set enddata bit to stop
transmitting to PC.
                ld a,buttons_flags
                and a,#09e         ; if one of the commands flags is set, reset enddata bit.
                ifgt a,#0
                rbit enddata,flags1
                ifbit enddata,flags1
                rbit start,flags1
                ifbit fix_t_en,flags2
                jsr data_send

                jmp main
;**************************************************
.sect autorun_select,rom,inpage
autorun_states:ld a,autorun_stat
                add a,#low(jmp_a_r_stat)
                jid            ; jmp pcu,[a]

jmp_a_r_stat: .addr
a_r0,a_r1,a_r2,a_r3,a_r4,a_r5,a_r6,a_r7,a_r8,a_r9,a_r10,a_r11,a_r12;,a_r13,a_r14
```

```
a_r0:       jmp a_r_stat0
a_r1:       jmp a_r_stat1
a_r2:       jmp a_r_stat2
a_r3:       jmp a_r_stat3
a_r4:       jmp a_r_stat4
a_r5:       jmp a_r_stat5
a_r6:       jmp a_r_stat6
a_r7:       jmp a_r_stat7
a_r8:       jmp a_r_stat8
a_r9:       jmp a_r_stat9
a_r10:      jmp a_r_stat10
a_r11:      jmp a_r_stat11
a_r12:      jmp a_r_stat12
;a_r13:     jmp a_r_stat13
;a_r14:     jmp a_r_stat14

end_a_r_stat:ret
;*************************************
.sect autorun,rom
a_r_stat0:ld autorun_stat,#1
            ld home_stat,#0
            sbit home_command,buttons_flags

a_r_stat1:ifbit home_command,buttons_flags
            ret

            ld linear_stat,#1   ; move linear forwards 1mm.
            ld rbyte1,#08       ; 0,1,2=0= speed1    ; 3=1= direction forwards ; 4=0=
linear motor.
            ld rbyte2,#136
            ld rbyte3,#0        ; 1mm*136pulse per mm = 136 pulses.
            ld autorun_stat,#2
            ld temp,#low(wordautorun)
            jsr type_string1

a_r_stat1_1:rbit limits_c_en,limits_flags
            rbit stop1,lflags
            rbit stuck,flags1
a_r_stat1_2:sbit fix_t_en,flags2
            jmp end_a_r_stat

a_r_stat2:ifeq linear_stat,#0   ; wait until linear motor complete mission.
            jmp a_r_stat2_0
            jmp end_a_r_stat

a_r_stat2_0:ld a,hall1
            x a,zero_h1
            ld a,hall2
```

```
                x a,zero_h2
                rbit home,flags1
                ld ang_stat,#1  ; move angular down 2000 pulses.
                ld rbyte1,#010     ; 0,1,2=0= speed1     ; 3=0= direction down  ; 4=1=
angular motor.
                ld rbyte2,#low(2000)
                ld rbyte3,#high(2000)
                rbit stop2,aflags
                ld autorun_stat,#3
                rbit stuck,flags1
                jmp a_r_stat1_2

a_r_stat3:ld linear_stat,#1 ; move linear forwards 40mm.
                ld rbyte1,#08       ; 0,1,2=0= speed1     ; 3=1= direction forwards ; 4=0=
linear motor.
                ld rbyte2,#low(5440)
                ld rbyte3,#high(5440)   ; 40mm*136pulse per mm = 5440.
                ld autorun_stat,#4
                jmp a_r_stat1_1

a_r_stat4:jsr epi_check     ; check if epiglotis sensed.
                ifbit epi,flags1
                jmp a_r_stat4_0
                ifeq linear_stat,#0    ; wait until linear motor complete mission.
                jmp a_r_stat7_0
                jmp end_a_r_stat

a_r_stat4_0:ld linear_stat,#1  ; move linear backwards 6mm.
                ld rbyte1,#0        ; 0,1,2=0= speed1     ; 3=0= direction backwards   ;
4=0= linear motor.
                ld rbyte2,#low(816)
                ld rbyte3,#high(816); 6mm*136pulse per mm = 816.
                ld autorun_stat,#5
                jmp a_r_stat1_1

a_r_stat5:ifeq linear_stat,#0   ; wait until linear motor complete mission.
                jmp a_r_stat5_0
                jmp end_a_r_stat

a_r_stat5_0:ld ang_stat,#1; move angular up 70 pulses.
                ld rbyte1,#018     ; 0,1,2=0= speed1     ; 3=1= direction up  ; 4=1=
angular motor.
                ld rbyte2,#70
                ld rbyte3,#0
                ld autorun_stat,#6
                rbit stop2,aflags
                jmp a_r_stat1_2
```

```
a_r_stat6:ifeq ang_stat,#0 ; wait until angular motor complete mission.
        jmp a_r_stat6_0
        jmp end_a_r_stat

a_r_stat6_0:rbit epi,flags1
        ld linear_stat,#1  ; move linear forwards 10mm.
        ld rbyte1,#08      ; 0,1,2=0= speed1   ; 3=1= direction forwards ; 4=0=
linear motor.
        ld rbyte2,#low(1360)
        ld rbyte3,#high(1360)  ; 10mm*136pulse per mm = 1360.
        ld autorun_stat,#7
        jmp a_r_stat1_1

a_r_stat7:ifeq linear_stat,#0  ; wait until linear motor complete mission.
        jmp a_r_stat7_0
        jmp end_a_r_stat


a_r_stat7_0:ld ang_stat,#1 ; move angular down 2000 pulses.
        ld rbyte1,#010     ; 0,1,2=0= speed1   ; 3=0= direction down  ; 4=1=
angular motor.
        ld rbyte2,#low(2000)
        ld rbyte3,#high(2000)
        ld autorun_stat,#8
        rbit stop2,aflags
        rbit stuck,flags1
        jmp a_r_stat1_2

a_r_stat8:;ld linear_stat,#1    ; move linear forwards 50mm.
        ;ld rbyte1,#08      ; 0,1,2=0= speed1   ; 3=1= direction forwards ; 4=0=
linear motor.
        ;ld rbyte2,#low(8160)
        ;ld rbyte3,#high(8160)  ; 50mm*136pulse per mm = 6800.
        ld pls_cntr0,#low(6800)
        ld pls_cntr1,#high(6800)   ; 50mm*136pulse per mm = 6800.
        sbit direction,lflags  ; turn motor forwards
        rbit t2c0,t2cntrl
        sbit t2a,pl
        rbit control2,pa
        sbit control1,pa
        ld linear_stat,#6
        rbit en_calc,lflags
        ld autorun_stat,#9
        jmp a_r_stat1_1

a_r_stat9:ifeq linear_stat,#0  ; wait until linear motor complete mission.
        jmp a_r_stat9_0
        jmp end_a_r_stat
```

```
a_r_stat9_0:ld ang_stat,#1 ; move angular up 2000 pulses.
            ld rbyte1,#018    ; 0,1,2=0= speed1    ; 3=1= direction up  ; 4=1=
angular motor.
            ld rbyte2,#low(2000)
            ld rbyte3,#high(2000)
            ld autorun_stat,#10
            rbit stop2,aflags
            jmp a_r_stat1_2

a_r_stat10:;ld linear_stat,#1  ; move linear forwards 70mm.
            ;ld rbyte1,#08     ; 0,1,2=0= speed1    ; 3=1= direction forwards ; 4=0=
linear motor.
            ;ld rbyte2,#low(9520)
            ;ld rbyte3,#high(9520)  ; 70mm*136pulse per mm = 9520.

            ld pls_cntr0,#low(9520)
            ld pls_cntr1,#high(9520)  ; 70mm*136pulse per mm = 9520.
            sbit direction,lflags  ; turn motor forwards
            rbit t2c0,t2cntrl
            sbit t2a,pl
            rbit control2,pa
            sbit control1,pa
            ld linear_stat,#6

            ld autorun_stat,#11
            jmp a_r_stat1_1

a_r_stat11:ifeq linear_stat,#0 ; wait until linear motor complete mission.
            jmp a_r_stat11_0
            jmp end_a_r_stat


a_r_stat11_0:sbit stop2,aflags
            rbit t3c0,t3cntrl
            sbit t3a,pl
            sbit control3,pa   ; turn off motor 2
            sbit control4,pa

            ;ld linear_stat,#1  ; move linear forwards 50mm.
            ;ld rbyte1,#08     ; 0,1,2=0= speed1    ; 3=1= direction forwards ; 4=0=
linear motor.
            ;ld rbyte2,#low(6800)
            ;ld rbyte3,#high(6800)  ; 50mm*136pulse per mm = 6800.

            ld pls_cntr0,#low(6800)
            ld pls_cntr1,#high(6800)  ; 50mm*136pulse per mm = 6800.
```

```
                sbit direction,lflags  ; turn motor forwards
                rbit t2c0,t2cntrl
                sbit t2a,pl
                rbit control2,pa
                sbit control1,pa
                ld linear_stat,#6

                ld autorun_stat,#12
                jmp a_r_stat1_1

a_r_stat12:ifeq linear_stat,#0 ; wait until linear motor complete mission.
                jmp a_r_stat12_0
                jmp end_a_r_stat

a_r_stat12_0:ld autorun_stat,#0
                jsr stop2motors
                sbit en_calc,lflags
                rbit start_stop,buttons_flags
                rbit stuck,flags1
                ld temp,#low(wordinplace)
                jsr type_string1
                jmp end_a_r_stat

;**************************************************
epi_check:;ld a,#4
                ;ifgt  a,pls_x1
                ;ret
                sc
                ld a,hall1
                ifgt a,zero_h1
                jmp epi_check0_1
                ld a,zero_h1
                subc a,hall1
                jmp epi_check0_2
epi_check0_1:subc a,zero_h1
epi_check0_2:ifgt a,#20
                sbit epi,flags1

                sc
                ld a,hall2
                ifgt a,zero_h2
                jmp epi_check0_3
                ld a,zero_h2
                subc a,hall2
                jmp epi_check0_4
epi_check0_3:subc a,zero_h2
epi_check0_4:ifgt a,#20
                sbit epi,flags1
```

```
                ret
;*************************************************
.sect l_s_select,rom,inpage
linear_states:ld a,linear_stat
                add a,#low(jmp_l_stat)
                jid             ; jmp pcu,[a]

jmp_l_stat: .addr l_s0,l_s1,l_s2,l_s3,l_s4,l_s5,l_s6

l_s0:           jmp l_stat0
l_s1:           jmp l_stat1
l_s2:           jmp l_stat2
l_s3:           jmp l_stat3
l_s4:           jmp l_stat4
l_s5:           jmp l_stat5
l_s6:           jmp l_stat6

end_l_stat:jmp angular_states
;************************************
.sect linear_states,rom

l_stat0:        ifbit pulse,lflags
                jmp l_stat0_01        ; the motor made another pulse after stop order.
                jmp e_l_stat0

l_stat0_01:rbit pulse,lflags

                ifbit direction,lflags ; x update
                jmp l_stat0_03          ; x forwards

                ld a,pls_x1     ; before decreasing pls_x, check if pls_x>1
                ifne a,#0
                jmp l_stat0_02
                ld a,pls_x0
                ifgt a,#0
                jmp l_stat0_02
                ifeq pls_x0,#0
                jmp e_l_stat0     ; do not decrease pls_x if 0.

l_stat0_02:sc
                ld a,pls_x0        ; x downwards
                subc a,#1
                x a,pls_x0
                ld a,pls_x1
                subc a,#0
                x a,pls_x1
                jmp e_l_stat0
```

```
l_stat0_03:rc             ; x forwards
            ld a,pls_x0
            adc a,#1
            x a,pls_x0
            ld a,pls_x1
            adc a,#0
            x a,pls_x1

e_l_stat0:jmp end_l_stat      ; ->O

;*****************************************
l_stat1:    ifbit direction,lflags ; check the previous direction.
            jmp l_stat1_02

                        ; the direction was backwards.
            ifbit new_direction,rbyte1 ; check the new direction.
            jmp l_stat1_01
            jmp l_stat3

l_stat1_01:ld nxt_l_stat,#4      ; change direction to forwards.
            jmp l_stat1_05

                        ; the direction was forwards.
l_stat1_02:ifbit new_direction,rbyte1  ; check the new direction.
            jmp l_stat4

            ld a,pls_x1         ; before changing diretion to backwards
            ifne a,#0           ; check if pls_x=0.
            jmp l_stat1_04          ; if not then...
            ld a,pls_x0
            ifne a,#0
            jmp l_stat1_04

l_stat1_03:ld linear_stat,#0      ; if 0 then just stop motor.
            sbit stop1,lflags      ; stop motor 1.
            rbit stop,flags1
            sbit limits_c_en,limits_flags
            sc
            ifbit stop2,aflags
            rc
            ifc
            jmp l_stat1_06
            rbit start,flags1
            sbit end,flags1
            sbit type_end,lcd_flags
            jmp l_stat1_06

l_stat1_04:ld nxt_l_stat,#3       ; stop motor, wait and then
```

```
                        ; change direction to backwards.
l_stat1_05:ld linear_stat,#2
           ld cd_dly,#020
l_stat1_06:rbit t2c0,t2cntrl
           sbit t2a,pl
           rbit control1,pa      ; stop motor 1.
           rbit control2,pa
           jmp end_l_stat        ; ->O
;*********************************************************************
l_stat2:   ifeq cd_dly,#0        ; delay before changing direction.
           jmp l_stat2_01
           jmp end_l_stat        ; ->O
l_stat2_01:ld a,nxt_l_stat
           x a,linear_stat
           jmp end_l_stat        ; ->O

l_stat3:   ld a,pls_x1         ; the direction is still backwards.
           ifne a,#0           ; check if pls_x=0
           jmp l_stat3_01          ; if not then...
           ld a,pls_x0
           ifne a,#0
           jmp l_stat3_01
           jmp l_stat1_03          ; if 0 then just stop motor and
                        ; return to linear stat 0.

l_stat3_01:ifbit home_limit,pbi
           jmp l_stat3_02
           jmp l_stat1_03
l_stat3_02:rbit direction,lflags   ; turn motor backwards.
           rbit t2c0,t2cntrl
           sbit t2a,pl
           rbit control1,pa
           sbit control2,pa
           rbit t2a,pl
           jmp l_stat4_02

l_stat4:   ;ld a,pls_x1        ; 255mm*128pulsepermm=7f80H
           ;ifgt a,#0fe        ; if pls_x>7f00H then stop motor1.
           ;jmp l_stat1_03
           ifbit bottom_limit,pbi
           jmp l_stat4_01
           jmp l_stat1_03
           ld linear_stat,#0
           sbit stop1,lflags
           jmp end_l_stat

l_stat4_01:sbit direction,lflags   ; turn motor forwards
           rbit t2c0,t2cntrl
```

```
                sbit t2a,pl
                rbit control2,pa
                sbit control1,pa
                rbit t2a,pl
l_stat4_02:ld a,rbyte2          ; distanse update
                x a,pls_cntr0
                ld a,rbyte3
                x a,pls_cntr1
                ld a,rbyte1          ; velosity update
                and a,#7
                ifne a,#0
                jmp l_stat4_03
                ld t_ref0,#low(1000)    ; 1000 -> 500u per pulse
                ld t_ref1,#high(1000)
                jmp end_l_stat4
l_stat4_03:ifne a,#1
                jmp l_stat4_04
                ld t_ref0,#low(2000)    ; 2000 -> 1000u per pulse
                ld t_ref1,#high(2000)
                jmp end_l_stat4
l_stat4_04:ifne a,#2
                jmp l_stat4_05
                ld t_ref0,#low(3000)    ; 3000 -> 1500u per pulse
                ld t_ref1,#high(3000)
                jmp end_l_stat4
l_stat4_05:ifne a,#3
                jmp end_l_stat4
                ld t_ref0,#low(4000)    ; 4000 -> 2000u per pulse
                ld t_ref1,#high(4000)

end_l_stat4:
;*************************************************
l_stat5:        ifbit t2c0,t2cntrl  ; if motor 1 is already on.
                jmp e_l_stat5

                rbit first_pulse,lflags
                rbit t2c1,t2cntrl   ; turn off the toggle output.
                rbit t2a,pl

                ld pt1hi,#020
                ld pt2hi,#080

                ld tmr2lo,#0ff
                ld tmr2hi,#0ff
                ld t2ralo,#0ff
                ld t2rahi,#0ff
                ld t2rblo,#0ff
                ld t2rbhi,#0ff
```

```
                rbit t2pndb,t2cntrl
                sbit t2c0,t2cntrl   ; start timer 2 - pwm.
l_stat5_01:ifbit t2pndb,t2cntrl
                jp l_stat5_02
                jp l_stat5_01
l_stat5_02:rbit t2c0,t2cntrl    ; stop timer 2 - pwm.
                ld tmr2lo,#250           ; 250->t2.
                ld tmr2hi,#0
                ld t2ralo,#low(400)      ; 400->r2a.
                ld t2rahi,#high(400)
                ld t2rblo,#low(600)      ; 600->r2b.
                ld t2rbhi,#high(600)
                rbit t2a,pl
                sbit t2c1,t2cntrl   ; turn on the toggle output.
                sbit t2c0,t2cntrl   ; start timer 2 - pwm.
;               rbit stop1,lflags
e_l_stat5:ld a,int_cntr
                sc
                subc a,#20
                x a,nolpulsetmr
                sbit limits_c_en,limits_flags
                ld linear_stat,#6
                ld nxt_l_stat,#0
                jmp end_l_stat    ; ->O

;*******************************************************************

l_stat6:        ifbit pulse,lflags
                jmp l_stat6_01
                ld a,nolpulsetmr
                ifne a,int_cntr
                jmp l_stat6_05
                sbit stop1,lflags
                sbit stuck,flags1
                jmp l_stat6_05

l_stat6_01:rbit pulse,lflags
                ld a,int_cntr
                sc
                subc a,#20
                x a,nolpulsetmr
                sbit limits_c_en,limits_flags
                sc              ; dec. pls_cntr
                ld a,pls_cntr0
                subc a,#1
                x a,pls_cntr0
                ld a,pls_cntr1
                subc  a,#0
```

```
                x a,pls_cntr1
                ld a,pls_cntr1       ; check if pls_cntr=0
                ifne a,#0
                jmp l_stat6_02
                ld a,pls_cntr0
                ifne a,#0
                jmp l_stat6_02
                sbit stop1,lflags

l_stat6_02:;ifbit first_pulse,lflags
                sbit en_calc,lflags
                sbit first_pulse,lflags

                ifbit direction,lflags ; x_update
                jmp l_stat6_04
                ld a,pls_x1          ; check if pls_x>1
                ifne a,#0
                jmp l_stat6_03
                ld a,pls_x0
                ifgt a,#0
                jmp l_stat6_03
                ld pls_x0,#0
                sbit stop1,lflags
                ld nxt_l_stat,#0
                jmp l_stat6_05


l_stat6_03:sc              ; x_downwards
                ld a,pls_x0
                subc a,#1
                x a,pls_x0
                ld a,pls_x1
                subc a,#0
                x a,pls_x1
                jmp l_stat6_05
l_stat6_04:rc              ; x_forwards
                ld a,pls_x0
                adc a,#1
                x a,pls_x0
                ld a,pls_x1
                adc a,#0
                x a,pls_x1
                ifgt a,#086  ; the lcd can show only 256 mm (=
256*136=34816=08800H).
                sbit stop1,lflags

l_stat6_05:ifbit stop1,lflags
                jmp e_l_stat6
```

```
                ifbit en1_calc,lflags
                jsr v_calc
                jmp end_l_stat      ; ->O

e_l_stat6:rbit t2c0,t2cntrl
                sbit t2a,pl
                rbit control1,pa    ; turn off motor 2.
                rbit control2,pa
                ld a,nxt_l_stat
                x a,linear_stat
                ifbit stop2,aflags
                jmp e_l_stat6_0
                jmp end_l_stat      ; ->O
e_l_stat6_0:rbit start,flags1
                rbit stop,flags1
                ifbit self_t_command,buttons_flags
                jmp end_l_stat      ; ->O
                ifbit start_stop,buttons_flags
                jmp end_l_stat      ; ->O
                ifbit home_command,buttons_flags
                jmp end_l_stat      ; ->O

                sbit type_end,lcd_flags
                sbit end,flags1
                jmp end_l_stat      ; ->O

;*************************************************
.sect a_s_select,rom,inpage
angular_states:ld a,ang_stat
                add a,#low(jmp_a_stat)
                jid             ; jmp pcu,[a]

jmp_a_stat: .addr a_s0,a_s1,a_s2,a_s3,a_s4,a_s5,a_s6,a_s7

a_s0:           jmp a_stat0
a_s1:           jmp a_stat1
a_s2:           jmp a_stat2
a_s3:           jmp a_stat3
a_s4:           jmp a_stat4
a_s5:           jmp a_stat5
a_s6:           jmp a_stat6
a_s7:           jmp a_stat7

end_a_stat:jmp main1
;**********************************
.sect angular_states,rom
a_stat0:        ifbit pulse2,aflags
                jmp a_stat0_01
```

```
                jmp e_a_stat0

 a_stat0_01:rbit pulse2,aflags
                ifbit direction2,aflags   ; y update
                jmp a_stat0_02
                jmp a_stat0_03

 a_stat0_02:sc              ; y down
                ld a,pls_y0
                subc a,#1
                x a,pls_y0
                ld a,pls_y1
                subc a,#0
                x a,pls_y1
                jmp e_a_stat0

 a_stat0_03:rc              ; y up
                ld a,pls_y0
                adc a,#1
                x a,pls_y0
                ld a,pls_y1
                adc a,#0
                x a,pls_y1

e_a_stat0:jmp end_a_stat      ; ->O
;*********************************
a_stat1:

                ld a,pls_y1         ; check if the the probe is not too high or to low.
                ifgt a,#094
                jmp a_stat1_00
                ld a,#066
                ifgt a,pls_y1
                jmp a_stat1_01
                jmp a_stat1_03
;a_stat1_00:ifbit new_direction,rbyte1 ; if too high enable only down movment.
                jmp a_stat1_02
                jmp a_stat1_03
;a_stat1_01:ifbit new_direction,rbyte1 ; if too low enable only up movment.
                jmp a_stat1_03
                jmp a_stat1_02

;a_stat1_02:ld ang_stat,#0    ; just stop motor.
                ld nxt_a_stat,#0
                sbit stop2,aflags     ; stop motor 2.
                sbit type_end,flags2
                jmp a_stat1_08
```

```
a_stat1_03:ifbit direction2,aflags    ; check the previous direction.
            jmp a_stat1_05

            ifbit new_direction,rbyte1 ; the direction was down-check the new
direction.
            jmp a_stat1_04
            jmp a_stat3

a_stat1_04:ld nxt_a_stat,#4        ; stop motor, wait and then change direction to up.
            jmp a_stat1_07

a_stat1_05:ifbit new_direction,rbyte1  ; the direction was up-check the new direction.
            jmp a_stat4

a_stat1_06:ld nxt_a_stat,#3        ; stop motor, wait and then change direction to down.

a_stat1_07:ld ang_stat,#2       ; delay for the motor to make a complete stop.
            ld cd_dly,#17
a_stat1_08:rbit t3c0,t3cntrl
            sbit t3a,pl
            sbit control3,pa        ; stop motor 2.
            sbit control4,pa
            jmp end_a_stat          ; ->O
;**********************************************************************
a_stat2:    ifeq cd_dly,#0          ; delay before changing direction.
            jmp a_stat2_01
            jmp end_a_stat          ; ->O
a_stat2_01:ld a,nxt_a_stat
            x a,ang_stat
            jmp end_a_stat          ; ->O
;**********************************************************************
*
a_stat3:    rbit direction2,aflags    ; turn motor backwards.
            rbit t3c0,t3cntrl
            sbit t3a,pl
            rbit control3,pa
            sbit control4,pa
            rbit t3a,pl
            jmp a_stat4_01
;*******************************************
a_stat4:    sbit direction2,aflags    ; turn motor forwards
            rbit t3c0,t3cntrl
            sbit t3a,pl
            rbit control4,pa
            sbit control3,pa
            rbit t3a,pl
a_stat4_01:ld a,rbyte2          ; distanse update
            x a,plsy_cntr0
```

```
            ld a,rbyte3
            x a,plsy_cntr1

            ld a,rbyte1         ; velosity update
            and a,#7
            ifne a,#0
            jmp a_stat4_02
            ld at_ref0,#low(6000)   ; 6000 -> 3000u per pulse
            ld at_ref1,#high(6000)
            jmp end_a_stat4
a_stat4_02:ifne a,#1
            jmp a_stat4_03
            ld at_ref0,#low(7000)   ; 7000 -> 3500u per pulse
            ld at_ref1,#high(7000)
            jmp end_a_stat4
a_stat4_03:ifne a,#2
            jmp a_stat4_04
            ld at_ref0,#low(8000)   ; 8000 -> 4000u per pulse
            ld at_ref1,#high(8000)
            jmp end_a_stat4
a_stat4_04:ifne a,#3
            jmp end_a_stat4
            ld at_ref0,#low(9000)   ; 9000 -> 4500u per pulse
            ld at_ref1,#high(9000)

end_a_stat4:ld nxt_a_Stat,#6
;*****************************************************
a_stat5:    ;ifbit t3c0,t3cntrl ; if motor 2 is already on.
            ;jmp e_a_stat5


            ld apt1hi,#020
            ld apt2hi,#080

            rbit firsty_pulse,aflags
            rbit t3c1,t3cntrl   ; turn off the toggle output.
            rbit t3a,pl
            ld tmr3lo,#0ff
            ld tmr3hi,#0ff
            ld t3ralo,#0ff
            ld t3rahi,#0ff
            ld t3rblo,#0ff
            ld t3rbhi,#0ff
            rbit t3pndb,t3cntrl
            sbit t3c0,t3cntrl   ; start timer 3 - pwm.
a_stat5_01:ifbit t3pndb,t3cntrl
            jp a_stat5_02
            jp a_stat5_01
```

```
a_stat5_02:rbit t3c0,t3cntrl    ; stop timer 3 - pwm.
           ld tmr3lo,#250          ; 250->t3.
           ld tmr3hi,#0
           ld t3ralo,#low(500)     ; 500->r3a.
           ld t3rahi,#high(500)
           ld t3rblo,#low(500)     ; 500->r3b.
           ld t3rbhi,#high(500)
           rbit t3a,pl
           sbit t3c1,t3cntrl   ; turn on the toggle output.
           sbit t3c0,t3cntrl   ; start timer 3 - pwm.
e_a_stat5:;ld a,int_cntr
           ;sc
           ;subc a,#50
           ;x a,noapulsetmr
           ld a,nxt_a_stat
           x a,ang_stat
           ld nxt_a_stat,#0
           jmp end_a_stat       ; ->O
;*********************************
a_stat6:   ifbit pulse2,aflags
           jmp a_stat6_01

           ;ld a,noapulsetmr
           ;ifne a,int_cntr
           ;jmp a_stat6_06
           ;sbit stop2,aflags
           ;sbit stuck,flags1
           jmp a_stat6_06

a_stat6_01:rbit pulse2,aflags
           ;ld a,int_cntr
           ;sc
           ;subc a,#50
           ;x a,noapulsetmr
           sc            ; dec. plsy_cntr
           ld a,plsy_cntr0
           subc a,#1
           x a,plsy_cntr0
           ld a,plsy_cntr1
           subc  a,#0
           x a,plsy_cntr1
           ld a,plsy_cntr1       ; check if plsy_cntr=0
           ifne a,#0
           jmp a_stat6_02
           ld a,plsy_cntr0
           ifne a,#0
           jmp a_stat6_02
           sbit stop2,aflags
```

```
                ld nxt_a_stat,#0

 a_stat6_02:;ifbit firsty_pulse,aflags
                sbit en_calc2,aflags
                sbit firsty_pulse,aflags

                ifbit direction2,aflags   ; y_update
                jmp a_stat6_04
                ld a,pls_y1         ; check if pls_y>6500H
                ifgt a,#0           ; 065
                jmp a_stat6_03
                sbit stop2,aflags
                ld nxt_a_stat,#0
                jmp a_stat6_06

 a_stat6_03:sc            ; y_down
                ld a,pls_y0
                subc a,#1
                x a,pls_y0
                ld a,pls_y1
                subc a,#0
                x a,pls_y1
                jmp a_stat6_06

 a_stat6_04:ld a,#0ff       ; 096
                ifgt a,pls_y1
                jmp a_stat6_05
                sbit stop2,aflags
                ld nxt_a_stat,#0
                jmp a_stat6_06

 a_stat6_05:rc            ; y_up
                ld a,pls_y0
                adc a,#1
                x a,pls_y0
                ld a,pls_y1
                adc a,#0
                x a,pls_y1

 a_stat6_06:ifbit stop2,aflags
                jmp e_a_stat6
                ifbit en1_calc2,aflags
                jsr v2_calc
                jmp end_a_stat       ; ->0

 e_a_stat6:
                rbit t3c0,t3cntrl
                sbit t3a,pl
```

```
                sbit control3,pa    ; turn off motor 2
                sbit control4,pa
                ld a,nxt_a_stat
                x a,ang_stat
                ifbit stop1,lflags
                jmp e_a_stat6_0
                jmp end_a_stat        ; ->O
e_a_stat6_0:rbit start,flags1
                rbit stop,flags1
                ifbit self_t_command,buttons_flags
                jmp end_a_stat        ; ->O
                ifbit start_stop,buttons_flags
                jmp end_a_stat        ; ->O
                ifbit home_command,buttons_flags
                jmp end_l_stat    ; ->O

                sbit end,flags1
                sbit type_end,lcd_flags
                ifbit stuck,flags1
                sbit type_stuck,lcd_flags
                jmp end_a_stat        ; ->O

;*********************************************************
a_stat7:        ifbit pulse2,aflags
                jmp a_stat7_01
                jmp e_a_stat7

a_stat7_01:rbit pulse2,aflags
                ifbit direction2,aflags    ; y update
                jmp a_stat0_03

a_stat7_02:sc              ; y down
                ld a,pls_y0
                subc a,#1
                x a,pls_y0
                ld a,pls_y1
                subc a,#0
                x a,pls_y1
                jmp e_a_stat7

a_stat7_03:rc              ; y up
                ld a,pls_y0
                adc a,#1
                x a,pls_y0
                ld a,pls_y1
                adc a,#0
                x a,pls_y1
```

```
e_a_stat7:jmp end_a_stat      ; ->O
;**************************************************
.sect stop_subroutines,rom
stop2motors:sbit stop1,lflags ; turn off motor 1
                rbit t2c0,t2cntrl
                sbit t2a,pl
                rbit control1,pa
                rbit control2,pa
                ld linear_stat,#0
                ld nxt_l_stat,#0
                sbit stop2,aflags  ; turn off motor 2
                rbit t3c0,t3cntrl
                sbit t3a,pl
                sbit control3,pa
                sbit control4,pa
                ld ang_stat,#0
                ld nxt_a_stat,#0
                ret
stop_operation:rbit stop_command,buttons_flags
                jsr stop2motors
                sbit en_calc,lflags
                sbit fix_t_en,flags2
                rbit enddata,flags1
                rbit start,flags1
                rbit end,flags1
                sbit stop,flags1
                sbit type_stop,lcd_flags
                rbit self_t_command,buttons_flags
                ld selft_stat,#0
                rbit start_stop,buttons_flags
                ld autorun_stat,#0
                rbit home_command_pc,buttons_flags
                rbit home_command,buttons_flags
                ld home_stat,#0
                ret
;**************************************************
.sect s_t_select,rom,inpage
self_t_states:ld a,selft_stat
                add a,#low(jmp_st_stat)
                jid           ; jmp pcu,[a]

jmp_st_stat: .addr s_t0,s_t1,s_t2,s_t3,s_t4,s_t5,s_t6

s_t0:           jmp self_test0
s_t1:           jmp self_test1
s_t2:           jmp self_test2
s_t3:           jmp self_test3
s_t4:           jmp self_test4
```

```
s_t5:          jmp self_test5
s_t6:          jmp self_test6

end_st_stat:jmp main0
;***********************************
.sect self_test,rom
self_test0:ld temp,#low(wordselftest)
               jsr type_string1
               ifbit home_limit,pbi
               jmp self_test0_0     ; 1-micro switch open - not in home position.
               rbit home_command,buttons_flags
               ld home_stat,#0
               jmp self_test1_0     ; 0-micro switch closed - in home position.

self_test0_0:sbit home_command,buttons_flags
               ld home_stat,#0
               ld selft_stat,#1
               jmp end_st_stat

self_test1:ifbit home_command,buttons_flags
               jmp end_st_stat

self_test1_0:ld linear_stat,#1 ; move linear forwards 50mm.
               ld rbyte1,#08      ; 0,1,2=0= speed1    ; 3=1= direction forwards ; 4=0=
linear motor.
               ld rbyte2,#low(6850)
               ld rbyte3,#high(6850)  ; 50mm*136pulse per mm = 6800.
               ld selft_stat,#2
self_test1_1:rbit limits_c_en,limits_flags
               rbit stop1,lflags
self_test1_2:jmp end_st_stat

self_test2:ifeq linear_stat,#0  ; wait until linear motor complete mission.
               jmp self_test2_0
               jmp end_st_stat

self_test2_0:ld ang_stat,#1    ; move angular up 150 pulses.
               ld rbyte1,#018    ; 0,1,2=0= speed1    ; 3=1= direction up      ; 4=1=
angular motor.
               ld rbyte2,#150
               ld rbyte3,#0
               ld selft_stat,#3
               rbit stop2,aflags
               sbit en_calc2,aflags
               jmp self_test1_2

self_test3:ifeq ang_stat,#0 ; wait until angular motor complete mission.
               jmp self_test3_0
```

```
                jmp end_st_stat

self_test3_0:rbit en_calc2,aflags
                ld ang_stat,#1  ; move angular down 400 pulses.
                ld rbyte1,#010     ; 0,1,2=0= speed1    ; 3=0= direction down  ; 4=1=
angular motor.
                ld rbyte2,#low(300)
                ld rbyte3,#high(300)
                ld selft_stat,#4
                rbit stop2,aflags
                jmp self_test1_2


self_test4:ifeq ang_stat,#0 ; wait until angular motor complete mission.
                jmp self_test4_0
                jmp end_st_stat

self_test4_0:ld ang_stat,#1    ; move angular again up 150 pulses.
                ld rbyte1,#018     ; 0,1,2=0= speed1    ; 3=1= direction up       ; 4=1=
angular motor.
                ld rbyte2,#150
                ld rbyte3,#0
                ld selft_stat,#5
                rbit stop2,aflags
                sbit en_calc2,aflags
                jmp self_test1_2

self_test5:ifeq ang_stat,#0 ; wait until angular motor complete mission.
                jmp self_test5_0
                jmp end_st_stat


self_test5_0:rbit en_calc2,aflags
                ld linear_stat,#1  ; move linear backwards 50mm.
                ld rbyte1,#0        ; 0,1,2=0= speed1    ; 3=0= direction backwards
4=0= linear motor.
                ld rbyte2,#low(6850)
                ld rbyte3,#high(6850)  ; 50mm*136pulse per mm = 6800.
                ld selft_stat,#6
                jmp self_test1_1

self_test6:ifeq linear_stat,#0  ; wait until linear motor complete mission.
                jmp self_test6_0
                jmp end_st_stat


self_test6_0:ld selft_stat,#0
                rbit self_t_command,buttons_flags
```

```
                rbit stuck,flags1
                ld temp,#low(wordready)
                jsr type_string1
                jmp end_st_stat


;************************************************
.sect h_p_select,rom,inpage
home_p_states:ld a,home_stat
                add a,#low(jmp_h_stat)
                jid             ; jmp pcu,[a]

jmp_h_stat: .addr h_p0,h_p1

h_p0:           jmp home_p0
h_p1:           jmp home_p1

;*****************************************************************
*****
.sect home_positioning,rom
home_p0:        ifbit home_limit,pbi ; 0-micro switch closed - in home position,
                jmp home_p0_2         ; 1-micro switch open - not in home position.
                jmp home_p1_0

home_p0_2:jsr stop2motors
                ld lcd_flags,#0
                rbit direction,lflags  ; so the bottom wouldn't shut down the motor.
                ld linear_stat,#1   ; move linear backwards 200mm.
                ld rbyte1,#0        ; 0,1,2=0= speed1    ; 3=0= direction backwards    ;
4=0= linear motor.
                ld rbyte2,#low(27200)
                ld rbyte3,#high(27200) ; 200mm*136pulse per mm = 27200.
                rbit stop1,lflags
                sbit fix_t_en,flags2
                rbit start,flags1
                rbit stop,flags1
                rbit end,flags1
                rbit enddata,flags1
                ld home_stat,#1
                ifbit self_t_command,buttons_flags
                ret
                ld temp,#low(wordhome)
                jsr type_string1

home_p1:        ifeq linear_stat,#0    ; wait until linear motor complete mission.
                jmp home_p1_0
                ret
```

```
home_p1_0:ld home_stat,#0
        rbit home_command,buttons_flags
        rbit epi,flags1
        ifbit stuck,flags1
        jmp home_p1_1
        ld pls_x0,#0
        ld pls_x1,#0
        ld pls_y0,#0
        ld pls_y1,#080
home_p1_1:ifbit self_t_command,buttons_flags
        ret

        ifbit stuck,flags1
        ret
        ld temp,#low(wordready)
        jsr type_string1
        ret
;***************************************************
.sect limits_check,rom
limits_check:ld a,pbi       ; general limits check (limits = b5,b6,b7).
        and a,#060      ; 0e0 - if the angular limit switch is on.
        ifne a,#060
        jmp limits_check0_0
        rbit home,flags1  ; signal to the pc that we are not in home position.
        rbit bottom,flags1      ; signal to the pc that we are not in buttom
position.
        ret

limits_check0_0:x a,b
        ifbit home_limit,b
        jmp limits_check1_0

        sbit home,flags1      ; signal to the pc that we are in home position.
        rbit bottom,flags1      ; signal to the pc that we are not in buttom
position.
        ifbit direction,lflags
        jmp limits_check0_1
        sbit stop1,lflags       ; turn off motor 1
        rbit t2c0,t2cntrl
        sbit t2a,pl
        rbit control1,pa
        rbit control2,pa
        ld linear_stat,#0
        ifbit stop2,aflags
        rbit start,flags1
        ld temp,#low(wordready)
        jsr type_string1
```

```
limits_check0_1:
                ld pls_x1,#0
                ld pls_x0,#0
                ld pls_y0,#0
                ld pls_y1,#080
                jmp limits_check2_1

limits_check1_0:rbit home,flags1   ; signal to the pc that we are not in home position.
                ifbit bottom_limit,b
                jmp limits_check2_0
                sbit bottom,flags1      ; signal to the pc that we are in buttom position.
                ifbit direction,lflags
                jmp limits_check1_1
                jmp limits_check1_2

limits_check1_1:jsr stop2motors
                rbit start,flags1
                ld temp,#low(wordbottom)
                jsr type_string1

limits_check1_2:ld pls_x1,#066 ; to be calibrated.
                ld pls_x0,#088
                jmp limits_check2_1

limits_check2_0:rbit bottom,flags1      ; signal to the pc that we are not in buttom
position.
limits_check2_1:
                ;ifbit angular_limit,b
                ret

;**************************************************

buttons_test:rbit buttons_t_en,buttons_flags
                ld a,pli
                and a,#0a0
                x a,b
                ifeq b,#0a0
                jmp b_t0_01
                jmp b_t0_03

b_t0_01:        ifeq ritut,#0    ; no key was pressed.
                jmp b_t0_02
                ld a,ritut
                dec a
                x a,ritut
b_t0_02:        ld start_stop_cntr,#0
                ld home_position_cntr,#0
                jmp end_b_test
```

```
b_t0_03:    ifeq ritut,#0     ; a key was pressed. ritut checks if it is a real press on
            jmp b_t1_00       ;   a key, or just a vibration of the key.
b_t0_04:    ld ritut,#5
;           ld start_stop_cntr,#0
;           ld home_position_cntr,#0
            jmp b_t0_02

b_t1_00:    ifbit start_stop,b
            jmp b_t2_00            ; start-stop key was not pressed.
            ifbit start_stop,buttons_flags  ; start-stop key was pressed to stop
operatio.
            jmp b_t1_02
            ifbit home_command,buttons_flags
            jmp b_t1_02
            ifbit self_t_command,buttons_flags
            jmp b_t1_02
            ld a,start_stop_cntr  ; start-stop key was pressed to start operation.
            inc a
            x a,start_stop_cntr
            ifgt a,#150
            jmp b_t1_01
            jmp b_t2_00
            ;--------------- start/stop  autorun key was pressed ------------------
b_t1_01:    ifbit start_stop,buttons_flags
            jmp b_t1_02
            sbit start_stop,buttons_flags   ; start button was pressed to start operation.
            ld autorun_stat,#0
            jmp b_t0_04

b_t1_02:    sbit stop_command,buttons_flags; start button was pressed again to stop
operation.
            rbit start_stop,buttons_flags
            ld autorun_stat,#0
            jmp b_t0_04

b_t2_00:    ifbit home_position,b
            jmp end_b_test
            ld a,home_position_cntr
            inc a
            x a,home_position_cntr
            ifgt a,#150
            jmp b_t2_01
            jmp end_b_test
            ;--------------- home positon/self test  key was pressed ------------------
b_t2_01:    ifbit home_limit,pbi      ; 0-micro switch closed - in home position,
            jmp b_t2_03
```

```
b_t2_02:        rbit home_command,buttons_flags ; not in home position - go to home
position.
                sbit self_t_command,buttons_flags
                ld selft_stat,#0
                sbit fix_t_en,flags2
                ld data_cntr,#21
                ld save_ptr,#0
                ld send_ptr,#0
                rbit enddata,flags1
                rbit start,flags1
                rbit end,flags1
                rbit stop,flags1
                jmp b_t0_04

b_t2_03:        ld a,pls_x0
                ifgt a,#0
                jmp b_t2_04
                ifeq pls_x1,#0
                jmp b_t2_02
b_t2_04:        sbit home_command,buttons_flags ; not in home position - go to home
position.
                ld home_stat,#0
                sbit fix_t_en,flags2
                ld data_cntr,#21
                ld save_ptr,#0
                ld send_ptr,#0
                rbit enddata,flags1
                rbit start,flags1
                rbit end,flags1
                rbit stop,flags1
                jmp b_t0_04

end_b_test:ret
;*************************************************
.sect interups,rom,abs=0ff ;interrupts address
                push a
                ld a,s
                push a
                ld a,b
                push a
                ld a,x
                push a
                ld a,psw
                push a
                ld s,#0
                vis

end_intr:       rc
```

```
                rbit hc,psw
                pop a
                and a,#0c0      ;save only c and hc
                or a,psw
                x a,psw

                pop a
                x a,x
                pop a
                x a,b
                pop a
                x a,s
                pop a
                reti
;***************************
.sect int_addres,rom,abs=01e0
.addrw reset   ;vis without any interrupt
.addrw reset   ;port l or wake up interupts
.addrw reset   ;t3 b
.addrw reset   ;t3 a
.addrw reset   ;t2 b
.addrw reset   ;t2 a
.addrw trns0   ;transmit
.addrw rec0    ;receive
.addrw reset   ;reserved
.addrw reset   ;micro wire
.addrw tmr1b   ;tmr1      ;t1b
.addrw tmr1a   ;tmr1      ;t1a
.addrw tmr0    ;timer0
.addrw reset   ;external interrupt-g0
.addrw reset   ;reserved
.addrw reset   ;software intr interrupt
;***********************
.sect timer0,rom

tmr0:           rbit t0pnd,icntrl
                drsz lcd_cntr       ; lcd counter to enable lcd update every 0.1sec
(25*4msec).
                jmp tmr0_01
                sbit lcdupdate,flags2

tmr0_01:        ld a,int_cntr       ; timer0 interrupts counter, used to help timing a2d,fix
                dec a       ; transmit, and other actions according to timer0 cycles.
                x a,int_cntr
                ifbit 0,int_cntr ; odd -    ; enable fix transmit.
                jmp tmr0_011
                sbit a2den,flags2 ; even -  ; enable a2d.
                jmp tmr0_02
```

```
tmr0_011:   sbit fix_t_en1,flags2
            sbit buttons_t_en,buttons_flags

tmr0_02:    ifbit stop1,lflags
            jmp tmr0_04

            ifbit en_calc,lflags
            jmp tmr0_03
            jmp tmr0_04

tmr0_03:    sc          ; pt=pt2-pt1 =time per pulse
            ld a,pt2lo
            subc a,pt1lo
            x a,ptlo
            ld a,pt2hi
            subc a,pt1hi
            x a,pthi

            sbit en1_calc,lflags

tmr0_04:    ifbit stop2,aflags
            jmp tmr0_06

            ifbit en_calc2,aflags
            jmp tmr0_05
            jmp tmr0_06

tmr0_05:    sc          ; pt=pt2-pt1 =time per pulse
            ld a,apt2lo
            subc a,apt1lo
            x a,aptlo
            ld a,apt2hi
            subc a,apt1hi
            x a,apthi

            sbit en1_calc2,aflags

tmr0_06:
end_tmr0:   ld a,cd_dly ; delay before changing direction.
            ifne a,#0
            dec a
            x a,cd_dly
            drsz uart_tmr
            jmp end_intr
            ld rec_stat,#0
            jmp end_intr
;**************************************************
.sect timer1,rom
```

```
tmr1a:          rbit t1c0,cntrl

                ifbit t1pnda,psw
                jmp tmr1a1
                jmp end_tmr1a

tmr1a1:         rbit t1pnda,psw
                ld a,pt1lo
                x a,pt2lo
                ld a,pt1hi
                x a,pt2hi
                ld a,t1ralo
                x a,pt1lo
                ld a,t1rahi
                x a,pt1hi
                sbit pulse,lflags

end_tmr1a:jmp end_intr
;*******************************************************
tmr1b:          rbit t1pndb,icntrl
                ld a,apt1lo
                x a,apt2lo
                ld a,apt1hi
                x a,apt2hi
                ld a,t1rblo
                x a,apt1lo
                ld a,t1rbhi
                x a,apt1hi

                sbit pulse2,aflags

end_tmr1b:jmp end_intr
;*******************************************************
.sect uart_transmit,rom,inpage

trns0:          ld a,trns_stat
                add a,#low(jmp_t_stat)
                jid             ; jmp pcu,[a]

jmp_t_stat: .addr t_s0,t_s1

t_s0:           jmp t_stat0
t_s1:           jmp t_stat1

end_t_stat:jmp end_intr
;***********************************************************
t_stat0:        rbit eti,enui
```

```
                ld trns_stat,#0
                jmp end_t_stat


t_statl:        ld a,send_ptr
                ifgt a,#89      ; 0-89 => 90 bytes
                jmp t_statl_01
                ld a,send_ptr
                x a,b
                ld s,#1
                ld a,[b+]
                x a,tbuf
                ld s,#0
                ld a,b
                x a,send_ptr
                jmp end_t_stat

t_statl_01:ifgt a,#183      ; 90-179 => 90
bytes+1(buttons_flags)+1(t_check)+2('ED'[=END])
                jmp end_t_statl
                ld a,send_ptr
                sc
                subc a,#90
                x a,b
                ld s,#2
                ld a,[b+]
                x a,tbuf
                ld s,#0
                ld a,b
                add a,#90
                x a,send_ptr
                jmp end_t_stat

end_t_statl:ld send_ptr,#0
                rbit eti,enui
                ld trns_stat,#0
                jmp end_t_stat

;*************************************************
.sect uart_receive,rom,inpage

rec0:           ld a,rbuf       ; receive interrupt.
                x a,b
                ld a,check_sum
                add a,b
                x a,check_sum
                ld a,rec_stat
                add a,#low(jmp_r_stat)
```

```
                jid             ; jmp pcu,[a]

jmp_r_stat: .addr r_s0,r_s1,r_s2,r_s3

r_s0:           jmp r_stat0
r_s1:           jmp r_stat1
r_s2:           jmp r_stat2
r_s3:           jmp r_stat3

end_r_stat:jmp end_intr
;***********************************
.sect receive_states,rom

r_stat0:        ld check_sum,#0
                ld a,b
                ifne a,#0f5
                jmp e_r_stat0

                ld rec_stat,#1
                ld check_sum,#0f5
e_r_stat0:ld uart_tmr,#0ff
                jmp end_r_stat

r_stat1:        ld a,b
                ifeq a,#'A'     ; (041)   ; Advance - moving command.
                jmp r_stat2_00
                ifeq a,#'S'     ; Stop command.
                jmp r_stat1_01
                ifeq a,#'H'     ; Home position command.
                jmp r_stat1_02
                ifeq a,#'T'     ; Self Test command.
                jmp r_stat1_03
                ifeq a,#'O'     ; Operate auto run command.
                jmp r_stat1_04
                ifeq a,#'P'     ; Ping (test communication) command.
                jmp r_stat1_05
                ld rec_stat,#0
                jmp end_r_stat

r_stat1_01:sbit stop_command,buttons_flags    ; 'S' - Stop.
                ld tbyte1,#0f5
                jmp e_r_stat2

r_stat1_02:sbit home_command,buttons_flags  ; 'H' - Home position.
                ld home_stat,#0
e_r_stat1:ld tbyte1,#0f5
                sbit fix_t_en,flags2
                ld data_cntr,#21
```

```
                ld save_ptr,#0
                ld send_ptr,#0
                rbit enddata,flags1
                rbit start,flags1
                rbit end,flags1
                rbit stop,flags1
                jmp e_r_stat2

r_stat1_03:sbit self_t_command,buttons_flags ; 'T' - Self Test.
                ld selft_stat,#0
                jmp e_r_stat1

r_stat1_04:sbit start_stop,buttons_flags   ; 'O' - Operate auto run command.
                ld autorun_stat,#0
                jmp e_r_stat1

r_stat1_05:ld tbyte1,#0f5               ; 'P' - Ping.
                ld pb,#0f0
                jmp e_r_stat2

r_stat2_00:ld rec_stat,#2
                ld rbyte_num,#4       ; number of bytes to be received
                ld receive_ptr,#rbyte1
                jmp end_r_stat
r_stat2:        ld a,receive_ptr      ; rbuf -> [receive_ptr]
                x a,x
                ld a,b            ; receive_ptr + 1 -> receive_ptr
                x a,[x+]
                ld a,x
                x a,receive_ptr
                drsz rbyte_num
                jmp end_r_stat
                sbit start,flags1
                rbit stop,flags1
                rbit end,flags1
                sbit fix_t_en,flags2
                ifeq trns_stat,#1
                jmp r_stat2_01
                ld data_cntr,#21      ; *************
                ld save_ptr,#0
                ld send_ptr,#0
r_stat2_01:ifbit motor,rbyte1 ; 0-motor1, 1-motor2.
                jmp r_stat2_03

                ld a,rbyte3       ; motor 1
                ifne a,#0
                jmp r_stat2_02
                ld a,rbyte2
```

```
                ifgt a,#0
                jmp r_stat2_02
                sbit stop1,lflags   ; distance=0  ->Stop motor!!
                rbit start,flags1
                sbit end,flags1
                ld nxt_l_stat,#0
                ld linear_stat,#6
                jmp r_stat2_05
r_stat2_02:ld linear_stat,#1
                sbit type_start,lcd_flags; type 'start' at line 2 of lcd.
                rbit limits_c_en,limits_flags
                rbit enddata,flags1
                rbit stop1,lflags
                jmp r_stat2_05

r_stat2_03:ld a,rbyte3       ; motor 2
                ifne a,#0
                jmp r_stat2_04
                ld a,rbyte2
                ifgt a,#0
                jmp r_stat2_04
                sbit stop2,aflags   ; distance=0  ->Stop motor!!
                rbit start,flags1
                sbit end,flags1
                ld nxt_a_stat,#0
                ld ang_stat,#6
                jmp r_stat2_05
r_stat2_04:ld ang_stat,#1   ; motor 2
                sbit type_start,lcd_flags; type 'start' at line 2 of lcd.
                rbit enddata,flags1
                rbit stop2,aflags


r_stat2_05:ld a,check_sum     ; load byte to transmit
                x a,tbyte1
e_r_stat2:ld a,tbyte1
                ifeq trns_stat,#0
                x a,tbuf
                ld rec_stat,#0
                rbit stuck,flags1
                jmp end_r_stat

r_stat3:        jmp end_r_stat
;**********************************************************
.sect datasend,rom

data_send:ifbit fix_t_en1,flags2
                jmp d_s0
```

```
            ret

d_s0:       rbit fix_t_en1,flags2
            drsz data_cntr
            jmp d_s1

                    ; transmit s2 and s3
            ld a,#13        ; 13 is the sync. sign.
            x a,tbuf        ; then send the data to the computer
            ld a,buttons_flags
            x a,b
            ld a,t_check
            ld s,#2
            x a,05a
            ld a,b
            x a,05b
            ld s,#1
            ld a,059
            ld s,#0
            x a,0
            ifbit enddata,0
            ifbit enddata,flags1
            rbit fix_t_en,flags2
            ld t_check,#0
            ld trns_stat,#1
            ld data_cntr,#21
            ld save_ptr,#0
            ld send_ptr,#0
            sbit eti,enui
            jmp end_d_s

d_s1:       ifeq data_cntr,#10
            ld save_ptr,#0
            ld a,#11
            ifgt a,data_cntr
            jmp d_s2

            ld b,#flags1    ; load data to stack.
            ld a,[b-]       ; flags1
            push a
            ld a,[b-]       ; pls_y1
            push a
            ld a,[b-]       ; pls_y0
            push a
            ld a,[b-]       ; pls_x1
            push a
            ld a,[b-]       ; pls_x0
            push a
```

```
ld a,[b-]          ; hall2
push a
ld a,[b-]          ; hall1
push a
ld a,[b-]          ; current2
push a
ld a,[b-]          ; current1
push a
ld a,save_ptr          ; save data from stack.
x a,b
ld a,b
x a,x
ld s,#1
pop a
x a,[b+]
pop a
x a,[b+]
pop a
x a,[b+]
pop a
x a,[b+]
pop a
x a,[b+]
pop a
x a,[b+]
pop a
x a,[b+]
pop a
x a,[b+]
pop a
x a,[b+]
ld a,t_check     ; compute check sum.
x a,b
ld a,[x+]      ; b=t_check, a = current1
add a,b        ; a = current1 + b
x a,b      ; b = a
ld a,[x+]
add a,b
x a,b
ld a,[x+]
add a,b
x a,b
ld a,[x+]
add a,b
x a,b
ld a,[x+]
add a,b
x a,b
```

```
            ld a,[x+]
            add a,b
            x a,b
            ld a,[x+]
            add a,b
            x a,b
            ld a,[x+]
            add a,b
            x a,b
            ld a,[x+]     ; a = flags1
            add a,b       ; a = flags1 + b

            ld s,#0       ; t_check = a
            x a,t_check
            ld a,x
            x a,save_ptr

            jmp end_d_s

d_s2:       ld b,#flags1     ; load data to stack.
            ld a,[b-]
            push a
            ld a,[b-]
            push a
            ld a,[b-]
            push a
            ld a,[b-]
            push a
            ld a,[b-]
            push a
            ld a,[b-]
            push a
            ld a,[b-]
            push a
            ld a,[b-]
            push a
            ld a,[b-]
            push a
            ld a,save_ptr       ; save data from stack.
            x a,b
            ld a,b
            x a,x
            ld s,#2
            pop a
            x a,[b+]
            pop a
            x a,[b+]
            pop a
```

```
            x a,[b+]
            pop a
            x a,[b+]
            pop a
            x a,[b+]
            pop a
            x a,[b+]
            pop a
            x a,[b+]
            pop a
            x a,[b+]
            pop a
            x a,[b+]
            ld a,t_check    ; compute check sum.
            x a,b
            ld a,[x+]     ; b=13, a = current1
            add a,b       ; a = current1 + b
            x a,b      ; b = a
            ld a,[x+]
            add a,b
            x a,b
            ld a,[x+]
            add a,b
            x a,b
            ld a,[x+]
            add a,b
            x a,b
            ld a,[x+]
            add a,b
            x a,b
            ld a,[x+]
            add a,b
            x a,b
            ld a,[x+]
            add a,b
            x a,b
            ld a,[x+]
            add a,b
            x a,b
            ld a,[x+]     ; a = flags1
            add a,b       ; a = flags1 + b

            ld s,#0       ; t_check = a
            x a,t_check
            ld a,x
            x a,save_ptr

end_d_s:    ret
```

```
;*****************************************************
.sect a2d_converter,rom
a2d00:      rbit a2den,flags2  ; the a2d prog. checks hall1+2 and current1+2
            ld enad,#082       ; c=>adch8=b0, 2=>psr=1=mclk divide by 16.
            sbit adbsy,enad
a2d01:      ifbit adbsy,enad
            jmp a2d01
            ld a,adrsth
            x a,hall1
            ld enad,#092       ; c=>adch9=b1, 2=>psr=1=mclk divide by 16.
            sbit adbsy,enad
a2d02:      ifbit adbsy,enad
            jmp a2d02
            ld a,adrsth
            x a,hall2
            ld enad,#0a2       ; c=>adch10=b2, 2=>psr=1=mclk divide by 16.
            sbit adbsy,enad
a2d03:      ifbit adbsy,enad
            jmp a2d03
            ld a,adrsth
            x a,current1
            ld enad,#0b2       ; c=>adch11=b3, 2=>psr=1=mclk divide by 16.
            sbit adbsy,enad
a2d04:      ifbit adbsy,enad
            jmp a2d04
            ld a,adrsth
            x a,current2
            ret
;*****************************************************
.sect velosity_caculation,rom

v_calc:     rbit en1_calc,lflags

            ld a,t_ref0
            x a,0
            ld a,t_ref1
            x a,1

            ld a,pthi
            ifgt a,1
            jmp tooslow
            ld a,1
            ifgt a,pthi
            jmp toofast
            ld a,ptlo
            ifgt a,0
            jmp tooslow
            ld a,0
```

```
            ifgt a,ptlo
            jmp toofast
            ret         ; if they are equal the speed is ok

tooslow:    sc          ; err= (pt - t_ref) => (4,5)
            ld a,ptlo     ; if t2ra + err*k >1000 then pwm=1000 (fastest)
            subc a,0
            x a,4
            ld a,pthi
            subc a,1
            x a,5
            ld a,t2ralo
            x a,2
            ld a,t2rahi
            x a,3
            jsr mybyk
            ld a,0
            x a,2
            ld a,1
            x a,3
            ld a,4
            x a,0
            ld a,5
            x a,1
            jmp end_v_calc

toofast:    sc          ; err= (t_ref - pt) => (4,5)
            ld a,0      ; if t2rb + err*k >1000 then pwm=0 (slowest)
            subc a,ptlo
            x a,4
            ld a,1
            subc a,pthi
            x a,5
            ld a,t2rblo
            x a,2
            ld a,t2rbhi
            x a,3
            jsr mybyk
            ld a,4
            x a,2
            ld a,5
            x a,3

end_v_calc:ld b,#t2ralo
            ld x,#0
            ld a,#1
            ld tmr2hi,#2
;loop2:      ifgt a,tmr2hi
```

```
                jp loop2
                ld a,[x+]
                x a,[b+]
                ld a,[x+]
                x a,[b+]
                ld a,[x+]
                x a,[b+]
                ld a,[x]
                x a,[b]
                ret
;*****************************************************
v2_calc:        rbit en1_calc2,aflags

                ld a,at_ref0
                x a,0
                ld a,at_ref1
                x a,1

                ld a,apthi
                ifgt a,1
                jmp atooslow
                ld a,1
                ifgt a,apthi
                jmp atoofast
                ld a,aptlo
                ifgt a,0
                jmp atooslow
                ld a,0
                ifgt a,aptlo
                jmp atoofast
                ret        ; if they are equal the speed is ok

atooslow:       sc         ; err= (pt2 - at_ref) => (4,5)
                ld a,aptlo   ; if t3ra + err*k >1000 then pwm=1000 (fastest)
                subc a,0
                x a,4
                ld a,apthi
                subc a,1
                x a,5
                ld a,t3ralo
                x a,2
                ld a,t3rahi
                x a,3
                jsr mybyk
                ld a,0
                x a,2
                ld a,1
                x a,3
```

```
                ld a,4
                x a,0
                ld a,5
                x a,1
                jmp end_v2_calc

atoofast:       sc          ; err= (at_ref - pt2) => (4,5)
                ld a,0      ; if t3rb + err*k >1000 then pwm=0 (slowest)
                subc a,aptlo
                x a,4
                ld a,1
                subc a,apthi
                x a,5
                ld a,t3rblo
                x a,2
                ld a,t3rbhi
                x a,3
                jsr mybyk
                ld a,4
                x a,2
                ld a,5
                x a,3


end_v2_calc:ld b,#t3ralo
                ld x,#0
                ld a,#1
                ld tmr3hi,#2
;loop3:         ifgt a,tmr3hi
                jp loop3
                ld a,[x+]
                x a,[b+]
                ld a,[x+]
                x a,[b+]
                ld a,[x+]
                x a,[b+]
                ld a,[x]
                x a,[b]
                ret
;*******************************************************
.sect math_functions,rom

mybyk:          ld cntr,#6   ; div. by 64 (=2^6)
dvby2:          rc
                ld a,5
                rrc a
                x a,5
                ld a,4
```

```
            rrc a
            x a,4
            drsz cntr
            jmp dvby2
            rc          ; 4,5 <- err*k + t2
            ld a,4
            adc a,2
            x a,4
            ld a,5
            adc a,3
            x a,5

            ifeq 5,#0
            jmp lowedge
            ld a,5
            ifgt a,#high(980)
            jmp highedge
            ld a,#high(980)
            ifgt a,5
            jmp end_mybyk  ; not edge
            ld a,4
            ifgt a,#low(980)
            jmp highedge

            jmp end_mybyk  ; not edge

highedge:   ld 4,#low(980)
            ld 5,#high(980)
            ld 0,#20
            ld 1,#0
            ret

lowedge:    ld a,4
            ifgt a,#20
            jmp end_mybyk
            ld 0,#low(980)
            ld 1,#high(980)
            ld 4,#20
            ld 5,#0
            ret

end_mybyk:sc
            ld a,#low(1000)
            subc a,4
            x a,0
            ld a,#high(1000)
            subc a,5
            x a,1
```

```
                ld a,1
                ifgt a,#0
                ret
                ld a,0
                ifgt a,#20
                ret
                ld 0,#20
                ld 4,#low(980)
                ld 5,#high(980)
                ret

;****** FDV168 - Fast 16 by 8 division subroutine ******************
; 490 instruction cycles maximum - 245usec.
; dividend in [1,0] (dd)        divisor in [3]  (dr)
; quotient in [1,0] (quot)      remainder in [2] (test field)

fdv168:         ld cntr,#16  ; load cntr with length of dividend field.
                ld 2,#0      ; clear test field.
fd168s:         ld b,#0
fd168l:         rc
                ld a,[b]
                adc a,[b]    ; left shift dividend lo
                x a,[b+]
                ld a,[b]
                adc a,[b]    ; left shift dividend hi
                x a,[b+]
                ld a,[b]
                adc a,[b]    ; left shift test field
                x a,[b]
                ld a,[b+]    ; test field to acc
                ifc        ; test if bit shiefted out of test field****
                jp fd168b
                sc
                subc a,[b]   ; test subtract divisor from test field
                ifnc         ; test if borrow from subtraction
                jp fd168t
fd168r:         ld b,#2      ; subtraction result to test field
                x a,[b]
                ld b,#0
                sbit 0,[b]   ; set quotient bit
                drsz cntr    ; dectement and test cntr for zero
                jp fd168l
                ret        ; return from subroutine
fd168t:         drsz cntr    ; dectement and test cntr for zero
                jp fd168s
                ret        ; return from subroutine
fd168b:         subc a,[b]   ; subtract divisor from test field***
                jp fd168r
```

```
;******* BINDEC - Binary to Decimal (packed BCD) *********************

bindec:     ld cntr,#8   ; Bindec - Binary to Decimal (packed BCD)
            rc           ; 856 cycles * 0.5 ~ 428 cycles = 213usec.
            ld b,#1      ; binary in 0 => decinmal in 1,2
bd1:        ld [b+],#0
            ifbne #3
            jmp bd1
bd2:        ld b,#0
bd3:        ld a,[b]
            adc a,[b]
            x a,[b+]
            ifbne #1
            jmp bd3
bd4:        ld a,[b]
            add a,#066
            adc a,[b]
            dcor  a
            x a,[b+]
            ifbne #3
            jmp bd4
            drsz cntr
            jmp bd2
            ret
;*********************************************
.sect lcd_update,rom
updatelcd:ifbit lcdupdate,flags2
            jmp updatelcd0
            ifeq lcd_flags,#0
            ret
            jmp updatelcd4

updatelcd0:rbit lcdupdate,flags2
            ld lcd_cntr,#50
            ld a,pls_x0
            x a,0
            ld a,pls_x1
            x a,1
            ld a,#lpulsepermm   ; linear pulses per mm
            x a,3
            jsr fdv168       ; mm = pls_x/linear_pulses_per_mm
            jsr bindec

            ld pd,#080       ; cursor home  - address 0.
            jsr lcd_com
            ld a,2
            and a,#0f
            add a,#'0'
```

```
                x a,pd
                jsr lcd_dat
                ld a,1
                swap a
                and a,#0f
                add a,#'0'
                x a,pd
                jsr lcd_dat
                ld a,1
                and a,#0f
                add a,#'0'
                x a,pd
                jsr lcd_dat

                ld pd,#085      ; cursor address 5.
                jsr lcd_com
                ifbit epi,flags1
                jmp updatelcd5

                ifbit 7,pls_y1
                jmp updatelcd1
                sc              ; angel= -  08000-pls_y
                ld a,#0
                subc a,pls_y0
                x a,0
                ld a,#080
                subc a,pls_y1
                x a,1
                ld pd,#'-'
                jmp updatelcd2
updatelcd1:ld a,pls_y1      ; angel= + pls_y-08000
                and a,#07f
                x a,1
                ld a,pls_y0
                x a,0
                ld pd,#'+'

updatelcd2:jsr lcd_dat
                ld cntr,#3
updatelcd3:rc
                ld a,1
                rrc a
                x a,1
                ld a,0
                rrc a
                x a,0
                drsz cntr
                jmp updatelcd3
```

```
                ld 1,#0
                jsr bindec
                ld a,1
                swap a
                and a,#0f
                add a,#'0'
                x a,pd
                jsr lcd_dat
                ld a,1
                and a,#0f
                add a,#'0'
                x a,pd
                jsr lcd_dat
                jmp updatelcd4
updatelcd5:ld pd,#'e'
                jsr lcd_dat
                ld pd,#'p'
                jsr lcd_dat
                ld pd,#'i'
                jsr lcd_dat

updatelcd4:ifeq lcd_flags,#0
                ret
                ifbit self_t_command,buttons_flags
                ld lcd_flags,#0
                ifbit start_stop,buttons_flags
                ld lcd_flags,#0
                ifeq lcd_flags,#0
                ret

                ifbit type_start,lcd_flags
                ld temp,#low(wordstart); type 'start' at line 2 of lcd.
                ifbit type_end,lcd_flags
                ld temp,#low(wordend)
                ifbit type_Stuck,lcd_flags
                ld temp,#low(wordstuck)
                ifbit type_stop,lcd_flags
                ld temp,#low(wordstop)

                jsr type_string1
                ld lcd_flags,#0


end_updatelcd:ret

;*********************************************
.sect lcd_orders,rom
clean_lcd:ld pd,#01
```

```
                jsr lcd_com
                jmp del16
                ret
;****************************************
type_string0:ld pd,#080        ; type string from the start of line 0.
                jsr lcd_com
                jmp type_string
type_string1:ld pd,#0c0        ; type string from the start of line 0.
                jsr lcd_com
type_string:ld a,temp
                inc a
                x a,temp
                jsr get_char
                ifeq a,#'@'
                ret
                x a,pd
                jsr lcd_dat
                jmp type_string

;********  subrutine to initialize lcd display
init_lcd: ld a,#10
init_lcd1:jsr del16
                dec a
                ifne a,#0
                jp init_lcd1

init_lcd2:ld pd,#01  ;display clear
                jsr lcd_com
                jsr del16

                ld pd,#06  ;increment cursor (cursor moves: left to right)
                jsr lcd_com

                ld pd,#0c  ;display on , cursor off
                jsr lcd_com

                ld pd,#03f  ;8 bits
                jmp lcd_com

,               ret
;********** subrutine to transfer command to lcd display
lcd_com:        rbit rs,pa ;command
end_com_dat:
                sbit cs_lcd,pa
                rbit cs_lcd,pa
                ld cntr,#10
loop1:          drsz cntr
                jp loop1
```

```
                ret
********** subrutine to transfer data to lcd display
lcd_dat:        sbit rs,pa ;command
                jmp end_com_dat

;******** delay ****************

del16:          ld cntr,#2
del160:         ld temp,#250 ;1.6 msec delay
del161:         drsz temp
                jmp del161
                ld temp,#150
del162:         drsz temp
                jmp del162
                drsz cntr
                jmp del160
                ret

;****************************************
.sect string_table,rom,inpage
get_char:laid
     ret
;***** ascii table ********************
wordmm:        .db '  mm  @'
wordstart:     .db 'start  @'
wordstop:      .db 'stop   @'
wordpoweron:.db 'power on@'
wordhome:      .db 'home   @'
wordstuck:     .db 'stuck  @'
wordend:       .db 'end    @'
wordbottom:    .db 'bottom @'
wordready:     .db 'ready  @'
wordselftest:  .db 'selftest@'
wordautorun:   .db 'autorun @'
wordinplace:   .db 'in place@'

.endsect


               .END 0
          ;end of program listing of intumed.asm
```

Appendix 2

```
; This is c8cdr.inc
;****************************************************************
*******
; This file include cop8cdr.inc, cop8.inc, cop8c3r.inc, 8cdr.chp, ports.inc(shortcuts).



;port definitions in cop8 with flash.

ped   =090    ; port e data (output); pe is already taken by parity enable.
pec   =091    ; port e configuration
pei   =092    ; port e input

pf =094    ; port f data (output)
pfc   =095    ; port f configuration
pfi=096    ; port f input

pa =0a0    ; port a data (output)
pac   =0a1    ; port a configuration
pai   =0a2    ; port a input

pb =0a4    ; port b data (output)
pbc   =0a5    ; port b configuration
pbi   =0a6    ; port b input


pl =0d0    ; port l data (output)
plc   =0d1    ; port l configuration
pli=0d2    ; port l input

pg=0d4    ; port g data (output)
pgc   =0d5    ; port g configuration
pgi   =0d6    ; port g input


pc =0d8    ; port c data (output)
pcc   =0d9    ; port c configuration
pci   =0da    ; port c input

pd =0dc    ; port d data (output)



; This is cop8.inc
```

```
;*************************************************************
************/
;* Primary Chip Names with Designators
;*************************************************************
************/
ANYCOP  = 0
COP912C = 1    ; Basic Family
COP820  = 2
COP840  = 3
COP880  = 4
COP820CJ = 5
COP840CJ = 6
COP8620 = 7
COP8640 = 8
COP8720 = 9
COP8780 =10
COP943  =11

COP888CF = 20   ; Feature Family
COP888CG = 21
COP888CL = 22
COP888CS = 23
COP888EG = 24
COP888EK = 25
COP8ACC  = 26
COP888BC = 27
COP888EB = 28
COP888EW = 29
COP888FH = 30
COP888GD = 31
COP888GG = 32
COP888GW = 33
COP888HG = 34
COP888KG = 35
COP8SAA  = 36
COP8SAB  = 37
COP8SAC  = 38
COP8SGR  = 39
COP8SGE  = 40
COP8SEC  = 41
COP8SER  = 42
COP8AJC  = 43
COP8AKC  = 44

;--------------   Flash based devices from here on
COP8CBR  = 60
COP8CCR  = 61
COP8CDR  = 62
```

```
COP8SBR  = 63
COP8SCR  = 64
COP8SDR  = 65

COPy8 = 99
;
; ---------------- End of COP8.INC -----------------------------------

;*****************************************************
     COPCHIP = COP8CDR        ; Chip Definition



; This is cop8C3R.inc
;
; PLEASE: Consider update for CBR,CDR, and CCR.
;
; Predeclare I/O and control registers frequently used by COP8 programmer.
    .macro   setopt
    .mloc sec,wd,halt,flex
;
    .ifb    @1    ; if null
sec    =  0  ; default value (not secure)
    .else
sec    =  @1
    .endif
    .ifb    @2    ; if null
wd     =  0  ; default value (Watchdog enabled)
    .else
wd     =  @2
    .endif
    .ifb    @3    ; if null
halt   =  0  ; default value (HALT enabled)
    .else
halt   =  @3
    .endif
    .ifb    @4    ; if null
flex   =  1  ; default value (Execute from Flash)
    .else
flex   =  @4
    .endif

    .sect  OPTION, CONF
CONFIG:  .db    ((sec shl 3 or wd) shl 1 or halt) shl 1 or flex
    .endm

; ---------------- End of setecon Macro Definition --------------------
```

```
; ---------------------------------------------------------------------
; SFR Names and Register Bit Names Agree with the Feature Family User's
; Manual Redundant names match corresponding functions on Basic Family
; Documentation
;

    PORTED  =  0x90:BYTE        ; Port E Data
    PORTEC  =  0x91:BYTE        ; Port E Configuration
    PORTEP  =  0x92:BYTE        ; Port E input pins (read only)
;
    PORTFD  =  0x94:BYTE        ; Port F Data
    PORTFC  =  0x95:BYTE        ; Port F Configuration
    PORTFP  =  0x96:BYTE        ; Port F input pins (read only)
;
    PORTAD  =  0xA0:BYTE        ; Port A Data
    PORTAC  =  0xA1:BYTE        ; Port A Configuration
    PORTAP  =  0xA2:BYTE        ; Port A input pins (read only)
;
    PORTBD  =  0xA4:BYTE        ; Port B Data
    PORTBC  =  0xA5:BYTE        ; Port B Configuration
    PORTBP  =  0xA6:BYTE        ; Port B input pins (read only)
;
   ISPADLO  =  0xA8:BYTE        ; ISP Address Register Low Byte
   ISPADHI  =  0xA9:BYTE        ; ISP Address Register High Byte
   ISPRD  =  0xAA:BYTE          ; ISP Read Data Register
   ISPWR  =  0xAB:BYTE          ; ISP Write Data Register
;
   TINTA  =  0xAD:BYTE          ; High Speed Timers Interrupt A
   TINTB  =  0xAE:BYTE          ; High Speed Timers Interrupt B
   HSTCR =  0xAF:BYTE           ; High Speed Timers Control Register
;
    TMR3LO  =  0xB0:BYTE        ; Timer 3 low byte
    TMR3HI  =  0xB1:BYTE        ; Timer 3 high byte
    T3RALO  =  0xB2:BYTE        ; Timer 3 RA register low byte
    T3RAHI  =  0xB3:BYTE        ; Timer 3 RA register high byte
    T3RBLO  =  0xB4:BYTE        ; Timer 3 RB register low byte
    T3RBHI  =  0xB5:BYTE        ; Timer 3 RB register high byte
    T3CNTRL =  0xB6:BYTE        ; Timer 3 control register
;
    TBUF    =  0xB8:BYTE        ; UART transmit buffer
    RBUF    =  0xB9:BYTE        ; UART receive buffer
    ENU     =  0xBA:BYTE        ; UART control and status register
    ENUR    =  0xBB:BYTE        ; UART receive control and status reg.
    ENUI    =  0xBC:BYTE        ; UART interrupt and clock source reg.
    BAUD    =  0xBD:BYTE        ; BAUD register
    PSR     =  0xBE:BYTE        ; UART prescaler select register
;
    TMR2LO  =  0xC0:BYTE        ; Timer 2 low byte
```

```
    TMR2HI  =  0xC1:BYTE      ; Timer 2 high byte
    T2RALO  =  0xC2:BYTE      ; Timer 2 RA register low byte
    T2RAHI  =  0xC3:BYTE      ; Timer 2 RA register high byte
    T2RBLO  =  0xC4:BYTE      ; Timer 2 RB register low byte
    T2RBHI  =  0xC5:BYTE      ; Timer 2 RB register high byte
    T2CNTRL =  0xC6:BYTE      ; Timer 2 control register
;
    WDSVR   =  0xC7:BYTE      ; Watch dog service register
;
    WKEDG   =  0xC8:BYTE      ; MIWU edge select register
    WKEN    =  0xC9:BYTE      ; MIWU enable register
    WKPND   =  0xCA:BYTE      ; MIWU pending register
;
  ENAD    =  0xCB:BYTE      ; A/D Converter Control register
  ADRSTH  =  0xCC:BYTE      ; A/D Converter Result Register High
Byte
  ADRSTL  =  0xCD:BYTE      ; A/D Converter Result Register Low
Byte
;
  ITMR    =  0xCF:BYTE      ; Idle Timer Control Register
;
    PORTLD  =  0xD0:BYTE      ; Port L data
    PORTLC  =  0xD1:BYTE      ; Port L configuration
    PORTLP  =  0xD2:BYTE      ; Port L pin
;
    PORTGD  =  0xD4:BYTE      ; Port G data
    PORTGC  =  0xD5:BYTE      ; Port G configuration
    PORTGP  =  0xD6:BYTE      ; Port G pin
;
    PORTCD  =  0xD8:BYTE      ; Port C data
    PORTCC  =  0xD9:BYTE      ; Port C configuration
    PORTCP  =  0xDA:BYTE      ; Port C pin
;
    PORTD   =  0xDC:BYTE      ; Port D
;
  PGMTIM  =  0xE1:BYTE      ; E2 and Flash Write Timing Register
  ISPKEY  =  0xE2:BYTE      ; ISP Key Register
;
    T1RBLO  =  0xE6:BYTE      ; Timer 1 RB register low byte
    T1RBHI  =  0xE7:BYTE      ; Timer 1 RB register high byte
;
    ICNTRL  =  0xE8:BYTE      ; Interrupt control register
;
    SIOR    =  0xE9:BYTE      ; SIO shift register
    SIO     =  0xE9:BYTE      ; SIO shift register
;
    TMR1LO  =  0xEA:BYTE      ; Timer 1 low byte
    TMR1HI  =  0xEB:BYTE      ; Timer 1 high byte
```

```
        T1RALO =  0xEC:BYTE        ; Timer 1 RA register low byte
        T1RAHI =  0xED:BYTE        ; Timer 1 RA register high byte
;
        CNTRL  =  0xEE:BYTE        ; control register
        PSW    =  0xEF:BYTE        ; PSW register
;
    BYTECOUNTLO = 0xF1:BYTE        ; When JSRB Boot Rom used
;
        S      =  0xFF:BYTE        ; Segment register, only COP888CG/CS!
;

;------------------------------------------------------------------------
; Bit Constant Declarations.
;
;----- Alternate function bit definitions on port G

        INT    =  0        ; Interrupt input
        INTR   =  0        ; Interrupt input
        WDOUT  =  1        ; Watchdog output
        T1B    =  2        ; Timer T1B output
        T1A    =  3        ; Timer T1A output
        SO     =  4        ; Seriell output
        SK     =  5        ; Seriell clock
        SI     =  6        ; Seriell input
        CKO    =  7        ; Halt,restart input
;
;----- Alternate function bit definitions on port L
        CKX    =  1        ; ext. clock I/O-pin/UART
        TDX    =  2        ; transmit data/UART
        RDX    =  3        ; receive data/UART
        T2A    =  4        ; Timer T2A output
        T2B    =  5        ; Timer T2B output
        T3A    =  6        ; Timer T3A output
        T3B    =  7        ; Timer T3B output
;
;       Alternate function bit definitions on port A
        ACH0   =  0        ; A/D-Channel 0
        ACH1   =  1        ; A/D-Channel 1
        ACH2   =  2        ; A/D-Channel 2
        ACH3   =  3        ; A/D-Channel 3
        ACH4   =  4        ; A/D-Channel 4
        ACH5   =  5        ; A/D-Channel 5
        ACH6   =  6        ; A/D-Channel 6
        ACH7   =  7        ; A/D-Channel 7
;
;       Alternate function bit definitions on port B
        ACH8   =  0        ; A/D-Channel 8
        ACH9   =  1        ; A/D-Channel 9
```

```
  ACH10  = 2        ; A/D-Channel 10
  ACH11  = 3        ; A/D-Channel 11
  ACH12  = 4        ; A/D-Channel 12
  ACH13  = 5        ; A/D-Channel 13
 MUXOUTN  = 5       ; A/D Mux Negative Output
  ACH14  = 6        ; A/D-Channel 14
 MUXOUTP  = 5       ; A/D Mux Positive Output
  ACH15  = 7        ; A/D-Channel 15
 ADIN  = 7          ; A/D Converter Input
;
;----- Bit definitions CNTRL register
    T1C3  = 7       ; Timer 1 mode control
    TC1   = T1C3    ; COP880/840/820 control signal name
    T1C2  = 6       ; Timer 1 mode control
    TC2   = T1C2    ; COP880/840/820 control signal name
    T1C1  = 5       ; Timer 1 mode control
    TC3   = T1C1    ; COP880/840/820 control signal name
    T1C0  = 4       ; Start/Stop timer in modes 1 and 2
                    ; Underflow interrupt pending in mode 3
    TRUN  = T1C0    ; COP880/840/820 control signal name
    MSEL  = 3       ; Enable Microwire
    IEDG  = 2       ; Selects external interr. edge polarity
    SL1   = 1       ; Microwire clock divide select
    SL0   = 0       ; Microwire clock divide select
;
;----- Bit definitions PSW register
    HC    = 7       ; Half Historical Redundant carry flag
    C     = 6       ; Carry flag
    T1PNDA = 5      ; Timer T1A interrupt pending
    TPND  = T1PNDA  ; Historical Redundant
    T1ENA  = 4      ; Timer T1A interrupt enable
    ENTI  = T1ENA   ; Historical Redundant
    EXPND  = 3      ; External interrupt pending
    IPND  = EXPND   ; Historical Redundant
    BUSY  = 2       ; Microwire busy shifting
    EXEN  = 1       ; External interurpt enable
    ENI   = EXEN    ; Historical Redundant
    GIE   = 0       ; Global interr. enable
;
;----- Bit definitions ICNTRL register
    LPEN  = 6       ; L-Port interr. enable
    T0PND  = 5      ; Timer T0 interr. pending
    T0EN  = 4       ; Timer T0 interr. enable
    WPND  = 3       ; Microwire interr. pending
    WEN   = 2       ; Microwire interr. enable
    T1PNDB = 1      ; Timer T1B interr. pending flag
    T1ENB  = 0      ; Timer T1B interr. enable
```

```
;----- Bit definitions T2CNTRL register
      T2C3   =  7        ; Timer T2 mode control
      T2C2   =  6        ; Timer T2 mode control
      T2C1   =  5        ; Timer T2 mode control
      T2C0   =  4        ; Timer T2A start/stop
      T2PNDA =  3        ; Timer T2A interr. pending flag
      T2ENA  =  2        ; Timer T2A interr. enable
      T2PNDB =  1        ; Timer T2B interr. pending flag
      T2ENB  =  0        ; Timer T2B interr. enable
;
;----- Bit definitions T3CNTRL register
      T3C3   =  7        ; Timer T3 mode control
      T3C2   =  6        ; Timer T3 mode control
      T3C1   =  5        ; Timer T3 mode control
      T3C0   =  4        ; Timer T3A start/stop
      T3PNDA =  3        ; Timer T3A interr. pending flag
      T3ENA  =  2        ; Timer T3A interr. enable
      T3PNDB =  1        ; Timer T3B interr. pending flag
      T3ENB  =  0        ; Timer T3B interr. enable
;
;     Bit definitions HSTCR register
    T9HS    =  7     ; Timer T9 High Speed Enable
    T8HS    =  6     ; Timer T8 High Speed Enable
    T7HS    =  5     ; Timer T7 High Speed Enable
    T6HS    =  4     ; Timer T6 High Speed Enable
    T5HS    =  3     ; Timer T5 High Speed Enable
    T4HS    =  2     ; Timer T4 High Speed Enable
    T3HS    =  1     ; Timer T3 High Speed Enable
    T2HS    =  0     ; Timer T2 High Speed Enable
;
;     Bit definitions TINTA register
    T9INTA=  7       ; Timer 9 Interrupt A
    T8INTA=  6       ; Timer 8 Interrupt A
    T7INTA=  5       ; Timer 7 Interrupt A
    T6INTA=  4       ; Timer 6 Interrupt A
    T5INTA=  3       ; Timer 5 Interrupt A
    T4INTA=  2       ; Timer 4 Interrupt A
    T3INTA=  1       ; Timer 3 Interrupt A
;
;     Bit definitions TINTB register
    T9INTB=  7       ; Timer 9 Interrupt B
    T8INTB=  6       ; Timer 8 Interrupt B
    T7INTB=  5       ; Timer 7 Interrupt B
    T6INTB=  4       ; Timer 6 Interrupt B
    T5INTB=  3       ; Timer 5 Interrupt B
    T4INTB=  2       ; Timer 4 Interrupt B
    T3INTB=  1       ; Timer 3 Interrupt B
;
```

```
;     Bit definitions ENAD register
      ADCH3  =  7     ; A/D Convertor Channel Select bit 3
    ADCH2 =  6        ; A/D Convertor Channel Select bit 2
      ADCH1  =  5        ; A/D Convertor Channel Select bit 1
      ADCH0  =  4        ; A/D Convertor Channel Select bit 0
      ADMOD =  3         ; A/D Convertor Mode Select bit
    ADMUX   =  2        ; A/D Mux Out Control
      PSC   =  1       ; A/D Convertor Prescale Select bit
    ADBSY =  0       ; A/D Convertor Busy Bit
;
;----- Bit definitions ENU register
      PEN    =  7        ; Parity enable
      PSEL1  =  6         ; Parity select
      PSEL0  =  5         ; Parity select
      XBIT9  =  5         ; 9th transmission bit in 9bit data mode
      CHL1   =  4         ; Select character frame format
      CHL0   =  3         ; Select character frame format
      ERR    =  2        ; Error flag
      RBFL   =  1         ; Received character
      TBMT   =  0          ; Transmited character
;
;----- Bit definitions ENUR register
      DOE    =  7         ; Data overrun error
      FE     =  6        ; Framing error
      PE     =  5        ; Parity error
      BD =  4      ; Break Detect
    RBIT9  =  3        ; Contains the ninth bit (nine bit frame!)
      ATTN   =  2         ; Attention mode
      XMTG   =  1          ; indicate transmitting mode
      RCVG   =  0         ; indicate framing error
;
;----- Bit definition ENUI register
      STP2   =  7        ; Select number of stop bits
      BRK  =  6        ; Holds TDX low to Generate a BREAK
      ETDX   =  5         ; Select transmit-pin I2
      SSEL   =  4        ; Select UART-mode
      XRCLK  =  3          ; Select clock source for the receiver
      XTCLK  =  2          ; Select clock source for the transmitter
      ERI    =  1        ; Enable interr. from the receiver
      ETI    =  0        ; enable interr. from the transmitter
;
;   Bit Definitions for ITMR Register
    LSON   =  7        ; Low Speed Oscillator Enable
    HSON   =  6        ; High Speed Oscillator Enable
    DCEN   =  5      ; Dual Clock Enable - Switches T0 To
          ;  Low Speed Clock
    CCKSEL   =  4      ; Core Clock Select - Switches Instr
          ;  Execution To Low Speed Clock
```

```
    ITSEL2 =  2      ; IDLE Timer Period Select bit 2
    ITSEL1 =  1      ; IDLE Timer Period Select bit 1
    ITSEL0 =  0      ; IDLE Timer Period Select bit 0
;
    KEY =  0x98 ; Required Value for ISP Key
;
; --------------- End of COP8C3R.INC ----------------------------------

;***************************************************************
********
;This is 8cdr.chip

     .CHIP 8CDR          ; specifies max. ROM address 7FFF
                         ; RAM = 1K

;CHIP_SPEC (chip_table) for COP8CDR9xxxx parts
; PLEASE: Consider also update of files for CBR and CCR when modifying
this file.

; 0 value if undefined, address value otherwise
mole   =   0
romsize  = 0x8000       ; ROM size
ramhi  =   0x6F         ; segment 0 high address
eelo   =   0            ; on-chip eerom range
eehi   =   0
t3lo   =   0xB0         ; timer 3 registers
t3hi   =   0xB6
comp     =0             ; comparator
uartlo     =   0xB8     ; uart registers
uarthi     =   0xBE
t2lo   =   0xC0         ; timer 2 registers
t2hi   =   0xC6
wdog       =   0xC7     ; watch dog service register
miwulo     =   0xC8     ; miwu registers
miwuhi     =   0xCA
a2dlo      =   0xCB     ; a/d registers
a2dhi      =   0xCD
lportlo  =  0xD0        ; l port registers
lporthi  =  0xD2
gportlo  =  0xD4        ; g port registers
gporthi  =  0xD6
iport  =   0            ; i port
cportlo  =  0xD8        ; c port
cporthi  =  0xDA
dport  =   0xDC         ; d port
eecr   =   0            ; eerom control register
eromdr    =   0         ; eerom data register
eearlo    =   0         ; eerom address registers
```

```
eearhi      =   0
;icntrl     =   0xE8        ; icntrl register       ; already defined
microwire = 0xE9            ; uWire SIO
t1alo   =   0xE6        ; t1 auto ld t1rb
t1ahi   =   0xE7
t1blo   =   0xEA        ; t1 reg
t1bhi   =   0xED
;cntrl  =   0xEE        ; cntrl reg     ; already defined
;psw    =   0xEF        ; psw reg           ; already defined
mlo     =   0xF0        ; RAM reg range
mhi     =   0xFF
segramlo =  0x0100          ; segments low to high
segramhi =  0x077F
cntrl2      =   0
wdogctr =   0
modrel      =   0
econ    =   0x7FFF          ; econ hex-file location
cfgsize =   1           ; econ array cell address.


;family = 0 for basic family, family = 1 for feature family


family      =   1
```

Appendix 3

```
;************* Constants definitions *******************
lpulsepermm=136       ; 16 * 22 / 2.54 = 138.58   = linear pulse per mm
;************* Register Definitions *****************
f0            =0f0    ; not used
uart_tmr      =0f1    ; used as receive watch dog - when 0, return rec_stat(receiving
state) to 0.
rbyte_num     =0f2    ; number of bytes to be received.
tbyte_num     =0f3    ; number of bytes to be transmitted.
temp          =0f4    ; used for temporary calculations as variable or counter.
;             =0f5    ; not used
cntr          =0f6    ; used for temporary calculations as counter.
lcd_cntr      =0f7    ; used to refresh lcd every 0.1 sec (according to timer0 -
25*4msec)
f8            =0f8    ; not used
data_cntr     =0f9    ; used to count 20 data packets.
fa            =0fa    ; not used
fb            =0fb    ; not used
;********** bits definitions   *****************
rs=2              ; pa      ; determines if the LCD gets command(0) or data(1).
cs_lcd=3      ; pa    ; send the information in the lcd data pins upon rise and
fall(_/\_) of cs_lcd.
control1=4    ; pa    ; \
control2=5    ; pa    ; / control 1+2 determine the direction of motor 1
control3=6    ; pa    ; \
control4=7    ; pa    ; / control 3+4 determine the direction of motor 2
;home_position=5; pl
;start_stop=7  ; pl
home_limit=5 ; pb
bottom_limit=6  ; pb
angular_limit=7; pb
;***********  flags ***************************************
direction=0   ; lflags  ; direction of motor 1
first_pulse=1 ; lflags  ; if set then there was already 1 pulse.
en_calc=2     ; lflags  ; enables calculation of time per pulse.
en1_calc=3    ; lflags  ; enables calculation of velosity every.
stop1=4       ; lflags  ; signals that motor1 sould be stopped
pulse=5       ; lflags  ; signals that there was a pulse from motor 1

direction2=0  ; aflags  ; direction of motor 2
firsty_pulse=1; aflags  ; if set then there was already 1 pulse.
en_calc2=2    ; aflags  ; enables calculation of time per pulse.
en1_calc2=3   ; aflags  ; enables calculation of velosity every.
stop2=4       ; aflags  ; signals that motor2 sould be stopped
pulse2=5      ; aflags  ; signals that there was a pulse from motor 2
```

```
start=0         ; flags1  ; 1 when start command is received, 0 when stop command is
issued.
home=1          ; flags1  ; 1 when home micro switch (Normally Closed) is closed, o
when open.
bottom=2        ; flags1  ; 1 when bottoming micro switch (NO) is closed, o when open.
epi=3           ; flags1  ; 1 when Epiglottis is sensed.
stop=4          ; flags1  ; 1 when stop command is received, 0 when start command is
issued.
end=5           ; flags1  ; 1 when planned mission ends.
stuck=6         ; flags1  ; 1 when a motor is stuck.
enddata=7       ; flags1  ;   additional bit for the PC to know when the micro stops
sending data.

fix_t_en=0      ; flags2  ; generatl enable for saving and transmitting the blockes of data.
fix_t_en1=1     ; flags2  ; enable 1 block saving, and set every 8msec by timer0.
a2den=2         ; flags2  ; enables a/d
lcdupdate=3     ; flags2  ; being set every 0.1sec by timer 0 to refresh lcd.


type_start=0  ; lcd_flags  ; if set lcd sould type "start" in line2.
type_stop=1   ; lcd_flags  ; if set lcd sould type "stop" in line2.
type_end=2    ; lcd_flags  ; if set lcd sould type "end" in line2.
type_stuck=3  ; lcd_flags  ; if set lcd sould type "stuck" in line2.

new_direction=3; rbyte1   ; the new direction for the motors as received from the pc.
motor=4         ; rbyte1  ; 0 - motor1, 1 - motor2.


buttons_t_en=0        ; buttons_flags
home_command=1        ; buttons_flags
home_command_pc=2 ; buttons_flags
self_t_command=3  ; buttons_flags
stop_command=4        ; buttons_flags
home_position=5 ; buttons_flags    + pl
start_stop=7    ; buttons_flags    + pl

limits_c_en=0 ; limits_flags        ________________to be shifted if it is the only bit in
this byte.
;****** s=0 *******bytes definitions ***************************
lflags          =020     ; flags that belongs to linear motor (motor1).
aflags          =021     ; flags that belongs to angular motor (motor2).
ang_stat        =022     ; angular motor work states.
nxt_a_stat=023        ; save the next ang_stat that come after a subroutine or an ang_stat.
plsy_cntr0=024        ; lsb  ; angular distance that motor 2 sould do in start command.
plsy_cntr1=025        ; msb
pls_cntr0       =026     ; lsb  ; linear distance that motor 1 sould do in start command.
pls_cntr1       =027     ; msb
linear_stat=028   ; linear motor work states.
```

```
nxt_l_stat=029       ; save the next linear_stat that come after a subroutine or an
linear_stat.
flags2       =02a    ; save flags of lcd, a/d and fix_t_en.
cd_dly       =02b    ; delay before changing direction to alow the motor to reach a
complete stop.
rec_stat     =02c    ; usart receiving work state.
trns_stat    =02d    ; usart transmitting work state.
int_cntr     =02e    ; counter to help with timming. decreased by 1 every 4msec.

current1     =030    ; digital current from motor 1.
current2     =031    ; digital current from motor 2.
hall1        =032    ; digital hall senssor from motor 1.
hall2        =033    ; digital hall senssor from motor 2.
pls_x0       =034 ; lsb   ; total linear distance in pulses.
pls_x1       =035    ; msb
pls_y0       =036 ; lsb   ; total angular distance in pulses.
pls_y1       =037    ; msb
flags1       =038    ;
t_check      =039    ; check sum of 1 packet of 20 blocks of current1+...+flags1
check_sum    =03a    ; check sum of received bytes in 1 command from the pc.
save_ptr     =03b    ; pointer to show where the next byte should be saved in the
packet of 20 blocks (s1,s2).
send_ptr     =03c    ; pointer to show from where the next byte should be sent in the
packet of 20 blocks (s1,s2).
zero_h1      =03d
zero_h2      =03e

pt1lo        =040    ; lsb   ; save the capture time of motor 1 last pulse.
timer 1a
pt1hi        =041    ; msb
pt2lo        =042    ; lsb   ; save the capture time of 1 pulse before motor 1 last
pulse.
pt2hi        =043    ; msb
ptlo         =044    ; lsb   ; save the time between the last 2 pulses of motor 1.
calculated in timer0.
pthi         =045    ; msb
t_ref0       =046    ; lsb   ; the desired time between pulses of motor 1 as received
from the pc.
t_ref1       =047    ; msb

apt1lo       =048    ; lsb   ; save the capture time of motor 2 last pulse.
timer 1b
apt1hi       =049    ; msb
apt2lo       =04a    ; lsb   ; save the capture time of 1 pulse before motor 2 last
pulse.
apt2hi       =04b    ; msb
aptlo        =04c    ; lsb   ; save the time between the last 2 pulses of motor 2.
calculated in timer0.
```

```
apthi         =04d   ; msb
at_ref0       =04e   ; lsb  ; the desired time between pulses of motor 2 as received
from the pc.
at_ref1       =04f   ; msb

receive_ptr=050  ; pointer where to store the byte that will be received next.
rbyte1        =051   ;
rbyte2        =052   ;   received bytes.
rbyte3        =053   ;
rbyte4        =054   ;
rbyte5        =055   ;
trns_ptr      =056   ; pointer where the next byte to be transmitted is stored.
tbyte1        =057   ;
tbyte2        =058   ;   bytes to be transmitted.
tbyte3        =059   ;
tbyte4        =05a   ;
tbyte5        =05b   ;
tbyte6        =05c   ;
tbyte7        =05d   ;

packet_cntr=05f  ; counts the packets that are send every 160msec untill the micro
returns to work state 0.

limits_flags    =060 ; micro(limit) switches - normally closed.
buttons_flags  =061 ; buttons - normally closed.
ritut              =062 ; ritut - counter to prevent buttons vibrations, only 3sec push is
considered a prese.
start_stop_cntr=063 ; counter of 3 sec.
home_position_cntr=064  ; counter of 3 sec.
selft_stat=065 ; work states of self test.
autorun_stat=066; work states of auto run.
lcd_flags=067 ; lcd flags - if set, something should be typed.
nolpulsetmr=068 ; timer to turn off motor if no pulses received - assuming the motor is
stuck.
noapulsetmr=069
home_stat=06a        ; work states of home position.
```

CLAIMS

1. An automatically operative medical insertion device comprising:

an insertable element which is adapted to be inserted within a living organism in vivo;

a surface following element, physically associated with said insertable element and being arranged to follow a physical surface within said living organism in vivo;

a driving subsystem operative to at least partially automatically direct said insertable element along said physical surface; and

a navigation subsystem operative to control said driving subsystem based at least partially on a perceived location of said surface following element along a reference pathway stored in said navigation subsystem.

2. An automatically operative medical insertion device according claim 1 and wherein said driving subsystem is operative to fully automatically direct said insertable element along said physical surface.

3. An automatically operative medical insertion device according to claim 1 and wherein said driving subsystem is operative to automatically and selectably direct said insertable element along said physical surface.

4. An automatically operative medical insertion device according to any of the preceding claims and wherein said navigation subsystem receives surface characteristic information relating to said physical surface from said surface following element and employs said surface characteristic information to perceive the location of said surface following element along said reference pathway.

5. An automatically operative medical insertion device according to claim 4 and wherein said surface characteristic information comprises surface contour information.

6. An automatically operative medical insertion device according to claim 4

and wherein said surface characteristic information comprises surface hardness information.

7. An automatically operative medical insertion device according to claim 5 and wherein said surface contour information is three-dimensional.

8. An automatically operative medical insertion device according to claim 5 and wherein said surface contour information is two-dimensional.

9. An automatically operative medical insertion device according to any of the preceding claims and wherein said insertable element is an endotracheal tube and wherein said physical surface comprises surfaces of the larynx and trachea.

10. An automatically operative medical insertion device according to any of claims 1 - 8 and wherein said insertable element is a gastroscope and wherein said physical surface comprises surfaces of the intestine.

11. An automatically operative medical insertion device according to any of claims 1 - 8 and wherein said insertable element is a catheter and wherein said physical surface comprises interior surfaces of the circulatory system.

12. An automatically operative medical insertion device according to any of the preceding claims and also comprising a reference pathway generator operative to image at least a portion of said living organism and to generate said reference pathway based at least partially on an image generated thereby.

13. An automatically operative medical insertion device according to claim 12 and wherein said reference pathway comprises a standard contour map of a portion of the human anatomy.

14. An automatically operative medical insertion device according to claim 13 and wherein said standard contour map is precisely adapted to a specific patient.

15. An automatically operative medical insertion device according to claim 13 or claim 14 and wherein said standard contour map is automatically precisely adapted to a specific patient.

16. An automatically operative medical insertion device according to any of claims 12 to 15 and wherein said reference pathway is operator adaptable to designate at least one impediment.

17. An automatically operative medical insertion device according to any of the preceding claims and wherein said insertable element comprises a housing in which is disposed said driving subsystem; a mouthpiece, a tube inserted through the mouthpiece and a flexible guide inserted through the tube, said surface following element being mounted at a front end of said guide.

18. An automatically operative medical insertion device according to claim 17 and wherein said mouthpiece comprises a curved pipe through which said tube is inserted.

19. An automatically operative medical insertion device according to claim 18 and wherein said driving subsystem is operative to move said guide in and out of said housing, through said curved pipe and through said tube.

20. An automatically operative medical insertion device according to claim 19 and wherein said driving subsystem is also operative to selectably bend a front end of said guide.

21. An automatically operative medical insertion device according to any of the preceding claims and wherein said driving subsystem is operative to move said insertable element in and out of said living organism.

22. An automatically operative medical insertion device according to any of

the preceding claims and wherein said driving subsystem is also operative to selectably bend a front end of said insertable element.

23. An automatically operative medical insertion device according to any of the preceding claims and wherein said surface following element comprises a tactile sensing element.

24. An automatically operative medical insertion device according to any of the preceding claims and wherein said surface following element comprises a tip sensor including a tip integrally formed at one end of a short rod having a magnet on its other end, said rod extends through the center of a spring disk and is firmly connected thereto, said spring disk being mounted on one end of a cylinder whose other end is mounted on a front end of said insertable element.

25. An automatically operative medical insertion device according to claim 24 and wherein said tip sensor also comprises two Hall effect sensors which are mounted inside said cylinder on a support and in close proximity to said magnet, said Hall effect sensors being spaced in the plane of the curvature of the curved pipe, each Hall effect sensor having electrical terminals operative to provide electric current representing the distance of the magnet therefrom, said tip sensor being operative such that when a force is exerted on the tip along an axis of symmetry of said cylinder, said tip is pushed against said spring disk, causing said magnet to approach said Hall effect sensors and when a force is exerted on said tip sideways in the plane of said Hall effect sensors, said tip rotates around a location where said rod engages said spring disk, causing said magnet to rotate away from one of said Hall effect sensors and closer to the other of the Hall effect sensors.

26. An automatically operative medical insertion device according to claim 17 and wherein said driving subsystem is operative, following partial insertion of said insertable element into the oral cavity, to cause the guide to extend in the direction of the trachea and bend the guide clockwise until said surface following element engages a surface of the tongue, whereby this engagement applies a force to said surface following

element.

27. An automatically operative medical insertion device according to claim 25 and wherein said navigation subsystem is operative to measure the changes in the electrical outputs produced by the Hall effect sensors indicating the direction in which the tip is bent.

28. An automatically operative medical insertion device according to claim 27 and wherein said navigation subsystem is operative to sense the position of said tip and the past history of tip positions and to determine the location of said tip in said living organism and relative to said reference pathway.

29. An automatically operative medical insertion device according to claim 27 and wherein said navigation subsystem is operative to navigate said tip according to said reference pathway.

30. An automatically operative medical insertion device according to claim 29 and wherein said navigation subsystem is operative to sense that said tip touches the end of the trough beneath the epiglottis.

31. An automatically operative medical insertion device according to claim 27 and wherein said navigation subsystem is operative to sense that said tip reaches the tip of the epiglottis.

32. An automatically operative medical insertion device according to claim 27 and wherein said navigation subsystem is operative to sense that the tip reached the first cartilage of the trachea.

33. An automatically operative medical insertion device according to claim 32 and wherein said navigation subsystem is operative to sense that the tip reached the second cartilage of the trachea.

34. An automatically operative medical insertion device according to claim 33 and wherein said navigation subsystem is operative to sense that the tip reached the third cartilage of the trachea.

35. An automatically operative medical insertion device according to any of the preceding claims and wherein said navigation subsystem is operative to load said reference pathway from a memory.

36. An automatically operative medical insertion device according to claim 17 and wherein said driving subsystem is operative to push said tube forward.

37. An automatically operative medical insertion device according to any of the preceding claims and wherein said driving subsystem comprises:

a first motor operative to selectably move said insertable element forward or backward;

a second motor operative to selectably bend said insertable element; and

electronic circuitry operative to control said first motor, said second motor and said surface following element.

38. An automatically operative medical insertion device according to claim 37 and wherein said electronic circuitry comprises a microprocessor operative to execute a program, said program operative to control the said first and second motors and said surface following element and to insert and bend said insertable element inside said living organism along said reference pathway.

39. An automatically operative medical insertion device according to claim 37 or claim 38 and wherein said driving subsystem is operative to measure the electric current drawn by at least one of said first and second motors to evaluate the position of said surface following element.

40. An automatically operative medical insertion device according to any of the preceding claims and wherein said reference pathway is operative to be at least

partially prepared before the insertion process is activated.

41. An automatically operative medical insertion device according to claim 40 and wherein said medical insertion device comprises a medical imaging system and wherein said medical imaging system is operative to at least partially prepare said reference pathway.

42. An automatically operative medical insertion device according to claim 41 and wherein said medical imaging subsystem comprises at least one of an ultrasound scanner, an X-ray imager, a CAT scan system and an MRI system.

43. An automatically operative medical insertion device according to claim 40 and wherein said medical imaging system is operative to prepare said reference pathway by marking at least one contour of at least one organ of said living organism.

44. An automatically operative medical insertion device according to claim 41 and wherein said medical imaging system is operative to prepare said reference pathway by creating an insertion instruction table comprising at least one insertion instruction.

45. An automatically operative medical insertion device according to claim 44 and wherein said insertion instruction comprises instruction to at least one of extend, retract and bend said insertable element.

46. An automatically operative medical insertion device according to claim 44 and wherein said navigation subsystem is operative to control said driving subsystem based at least partially on a perceived location of said surface following element and according to said insertion instruction table stored in said navigation subsystem.

47. An automatically operative medical insertion device according to any of the preceding claims and wherein said operative medical insertion device is operative to at least partially store a log of a process of insertion of said insertable element.

48. An automatically operative medical insertion device according to claim 47 and wherein said medical insertion device comprises a computer and wherein said medical insertion device is operative to transmit said log of a process of insertion of said insertable element.

49. An automatically operative medical insertion device according to claim 48 and wherein said computer is operative to aggregate said logs of a process of insertion of said insertable element.

50. An automatically operative medical insertion device according to claim 49 and wherein said computer is operative to prepare said reference pathway based at least partially on said aggregate.

51. An automatically operative medical insertion device according to claim 50 and wherein said computer transmits said reference pathway to said medical insertion device.

52. An automatically operative medical insertion device according to claim 1 and wherein said insertable element comprises a guiding element and a guided element.

53. An automatically operative medical insertion device according to claim 52 and wherein said driving subsystem is operative to direct said guiding element and said guided element at least partially together.

54. An automatically operative medical insertion device according to any of claims 17 – 51 and wherein said mouthpiece comprises a disposable mouthpiece.

55. An automatically operative medical insertion device according to claim 17 and wherein said driving subsystem is operative to at least partially automatically direct said guide in a combined motion comprising a longitudinal motion and lateral motion.

56. An automatically operative medical insertion device according to any of the preceding claims and wherein said insertable element is extendable.

57. An automatically operative medical insertion device according to claim 56 and wherein said insertable element comprises:

a mounting element which is arranged to be removably engaged with an intubator assembly; and

an extendable tube operatively associated with said mounting element.

58. An automatically operative medical insertion device according to claim 57 and wherein said extendable tube is arranged to be pulled by a flexible guide operated by said intubator assembly.

59. An automatically operative medical insertion device according to claim 57 or claim 58 and wherein said extendable tube comprises a coil spring.

60. An automatically operative medical insertion device according to any of claims 57-59 and wherein said extendable tube also comprises a forward end member, on a distal end thereof.

61. An automatically operative medical insertion device according to claim 60 and wherein said forward end member includes a diagonally cut pointed forward facing tube end surface.

62. An automatically operative medical insertion device according to claim 60 or claim 61 and also comprising a forward end member mounted inflatable and radially outwardly expandable circumferential balloon.

63. An automatically operative medical insertion device according to claim 62 and wherein said forward end member mounted inflatable and radially outwardly expandable circumferential balloon receives inflation gas through a conduit formed in a

wall of said forward end member and continuing through said tube to a one way valve.

64. An automatically operative medical insertion device according to any of claims 57 - 63 and also comprising a flexible guide having mounted at a distal end thereof a tip sensor.

65. An automatically operative medical insertion device according to claim 64 and wherein said flexible guide is formed with an inflatable and radially outwardly expandable guide mounted balloon.

66. An automatically operative medical insertion device according to claim 65 and wherein said inflatable and radially outwardly expandable guide mounted balloon receives inflation gas through a conduit formed in said flexible guide and extending therealong.

67. An automatically operative medical insertion device according to claim 66 and wherein said conduit is connected to a source of pressurized inflation gas.

68. An automatically operative medical insertion device according to claim 67 and wherein said source of pressurized inflation gas is located within said intubator assembly.

69. An automatically operative medical insertion device according to claim 63 and wherein said inflation gas comprises pressurized air.

70. An automatically operative medical insertion device according to claim 66 and wherein said inflation gas comprises pressurized air.

71. An automatically operative medical insertion method comprising:

inserting an insertable element within a living organism in vivo;

physically associating a surface following element with said insertable element and causing said surface following element to follow a physical surface within said living organism in vivo;

directing said insertable element along said physical surface using a driving subsystem; and

controlling direction of said insertable element based at least partially on a perceived location of said surface following element along a reference pathway stored in a navigation subsystem.

72. An automatically operative medical insertion method according to claim 71 and wherein said directing comprises fully automatic directing.

73. An automatically operative medical insertion method according to claim 71 and wherein said directing comprises automatically and selectably directing.

74. An automatically operative medical insertion method according to any of claims 71 - 73 and wherein said controlling comprises receiving surface characteristic information relating to said physical surface from said surface following element and employing said surface characteristic information to perceive the location of said surface following element along said reference pathway.

75. An automatically operative medical insertion method according to claim 74 and wherein said surface characteristic information comprises surface contour information.

76. An automatically operative medical insertion method according to claim 74 and wherein said surface characteristic information comprises surface hardness information.

77. An automatically operative medical insertion method according to claim 75 and wherein said surface contour information is three-dimensional.

78. An automatically operative medical insertion method according to claim 75 and wherein said surface contour information is two-dimensional.

79. An automatically operative medical insertion method according to any of claims 71 to 78 and wherein said insertable element is an endotracheal tube and wherein said physical surface comprises surfaces of the larynx and trachea.

80. An automatically operative medical insertion method according to any of claims 71 to 78 and wherein said insertable element is a gastroscope and wherein said physical surface comprises surfaces of the intestine.

81. An automatically operative medical insertion method according to any of claims 71 to 78 and wherein said insertable element is a catheter and wherein said physical surface comprises interior surfaces of the circulatory system.

82. An automatically operative medical insertion method according to any of claims 71 to 81 and also comprising generating an image by imaging at least a portion of said living organism and generating said reference pathway based at least partially on said image.

83. An automatically operative medical insertion method according to any of claims 71 to 82 and wherein said reference pathway comprises a standard contour map of a portion of the human anatomy.

84. An automatically operative medical insertion method according to claim 83 and also comprising precisely adapting said standard contour map to a specific patient.

85. An automatically operative medical insertion method according to claim 84 and also comprising automatically precisely adapting said standard contour map to a specific patient.

86. An automatically operative medical insertion method according to any of claims 71 to 85 and also comprising adapting said reference pathway.

87. An automatically operative medical insertion method according to claim 86 and wherein said adapting comprises receiving inputs from an operator.

88. An automatically operative medical insertion method according to any of claim 87 and wherein said adapting comprises designating at least one impediment.

89. An automatically operative medical insertion method according to any of claims 71 to 88 and also comprising:

providing:

a flexible guide, said surface following element being mounted at a front end of said flexible guide;

a housing in which is disposed said driving subsystem;

a mouthpiece and a tube;

inserting said flexible guide through said tube;

inserting said tube through said mouthpiece; and

driving said flexible guide employing said driving subsystem.

90. An automatically operative medical insertion method according to claim 89 and wherein said mouthpiece comprises a curved pipe through which said tube is inserted.

91. An automatically operative medical insertion method according to claim 90 and also comprising moving said guide in and out of said housing, through said curved pipe and through said tube employing said driving subsystem.

92. An automatically operative medical insertion method according to claim 91 and also comprising selectably bending a front end of said guide employing said driving subsystem.

93. An automatically operative medical insertion method according to any of claims 71 to 92 and also comprising moving said insertable element in and out of said living organism employing said driving subsystem.

94. An automatically operative medical insertion method according to any of claims 71 to 93 and also comprising selectably bending a front end of said insertable element.

95. An automatically operative medical insertion method according to any of claims 71 to 94 and wherein said surface following element comprises a tactile sensing element.

96. An automatically operative medical insertion method according to any of claims 71 to 95 and wherein said physically associating a surface following element with said insertable element comprises:

integrally forming a tip at one end of a short rod having a magnet on its other end;

extending said rod through the center of a spring disk;

firmly connecting said spring disk to said rod;

mounting said spring disk on one end of a cylinder;

mounting another end of said cylinder on a front end of said insertable element.

97. An automatically operative medical insertion method according to claim 96 and wherein said surface following element also comprises two Hall effect sensors, each Hall effect sensor having electrical terminals operative to provide electric current representing the distance of the magnet therefrom and also comprising:

mounting said Hall effect sensors inside said cylinder on a support and in close proximity to said magnet;

spacing said Hall effect sensors in the plane of the curvature of said curved pipe;

said tip sensor being operative such that when a force is exerted on said tip along an axis of symmetry of said cylinder, said tip is pushed against said spring disk, causing said magnet to approach said Hall effect sensors and when a force is exerted on said tip sideways in the plane of said Hall effect sensors, said tip rotates around a location where said rod engages said spring disk, causing said magnet to rotate away from one of said Hall effect sensors and closer to the other of the Hall effect sensors.

98. An automatically operative medical insertion method according to claim 89 and also comprising:

partially inserting said insertable element into the oral cavity;

causing said insertable element to extend in the direction of the trachea;

bending said guide clockwise until said surface following element engages a surface of the tongue, whereby this engagement applies a force to said surface following element.

99. An automatically operative medical insertion method according to claim 96 and also comprising measuring the changes in the electrical outputs produced by the Hall effect sensors indicating the direction in which the tip is bent by employing said navigation subsystem.

100. An automatically operative medical insertion method according to claim 99 and also comprising sensing the position of said tip and determining the location of said tip in said living organism and relative to said reference pathway based on the past history of tip positions.

101. An automatically operative medical insertion method according to claim 99 and also comprising navigating said tip according to said reference pathway employing said navigation subsystem.

102. An automatically operative medical insertion method according to claim 101 and also comprising sensing said tip touching the end of the trough beneath the epiglottis.

103. An automatically operative medical insertion method according to claim 99 and also comprising sensing said tip reaching the tip of the epiglottis.

104. An automatically operative medical insertion method according to claim 99 and also comprising sensing the tip reaching the first cartilage of the trachea.

105. An automatically operative medical insertion method according to claim 104 and also comprising sensing the tip reaching the second cartilage of the trachea.

106. An automatically operative medical insertion method according to claim 105 and also comprising sensing the tip reaching the third cartilage of the trachea.

107. An automatically operative medical insertion method according to any of claims 71 to 106 and also comprising loading said reference pathway from a memory to said navigation subsystem.

108. An automatically operative medical insertion method according to claim 89 and also comprising pushing said tube forward employing said driving subsystem.

109. An automatically operative medical insertion method according to any of claims 71 to 108 and also comprising:

operating a first motor to selectably move said insertable element forward or backward;

operating a second motor to selectably bend said insertable element; and

controlling said first motor, said second motor and said surface following element by employing electronic circuitry.

110. An automatically operative medical insertion method according to claim 109 and wherein said electronic circuitry comprises a microprocessor and also comprising executing a program, said executing a program comprising:

controlling said first and second motors and said surface following element; and

inserting and bending said insertable element inside said living organism along said reference pathway.

111. An automatically operative medical insertion method according to claim 109 or claim 110 and also comprising:

measuring the electric current drawn by at least one of said first and second motors; and

evaluating the position of said surface following element, by employing said driving subsystem.

112. An automatically operative medical insertion method according to any of claims 71 to 111 and also comprising preparing said reference pathway at least partially before the insertion process is activated.

113. An automatically operative medical insertion method according to claim 112 and also comprising:

providing a medical imaging system; and

preparing said reference pathway at least partially by employing said medical imaging system.

114. An automatically operative medical insertion method according to claim 113 and wherein said medical imaging subsystem comprises at least one of an ultrasound scanner, an X-ray imager, a CAT scan system and an MRI system.

115. An automatically operative medical insertion method according to claim 112 and also comprising preparing said reference pathway by marking at least one contour of at least one organ of said living organism.

116. An automatically operative medical insertion method according to claims 71 to 115 and also comprising preparing said reference pathway by creating an insertion instruction table comprising at least one insertion instruction.

117. An automatically operative medical insertion method according to claim 116 and wherein said insertion instruction comprises instruction to at least one of

extend, retract and bend said insertable element.

118. An automatically operative medical insertion method according to claim 116 and also comprising controlling said driving subsystem based at least partially on a perceived location of said surface following element and according to said insertion instruction table stored in said navigation subsystem.

119. An automatically operative medical insertion method according to any of claims 71 to 118 and also comprising storing at least partially a log of a process of insertion of said insertable element.

120. An automatically operative medical insertion method according to claim 119 and also comprising:

providing a computer; and

transmitting said log of a process of insertion of said insertable element to said computer.

121. An automatically operative medical insertion method according to claim 120 and also comprising aggregating said logs of a process of insertion of said insertable element by employing said computer.

122. An automatically operative medical insertion method according to claim 121 and also comprising preparing said reference pathway based at least partially on the output of said aggregating.

123. An automatically operative medical insertion method according to claim 122 and also comprising transmitting said reference pathway from said computer to said medical insertion device.

124. An automatically operative medical insertion method according to any of claims 71 to 123 and wherein said insertable element comprises a guiding element and a guided element.

125. An automatically operative medical insertion method according to claim 124 and also comprising directing said guiding element and said guided element at least partially together.

126. An automatically operative medical insertion method according to claim 73 and wherein said directing comprises automatically and selectably directing said insertable element in a combined motion comprising a longitudinal motion and lateral motion.

127. An automatically operative medical insertion method according to any of claims 71 - 126 and wherein said inserting also comprises extending said insertable element.

128. An automatically operative medical insertion method according to claim 127 and also comprising:

removably engaging said insertion element with an intubator assembly; and

operatively associating an extendable tube with said insertion element.

129. An automatically operative medical insertion method according to claim 128 and wherein said extending comprises:

operating a flexible guide; and

pulling said extendable tube by said flexible guide.

130. An automatically operative medical insertion method according to claim 128 or claim 129 and wherein said extending comprises at least one of expanding and contracting a coil spring.

131. An automatically operative medical insertion method according to any of claims 128 - 130 and also comprising forming a forward end member, on a distal end of said extendable tube.

132. An automatically operative medical insertion method according to claim 131 and also comprising forming a diagonally cut pointed forward facing tube end surface on said forward end member.

133. An automatically operative medical insertion method according to claim 131 or claim 132 and also comprising forming an inflatable and radially outwardly expandable circumferential balloon on said forward end member.

134. An automatically operative medical insertion method according to claim 133 and also comprising receiving inflation gas into said circumferential balloon through a conduit formed in a wall of said forward end member and continuing through said tube to a one way valve.

135. An automatically operative medical insertion method according to any of claims 129 - 134 and also comprising mounting a tip sensor at a distal end of said flexible guide.

136. An automatically operative medical insertion method according to claim 135 and also comprising forming an inflatable and radially outwardly expandable guide balloon on said flexible guide.

137. An automatically operative medical insertion method according to claim 136 and also comprising receiving inflation gas into said guide balloon through a conduit formed in said said flexible guide and extending therealong.

138. An automatically operative medical insertion method according to claim 137 and also comprising connecting said conduit to a source of pressurized inflation gas.

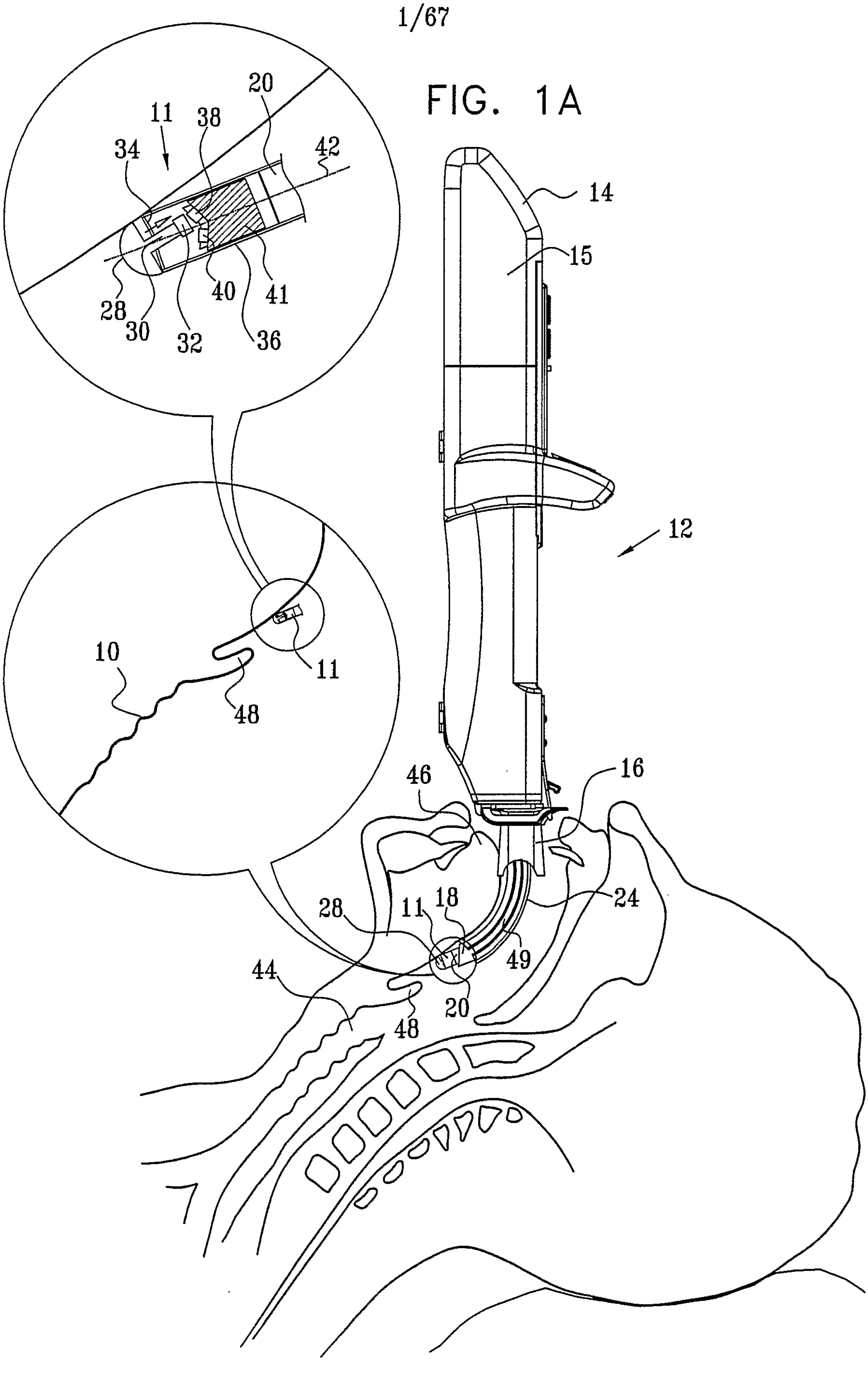
139. An automatically operative medical insertion method according to claim 138 and also comprising locating said source of pressurized inflation gas within said intubator assembly.

140. An automatically operative medical insertion method according to any of claims 136 - 139 and also comprising inflating said guide mounted balloon to tightly engage the interior of said forward end member to provide extension of said tube in response to forward driven movement of said flexible guide.

141. An automatically operative medical insertion method according to claim 134 and wherein said inflating comprises inflating said circumferential balloon with pressurized air.

142. An automatically operative medical insertion method according to claim 137 and wherein said inflating comprises inflating said guide balloon with pressurized air.

FIG. 1A



20
11
38
42
34
14
15
28
30
32
40
41
36
12
10
11
48
46
16
24
28
11
18
49
44
20
48

FIG. 1B

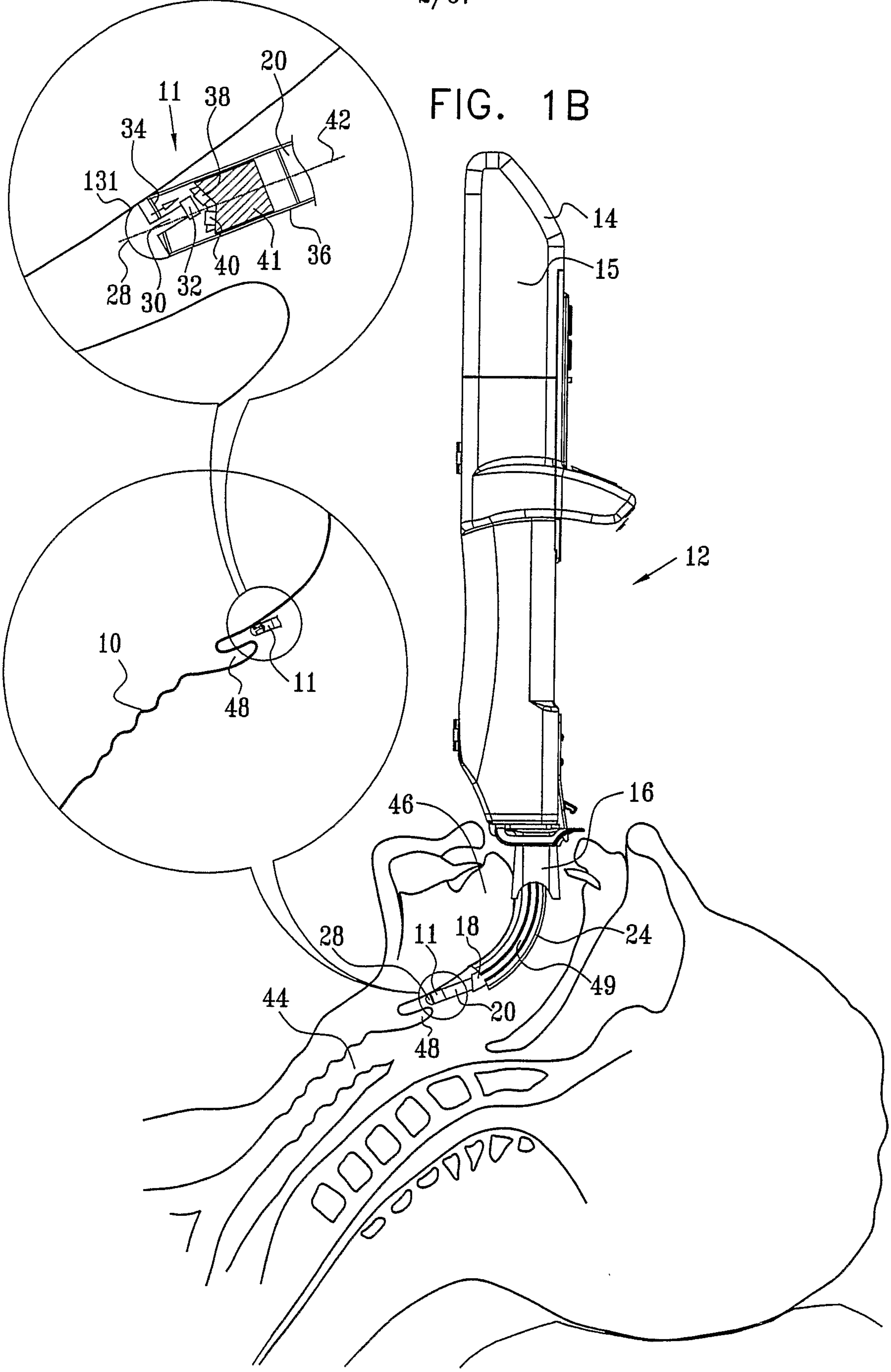

11
38
20
42
34
131
28
30
32
40
41
36
14
15
12
10
48
11
46
16
28
11
18
24
49
20
44
48

FIG. 1C

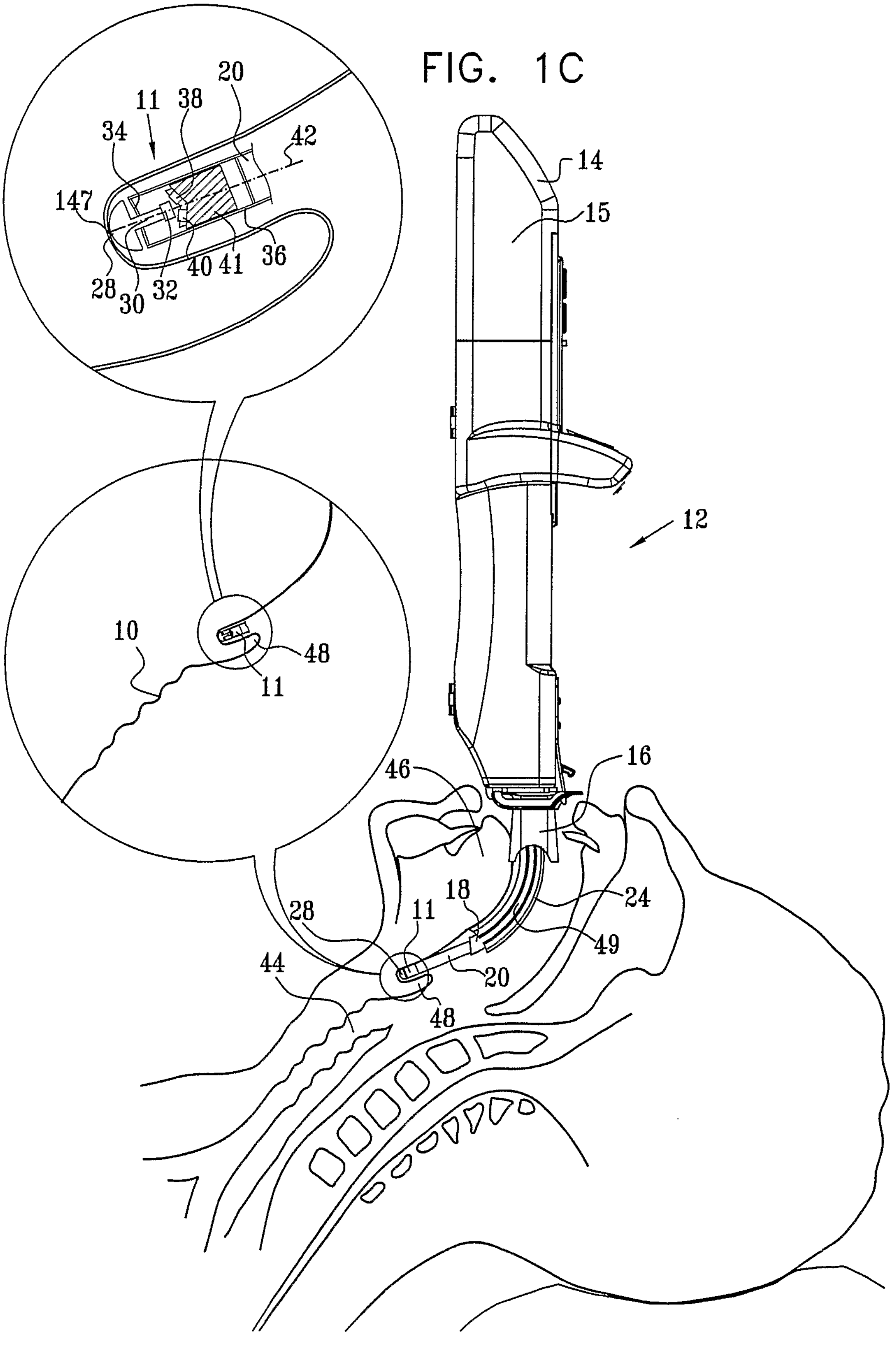

20
11
38
34
42
14
147
15
28
30
32
40
41
36
12
10
48
11
16
46
24
18
28
11
49
20
44
48

FIG. 1D

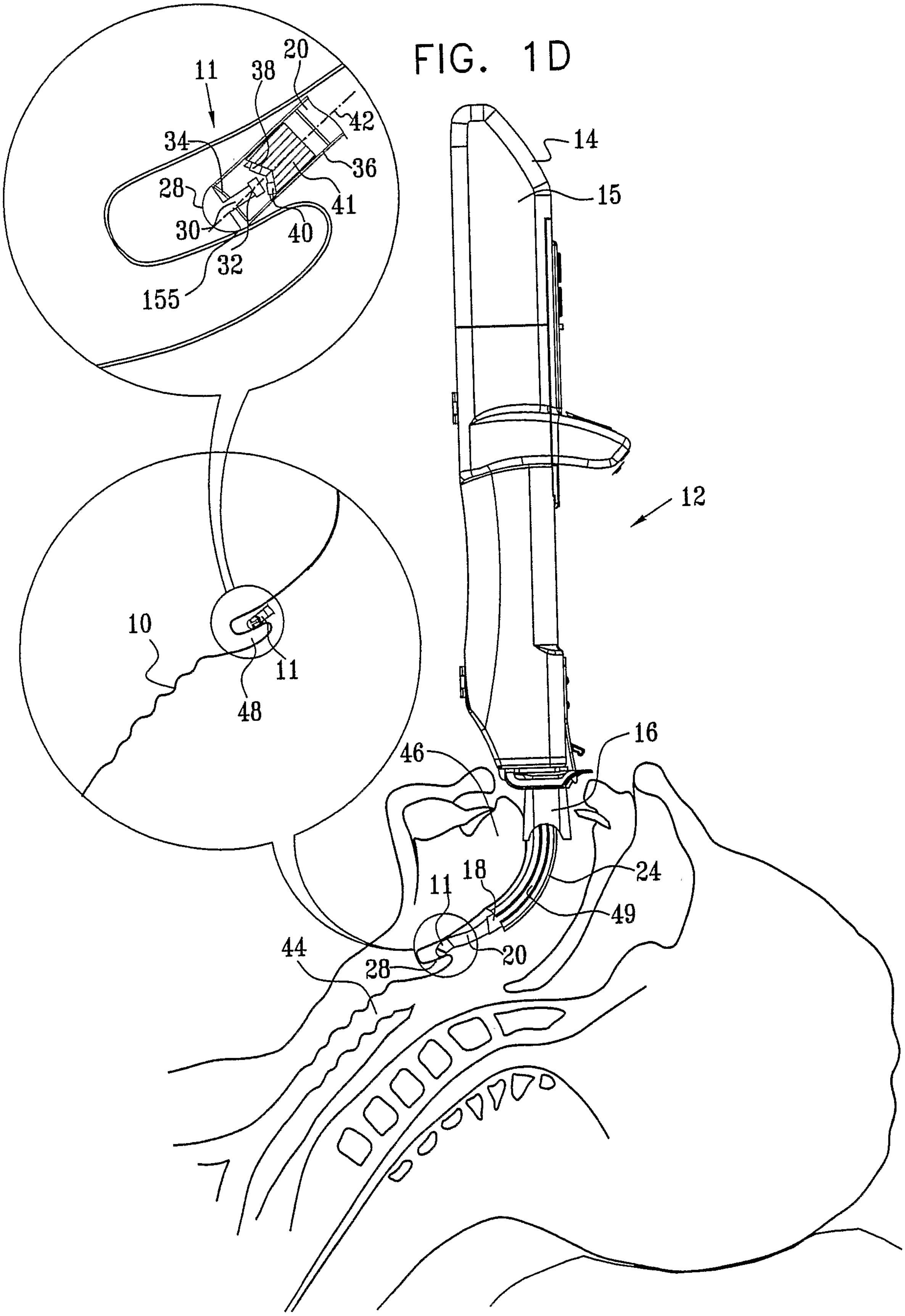
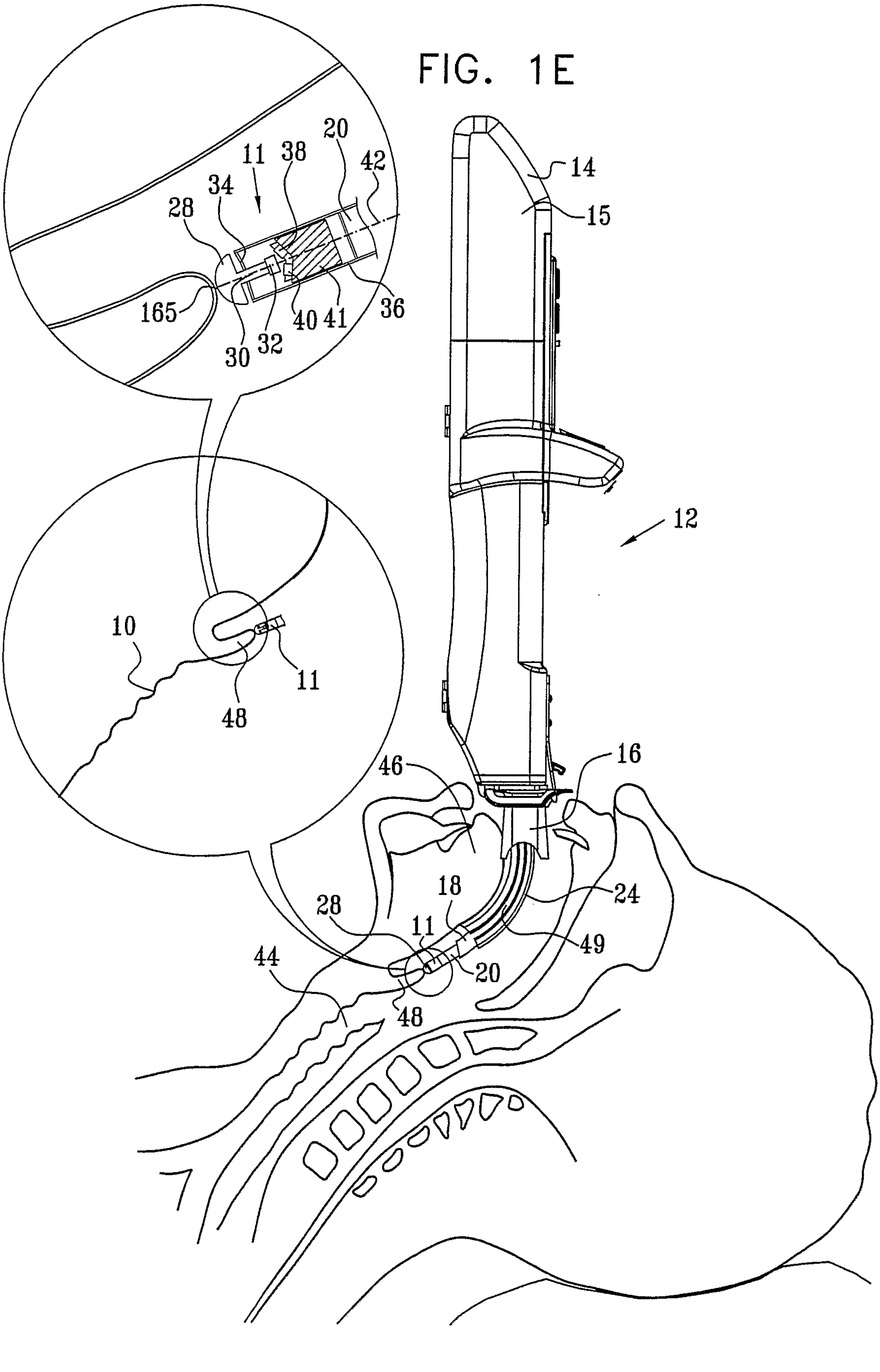

11
38
20
42
34
14
36
28
15
41
30
40
32
155
12
10
11
48
16
46
24
11
18
49
20
44
28

FIG. 1E



11
38
20
42
34
28
165
30
32
40
41
36
14
15
12
10
11
48
46
16
18
24
28
11
49
20
44
48

FIG. 1F

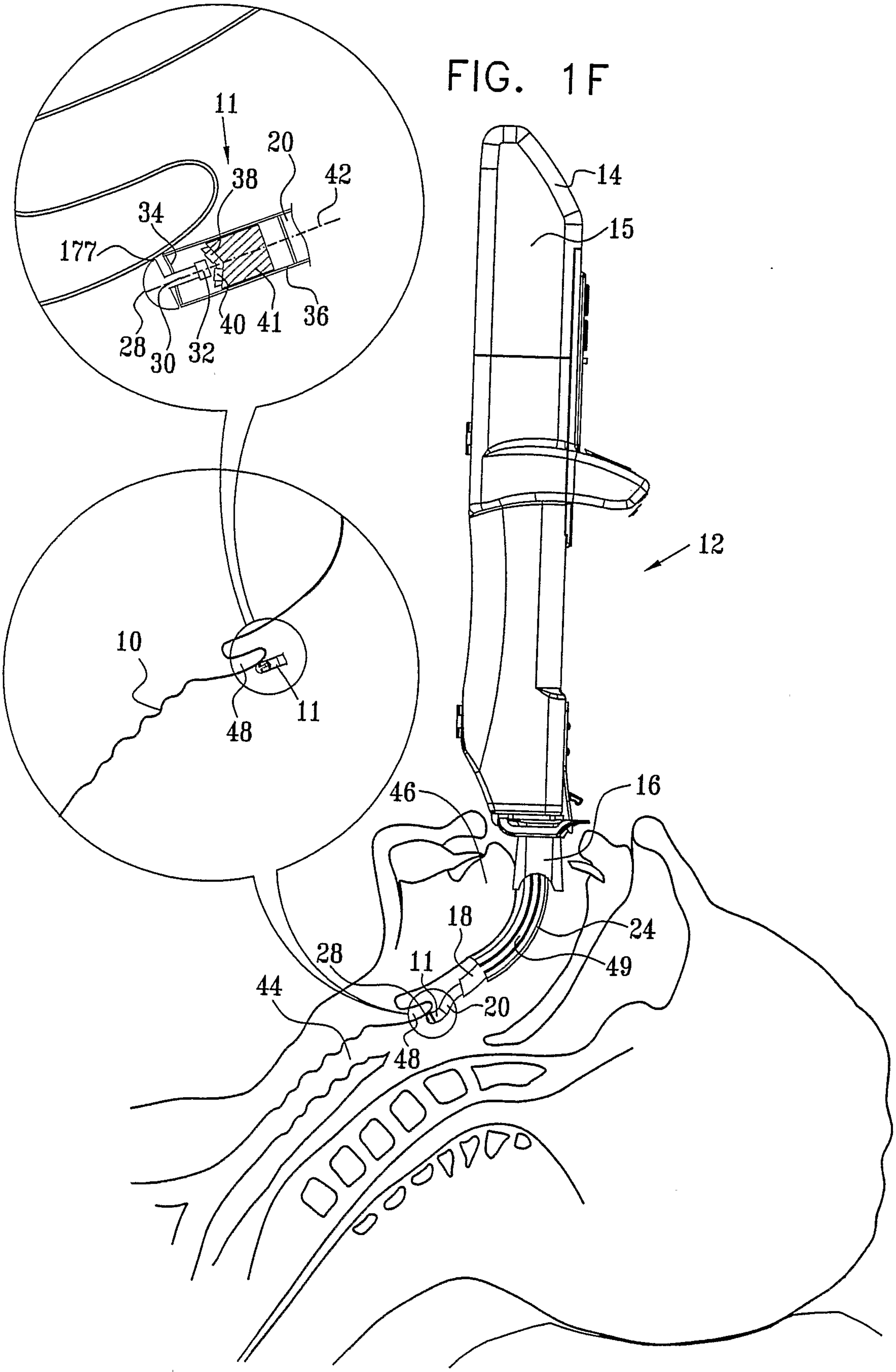

11
20
38
42
14
34
177
15
28
30
32
40
41
36
12
10
11
48
46
16
18
24
28
11
49
44
20
48

FIG. 1G

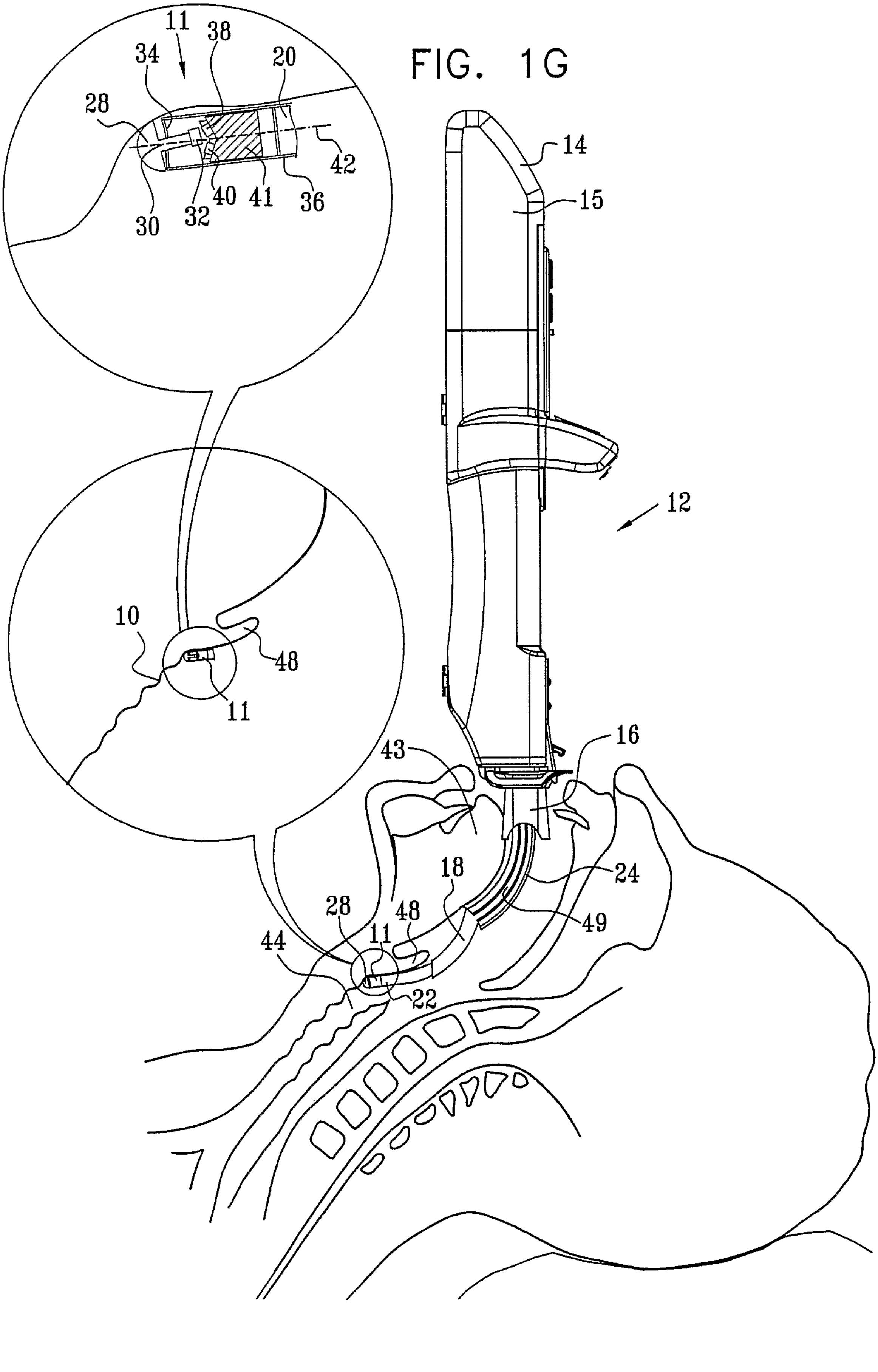

11
34
38
20
28
42
30
32
40
41
36
14
15
12
10
48
11
43
16
18
24
49
28
48
11
44
22

FIG. 1H

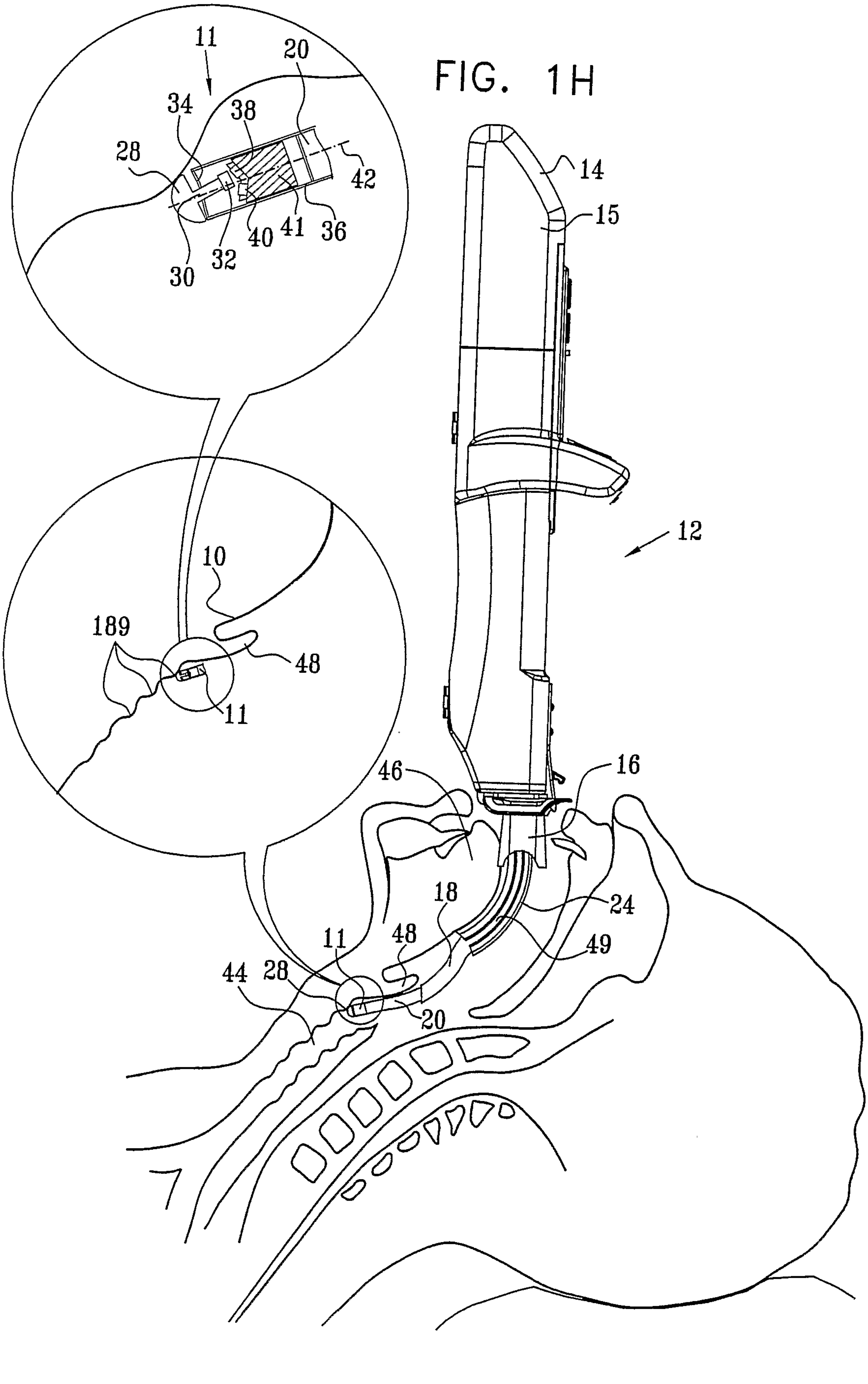

11
20
34
38
28
42
40
41
36
30
32
14
15
12
10
189
48
11
46
16
18
24
11
48
49
44
28
20

FIG. 11

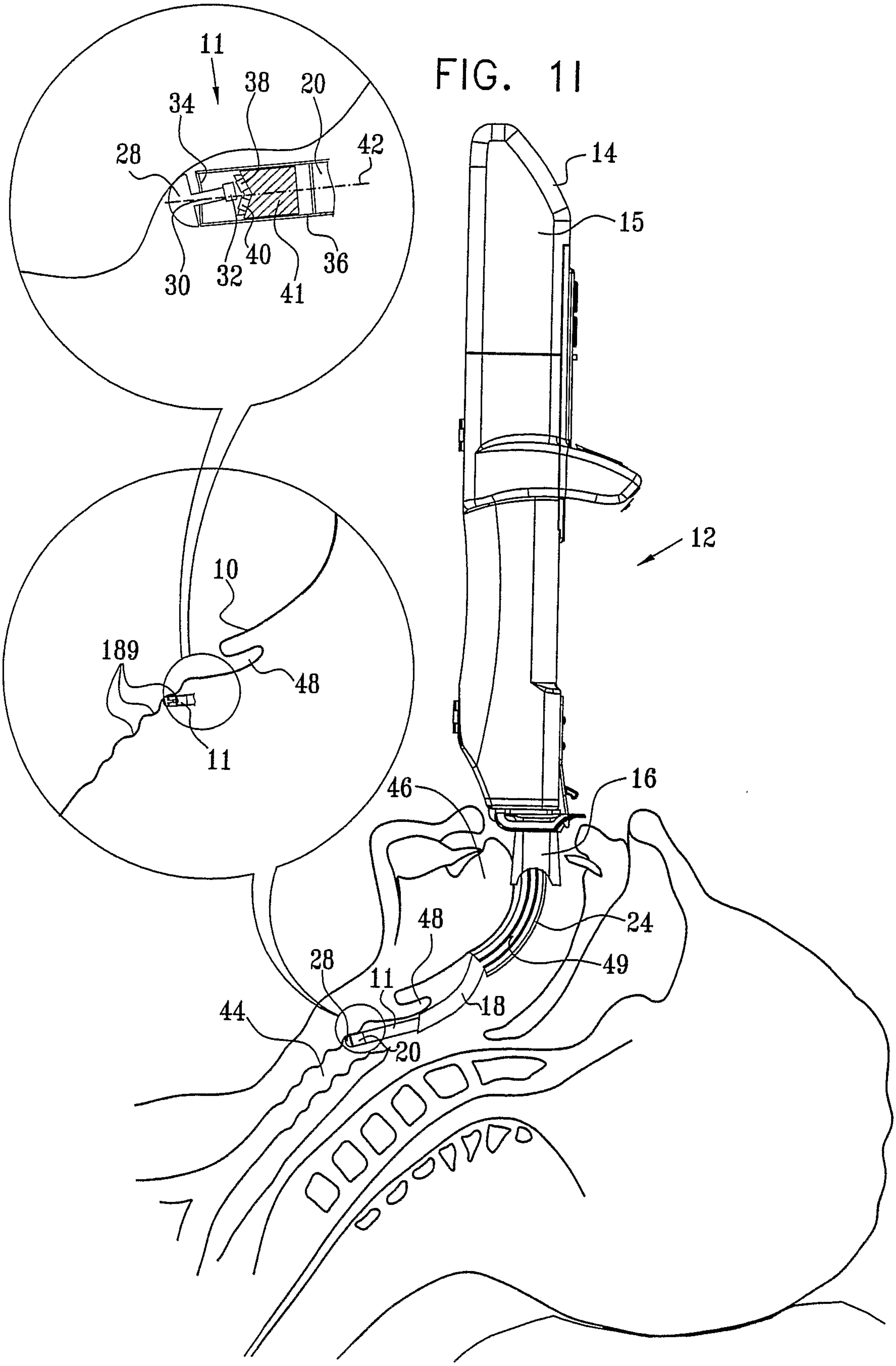

11
34
38
20
28
42
14
15
30
32
40
41
36
12
10
189
48
11
16
46
24
48
49
28
11
18
44
20

FIG. 1J

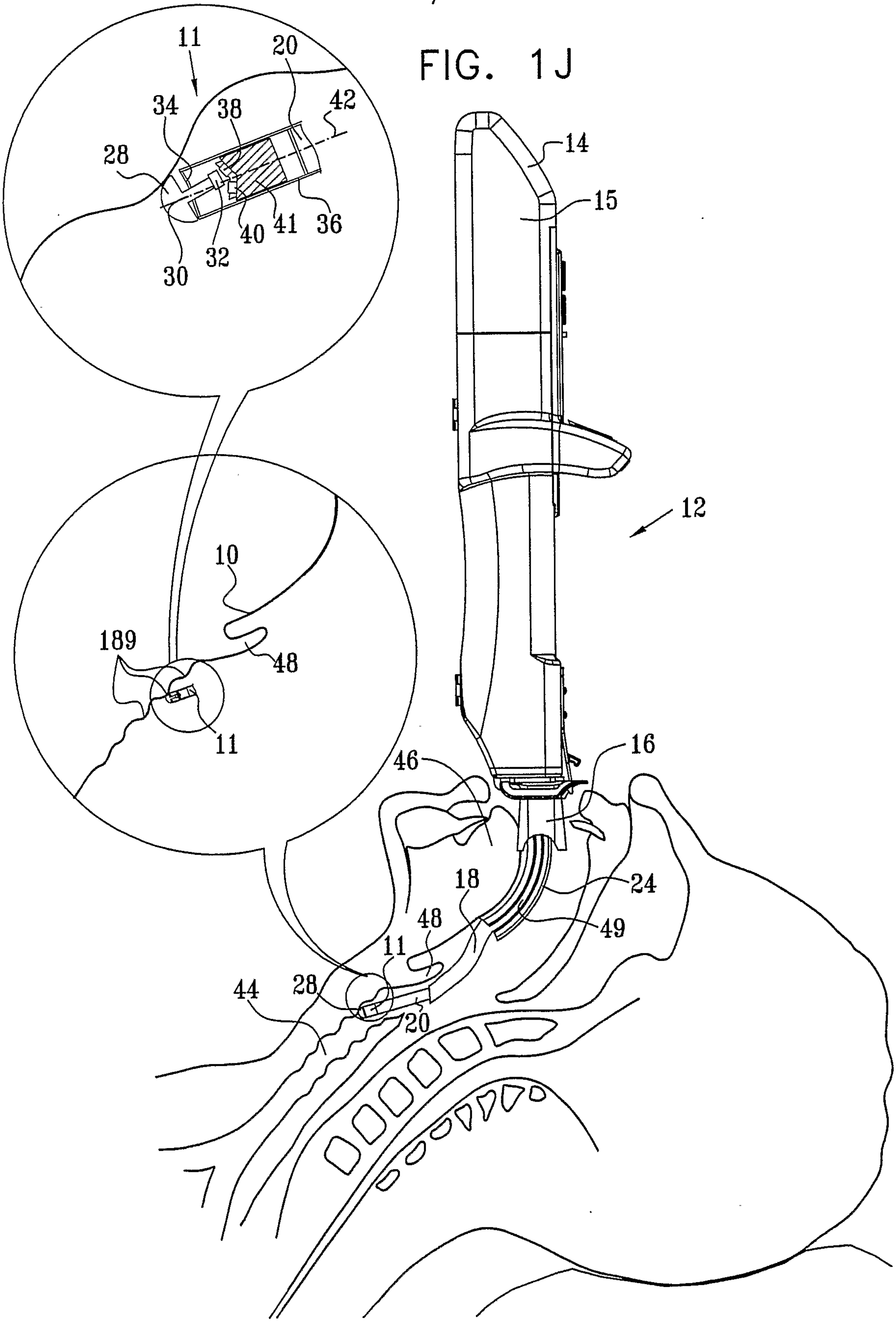

11
20
42
34
38
28
14
15
30
32
40
41
36
12
10
189
48
11
46
16
18
24
48
49
11
28
44
20

FIG. 1K

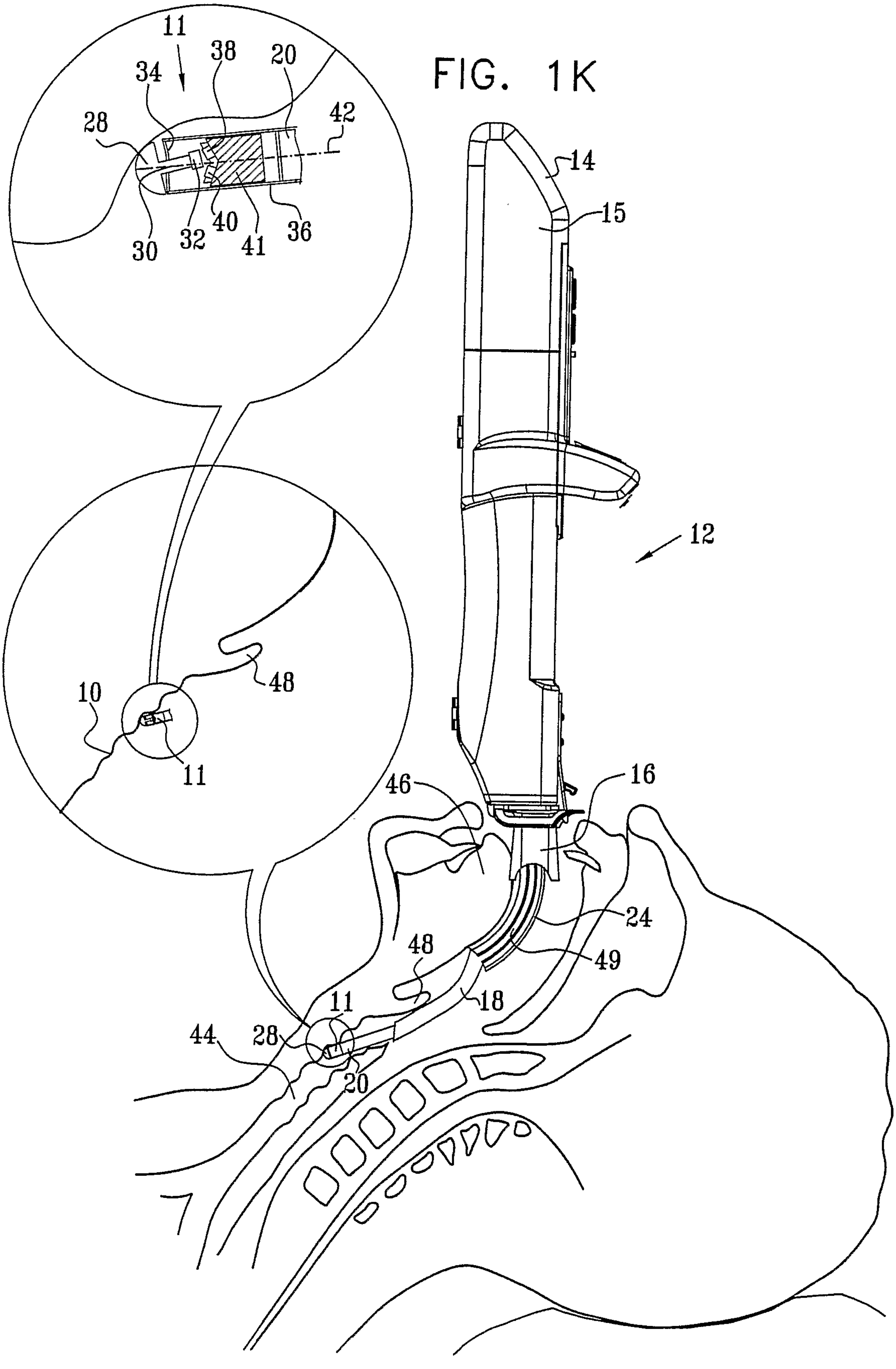

11
38
20
34
28
42
30
32
40
41
36
14
15
12
48
10
11
46
16
24
49
48
18
11
44
28
20

FIG. 1L

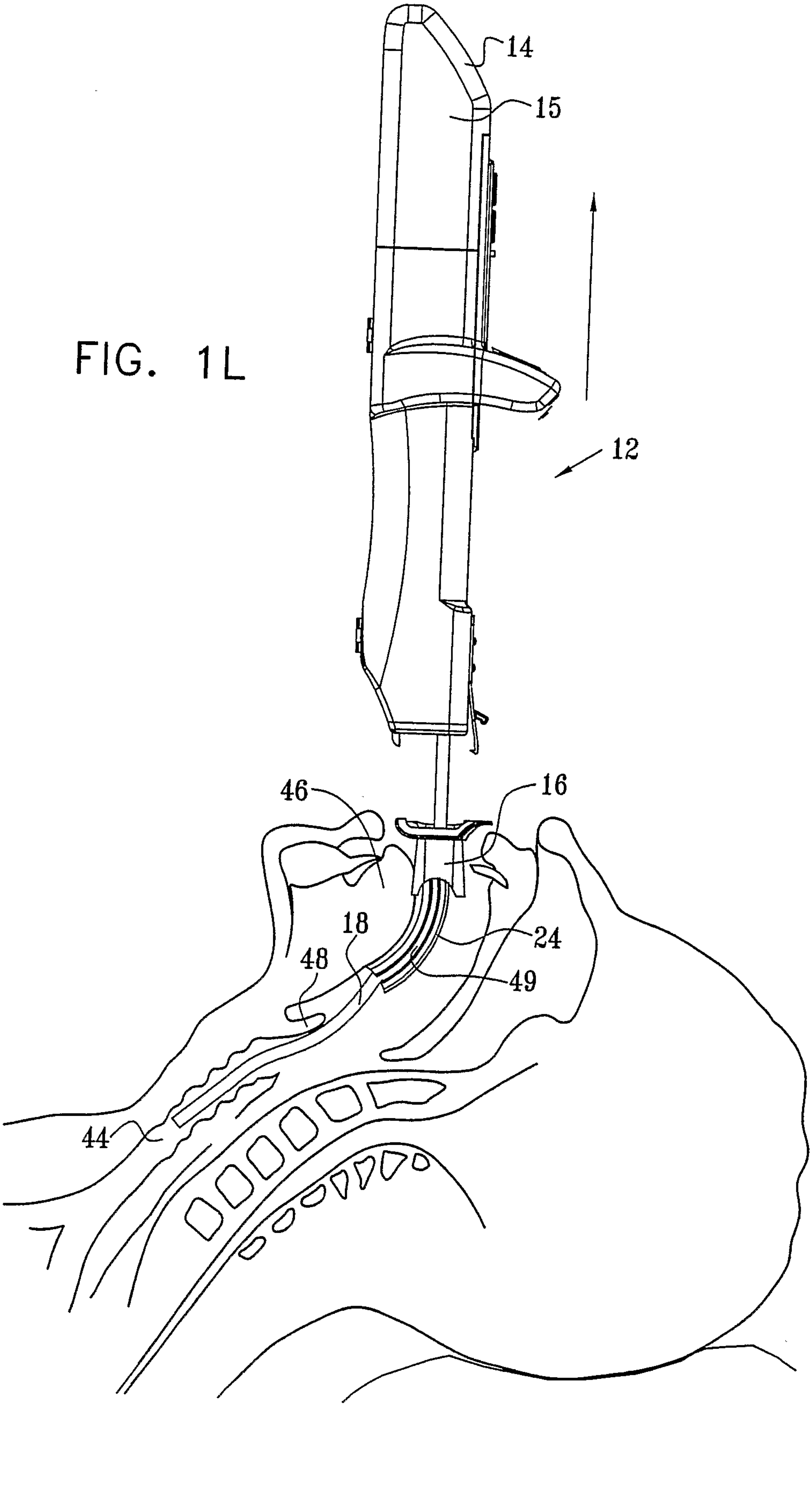


FIG. 2A

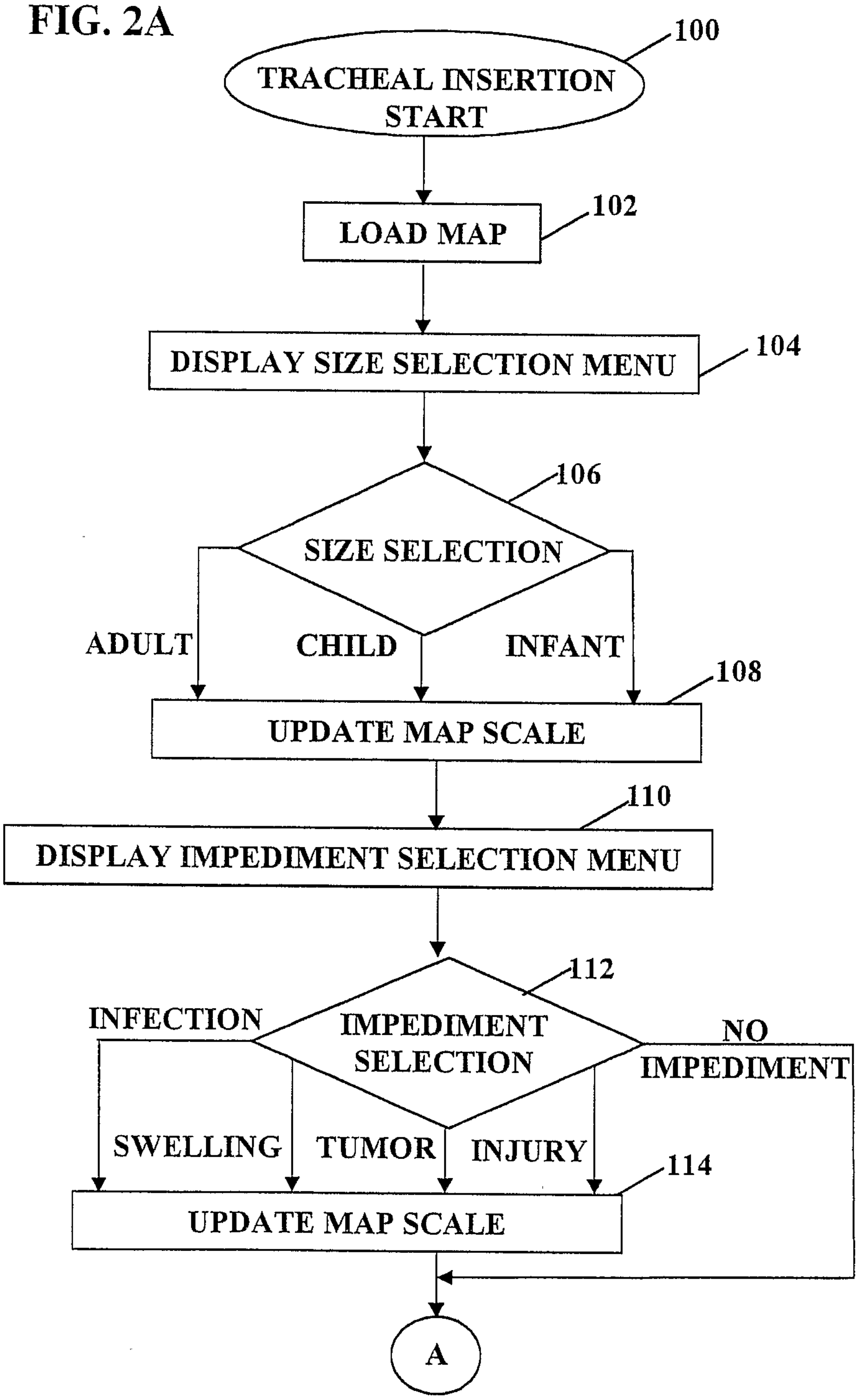

100
TRACHEAL INSERTION START
102
LOAD MAP
104
DISPLAY SIZE SELECTION MENU
106
SIZE SELECTION
ADULT
CHILD
INFANT
108
UPDATE MAP SCALE
110
DISPLAY IMPEDIMENT SELECTION MENU
112
IMPEDIMENT SELECTION
INFECTION
NO IMPEDIMENT
SWELLING
TUMOR
INJURY
114
UPDATE MAP SCALE
A

FIG. 2B

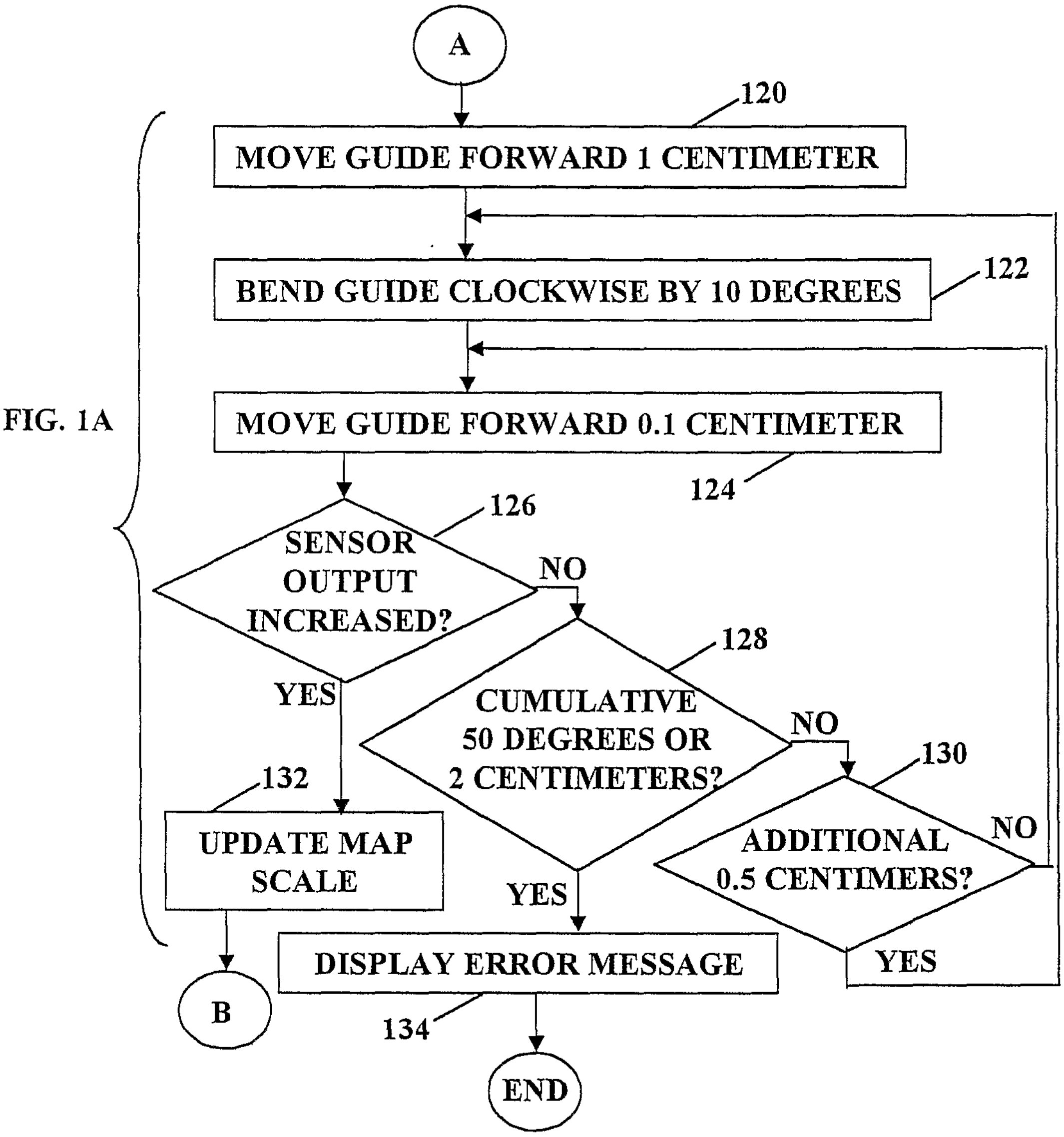

A
120
MOVE GUIDE FORWARD 1 CENTIMETER
BEND GUIDE CLOCKWISE BY 10 DEGREES
122
FIG. 1A
MOVE GUIDE FORWARD 0.1 CENTIMETER
124
126
SENSOR OUTPUT INCREASED?
NO
YES
128
CUMULATIVE 50 DEGREES OR 2 CENTIMETERS?
NO
130
ADDITIONAL 0.5 CENTIMERS?
NO
132
UPDATE MAP SCALE
YES
DISPLAY ERROR MESSAGE
YES
B
134
END

FIG. 2C

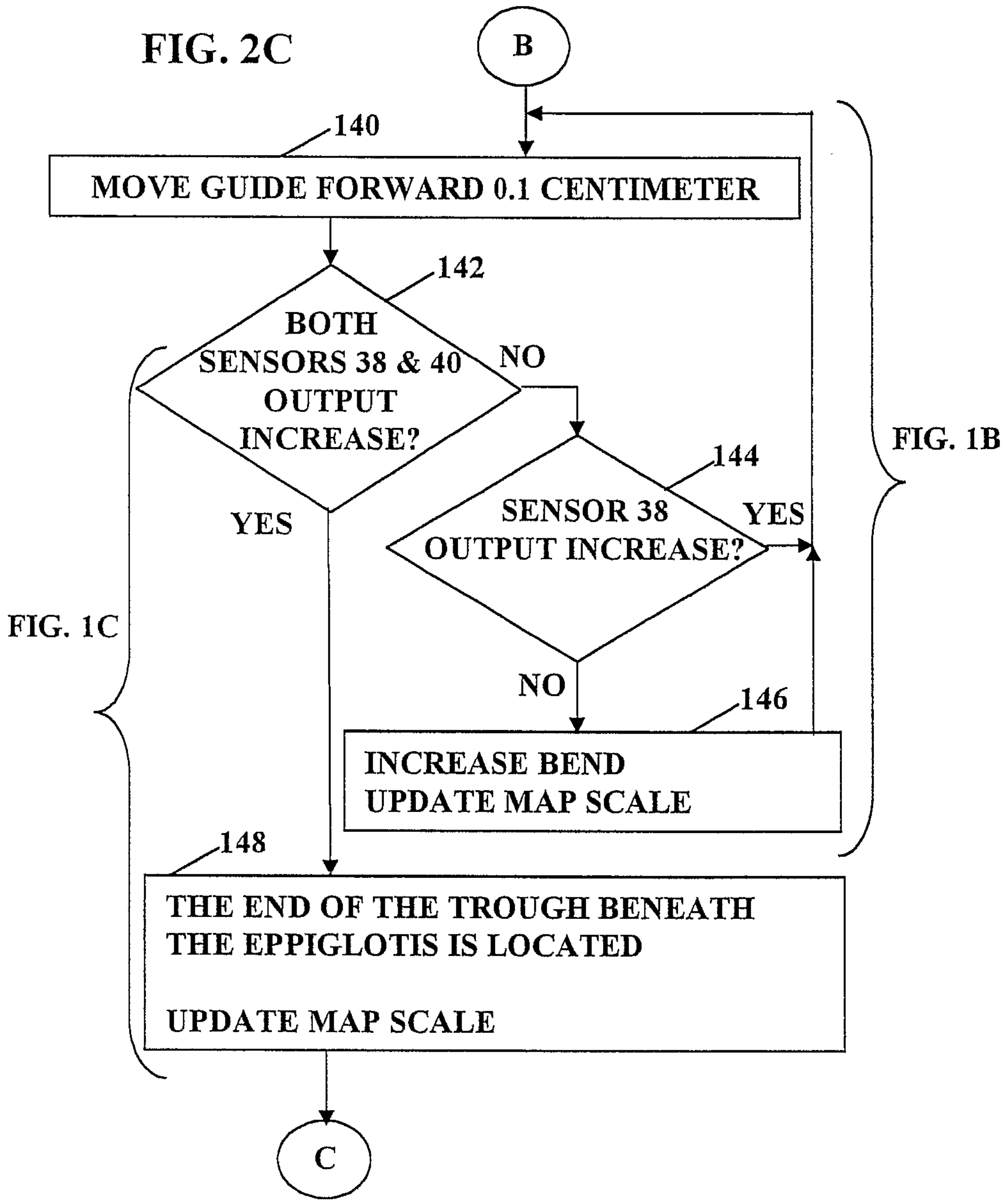

B
140
MOVE GUIDE FORWARD 0.1 CENTIMETER
142
BOTH SENSORS 38 & 40 OUTPUT INCREASE?
NO
YES
144
SENSOR 38 OUTPUT INCREASE?
YES
NO
146
INCREASE BEND
UPDATE MAP SCALE
FIG. 1B
FIG. 1C
148
THE END OF THE TROUGH BENEATH
THE EPPIGLOTIS IS LOCATED
UPDATE MAP SCALE
C

FIG. 2D

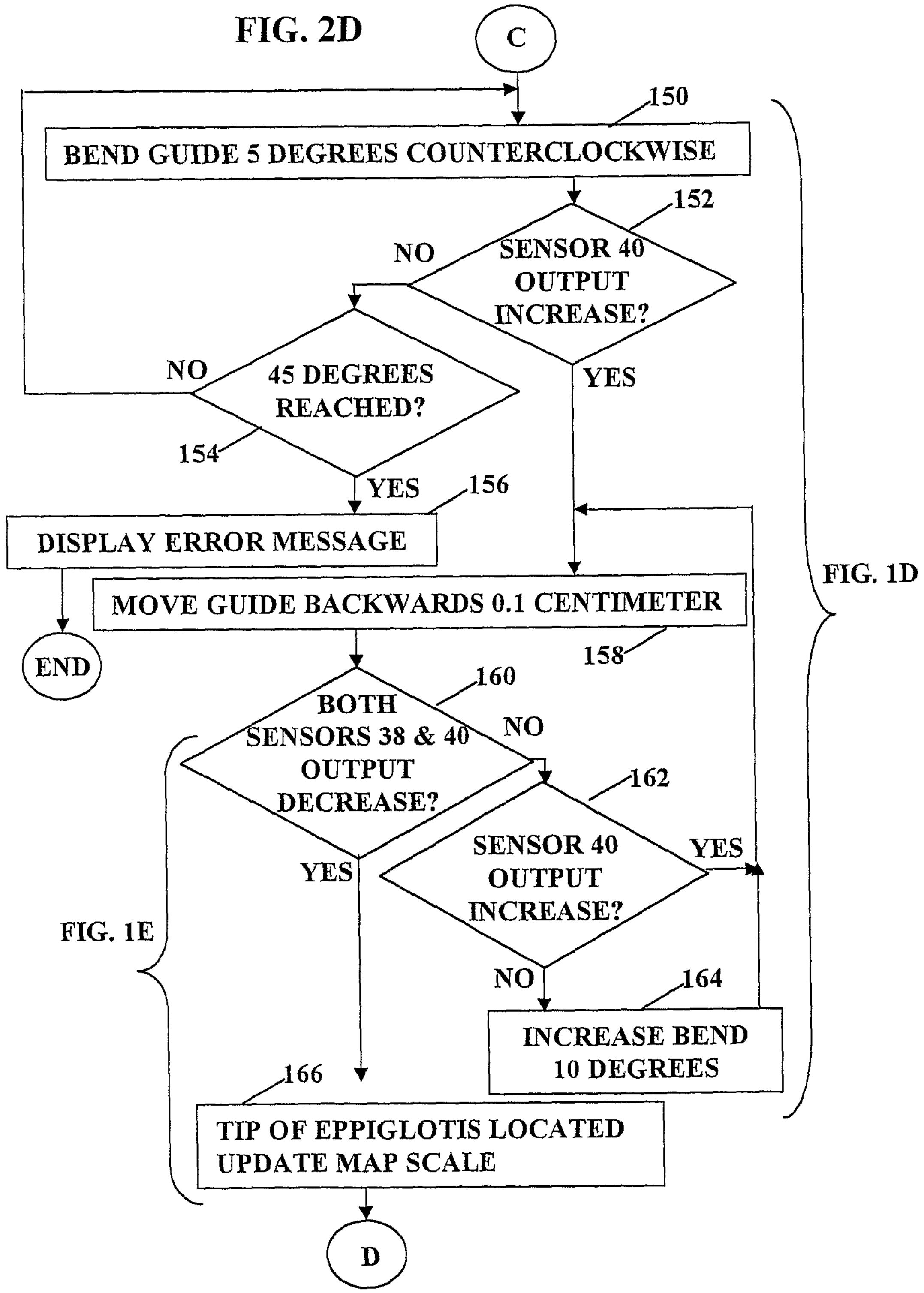

C
150
BEND GUIDE 5 DEGREES COUNTERCLOCKWISE
152
SENSOR 40 OUTPUT INCREASE?
NO
YES
45 DEGREES REACHED?
NO
154
YES
156
DISPLAY ERROR MESSAGE
END
MOVE GUIDE BACKWARDS 0.1 CENTIMETER
158
FIG. 1D
160
BOTH SENSORS 38 & 40 OUTPUT DECREASE?
NO
YES
162
SENSOR 40 OUTPUT INCREASE?
YES
NO
164
INCREASE BEND 10 DEGREES
FIG. 1E
166
TIP OF EPPIGLOTIS LOCATED UPDATE MAP SCALE
D

FIG. 2E

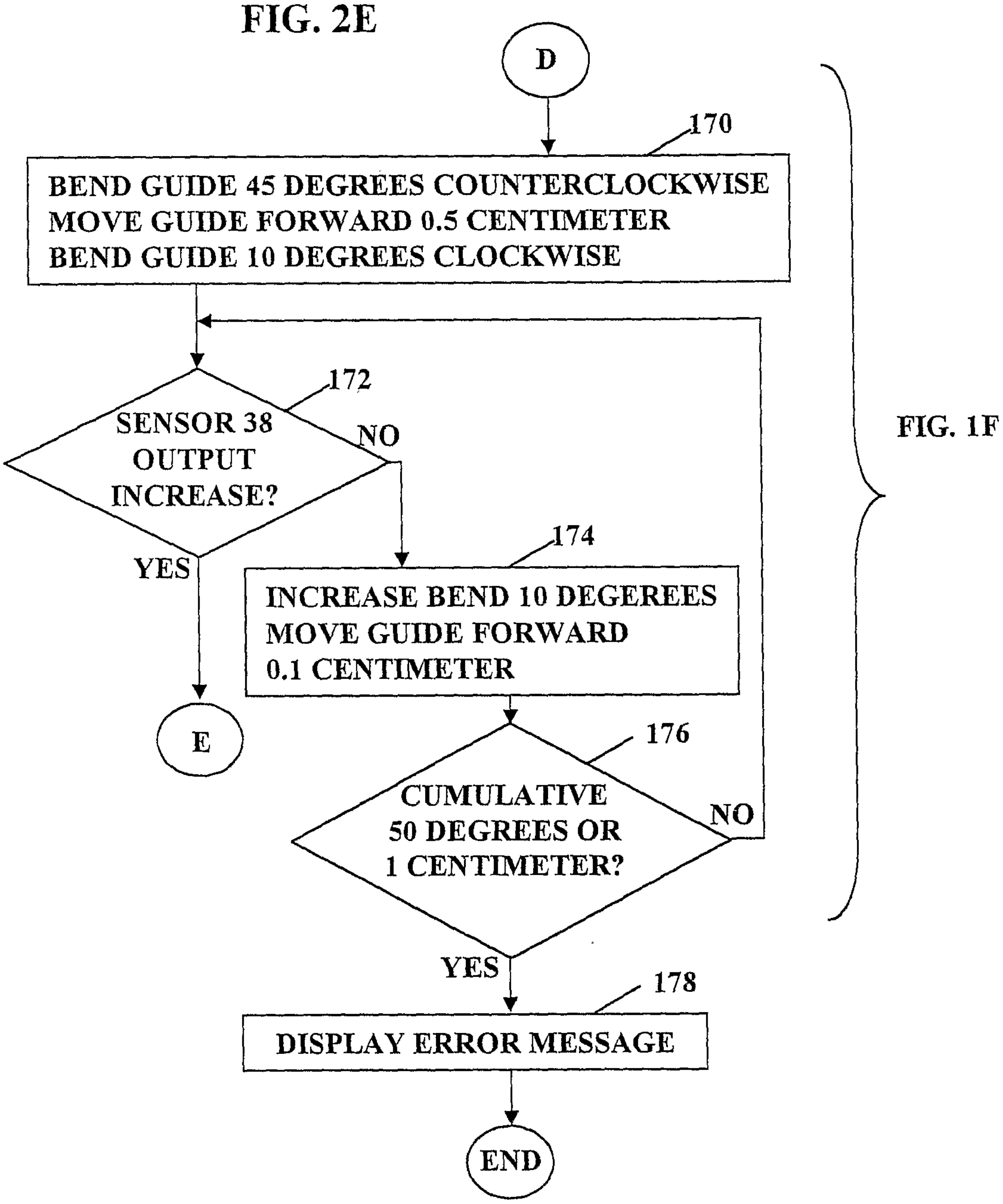

D
170
BEND GUIDE 45 DEGREES COUNTERCLOCKWISE
MOVE GUIDE FORWARD 0.5 CENTIMETER
BEND GUIDE 10 DEGREES CLOCKWISE
172
SENSOR 38 OUTPUT INCREASE?
NO
YES
E
174
INCREASE BEND 10 DEGEREES
MOVE GUIDE FORWARD
0.1 CENTIMETER
176
CUMULATIVE 50 DEGREES OR 1 CENTIMETER?
NO
YES
178
DISPLAY ERROR MESSAGE
END
FIG. 1F

FIG. 2F

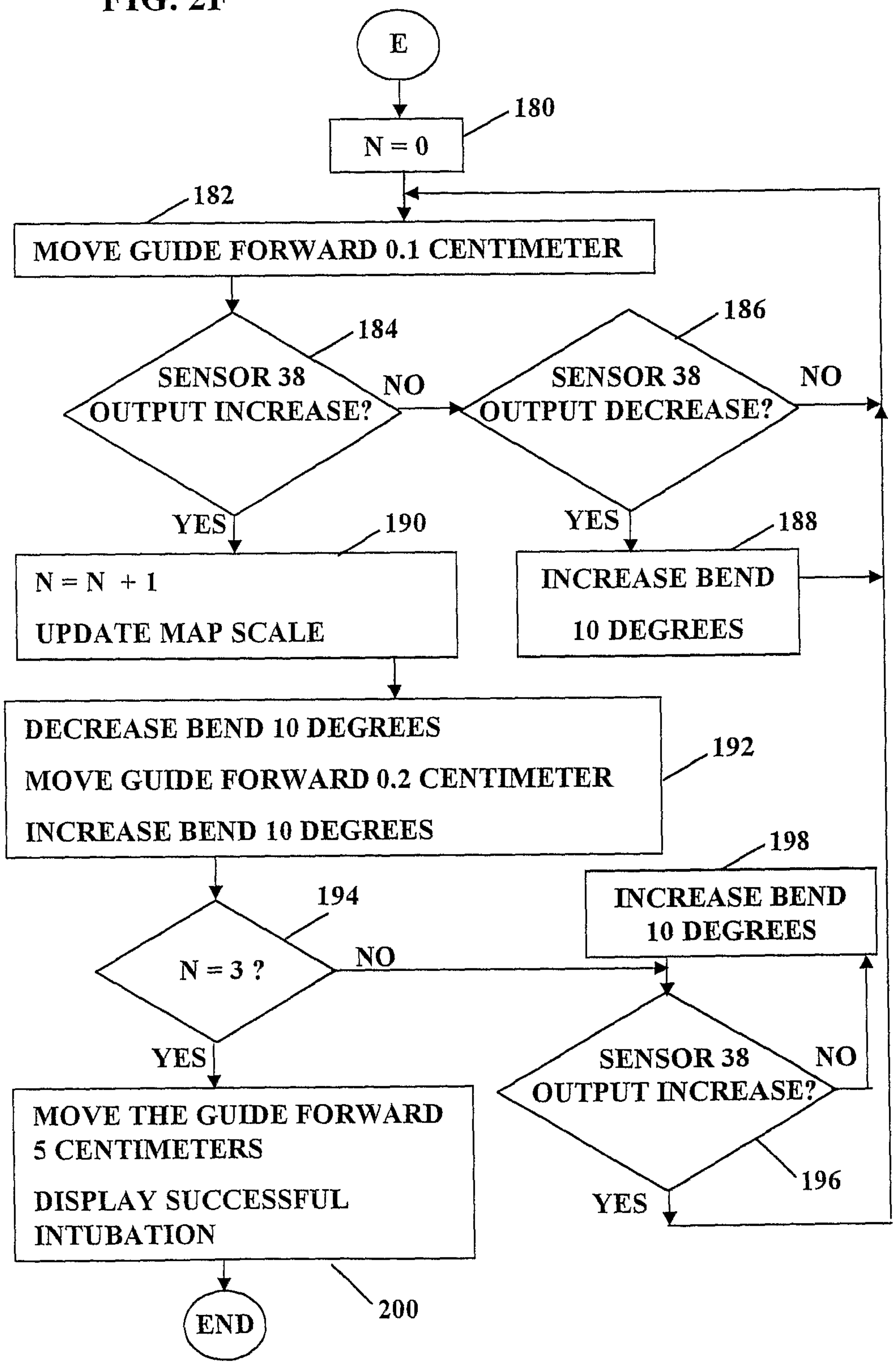
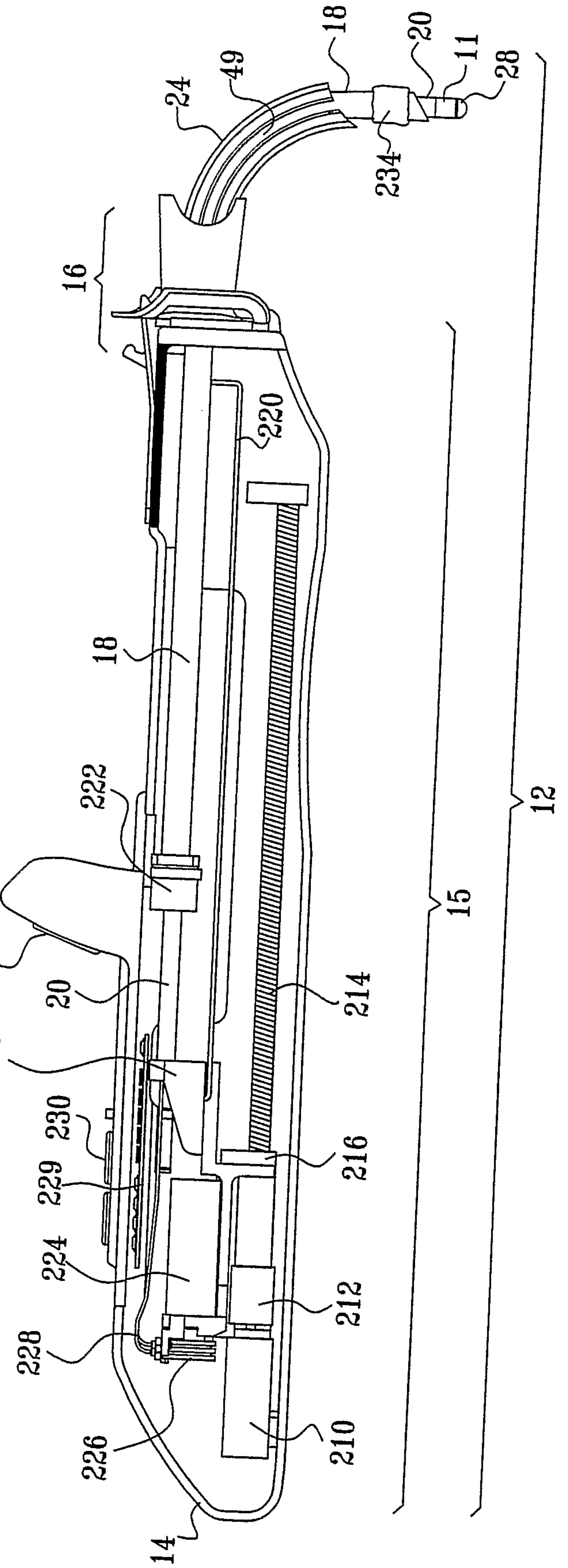

E
180
N = 0
182
MOVE GUIDE FORWARD 0.1 CENTIMETER
184
SENSOR 38
OUTPUT INCREASE?
NO
186
SENSOR 38
OUTPUT DECREASE?
NO
YES
190
N = N + 1
UPDATE MAP SCALE
YES
188
INCREASE BEND
10 DEGREES
DECREASE BEND 10 DEGREES
MOVE GUIDE FORWARD 0.2 CENTIMETER
INCREASE BEND 10 DEGREES
192
198
INCREASE BEND
10 DEGREES
194
N = 3 ?
NO
YES
SENSOR 38
OUTPUT INCREASE?
NO
MOVE THE GUIDE FORWARD
5 CENTIMETERS
DISPLAY SUCCESSFUL
INTUBATION
196
YES
END
200

FIG. 3


18
20
11
28
49
24
234
16
220
18
222
232
20
218
230
229
224
228
226
14
214
216
212
210
15
12

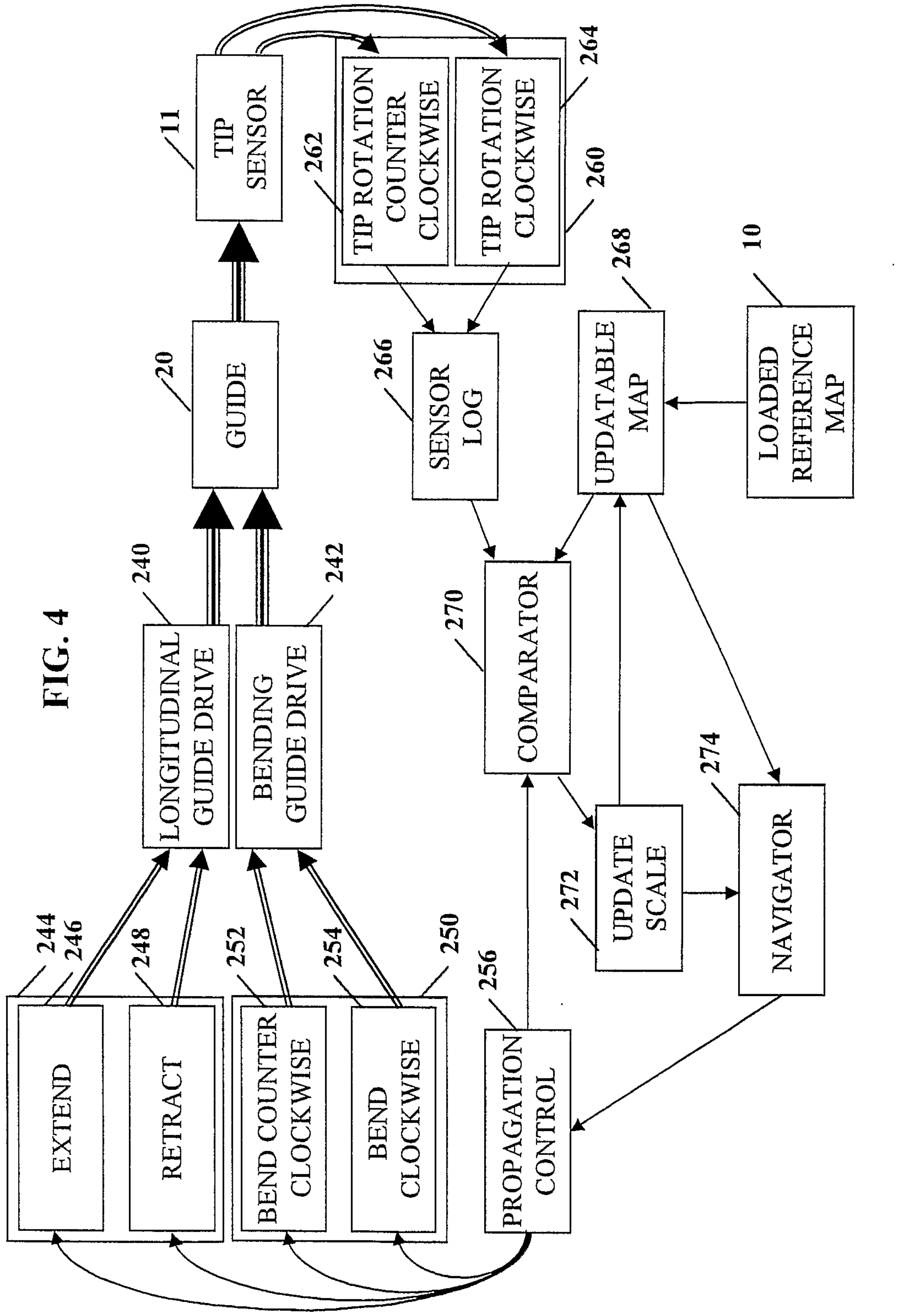

TIP SENSOR
11
TIP ROTATION COUNTER CLOCKWISE
262
TIP ROTATION CLOCKWISE
264
260
GUIDE
20
SENSOR LOG
266
UPDATABLE MAP
268
LOADED REFERENCE MAP
10
LONGITUDINAL GUIDE DRIVE
240
BENDING GUIDE DRIVE
242
COMPARATOR
270
UPDATE SCALE
272
NAVIGATOR
274
EXTEND
RETRACT
BEND COUNTER CLOCKWISE
BEND CLOCKWISE
244
246
248
252
254
250
PROPAGATION CONTROL
256

FIG. 4

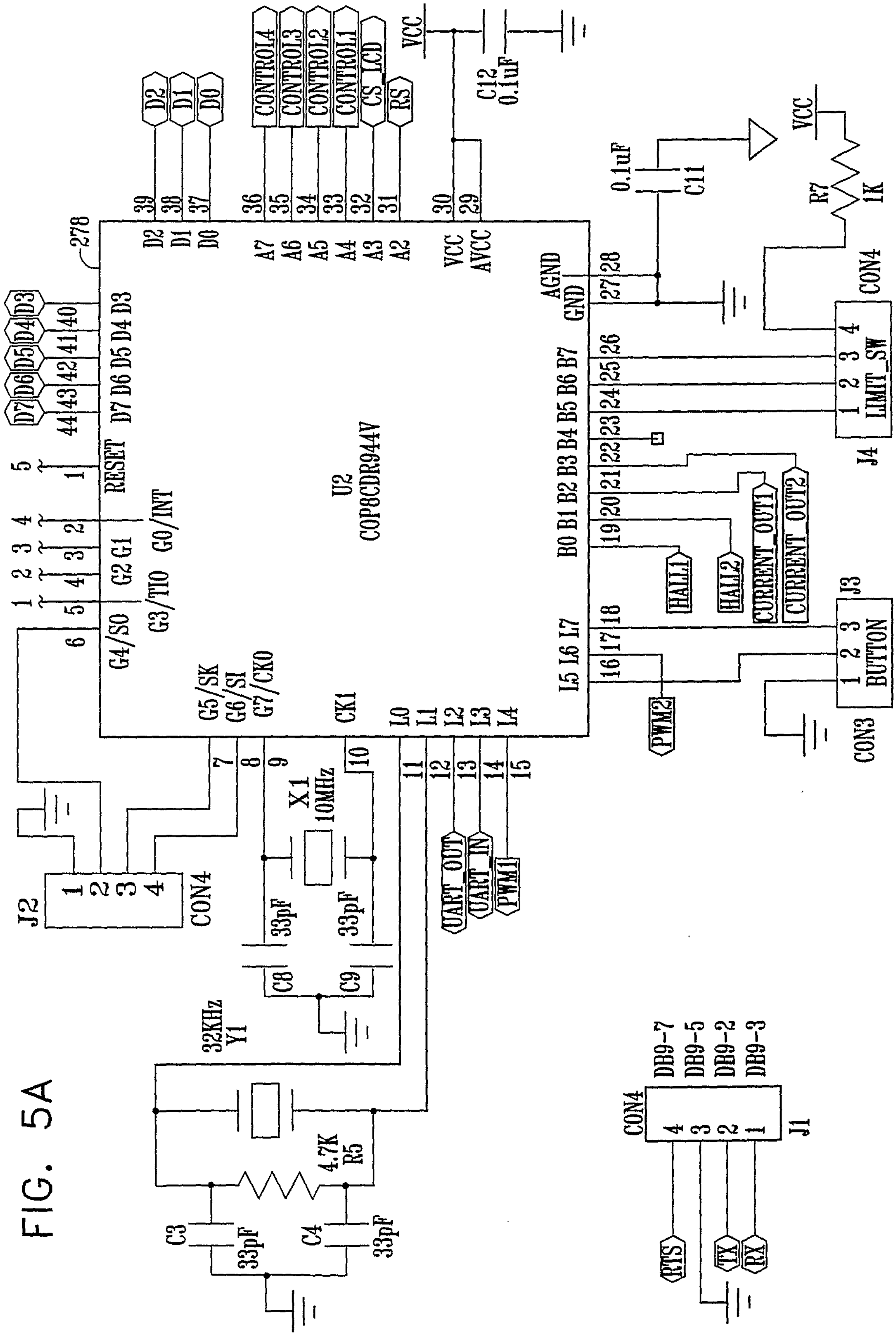

U2
COP8CDR944V
278
D2
D1
D0
D3
D4
D5
D6
D7
CONTROL4
CONTROL3
CONTROL2
CONTROL1
CS_LCD
RS
VCC
AVCC
C12
0.1uF
C11
0.1uF
R7
1K
AGND
GND
RESET
G0/INT
G1
G2
G3/TIO
G4/SO
G5/SK
G6/SI
G7/CKO
CK1
L0 L1 L2 L3 L4 L5 L6 L7
B0 B1 B2 B3 B4 B5 B6 B7
A7 A6 A5 A4 A3 A2
HALL1
HALL2
CURRENT_OUT1
CURRENT_OUT2
PWM1
PWM2
UART_OUT
UART_IN
J4
CON4
LIMIT_SW
J3
CON3
BUTTON
J2
CON4
X1
10MHz
C8
33pF
C9
33pF
32KHz
Y1
4.7K
R5
C3
33pF
C4
33pF
J1
CON4
DB9-7
DB9-5
DB9-2
DB9-3
RTS
TX
RX

FIG. 5A

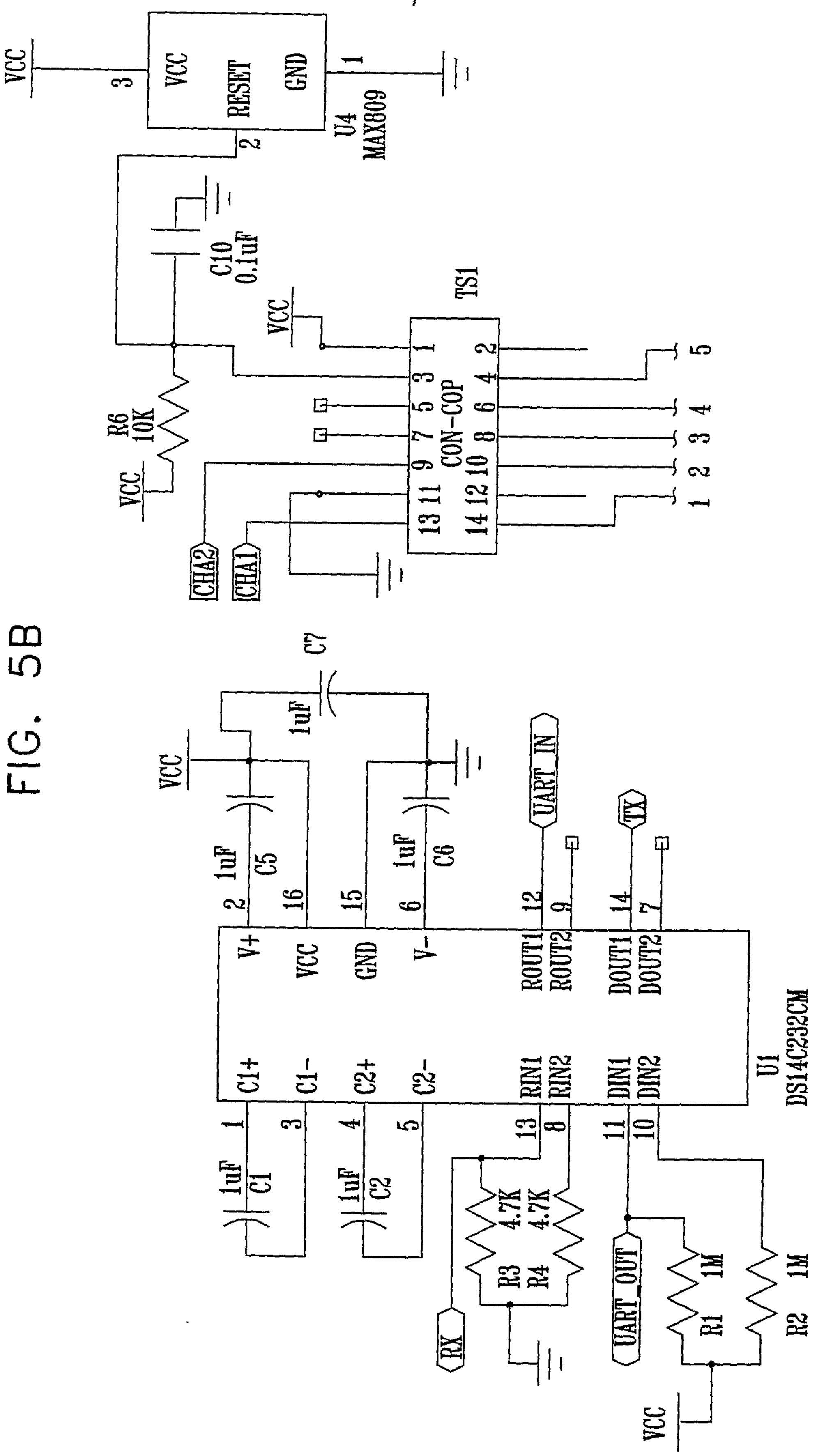
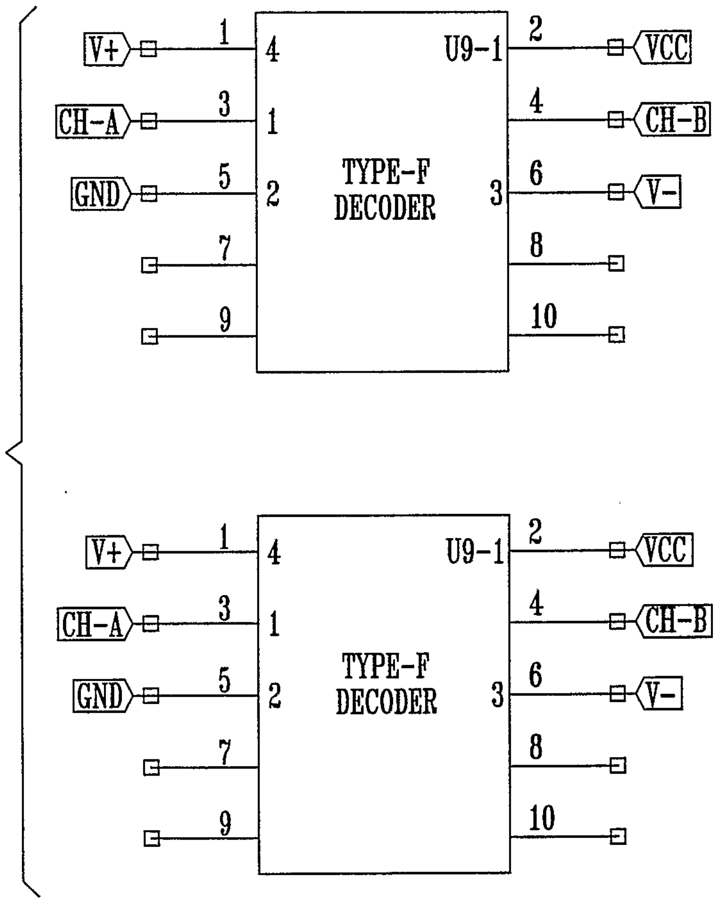

VCC
RESET
GND
U4
MAX809
C10
0.1uF
TS1
CON-COP
R6
10K
CHA2
CHA1
C7
1uF
C5
C6
UART_IN
TX
V+
VCC
GND
V-
ROUT1
ROUT2
DOUT1
DOUT2
C1+
C1-
C2+
C2-
RIN1
RIN2
DIN1
DIN2
U1
DS14C232CM
C1
C2
R3
R4
4.7K
UART_OUT
R1
R2
1M
RX

FIG. 5B

FIG. 5C


V+
CH-A
GND
1
3
5
7
9
4
1
2
U9-1
TYPE-F
DECODER
3
2
4
6
8
10
VCC
CH-B
V-
V+
CH-A
GND
1
3
5
7
9
4
1
2
U9-1
TYPE-F
DECODER
3
2
4
6
8
10
VCC
CH-B
V-

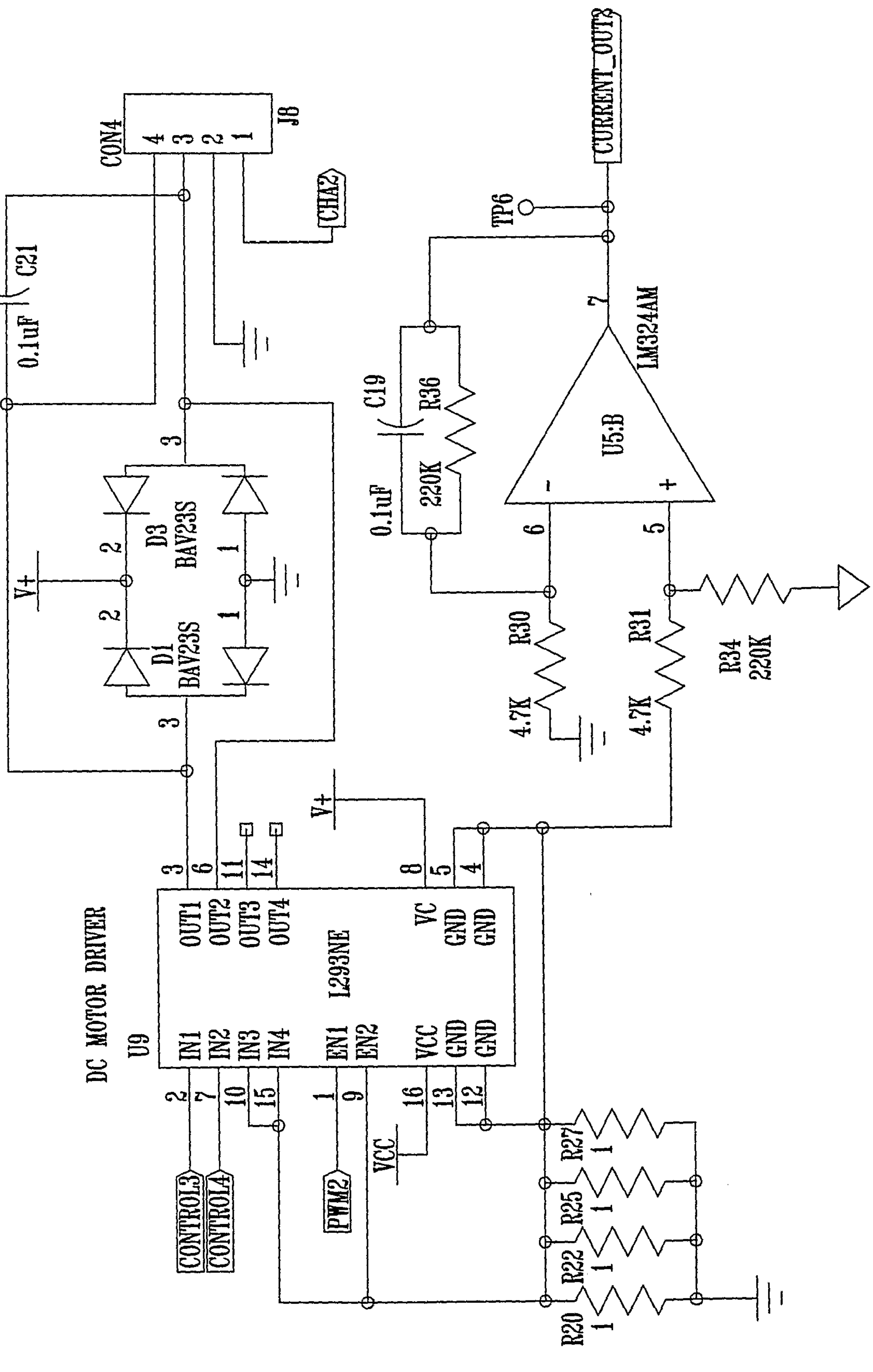
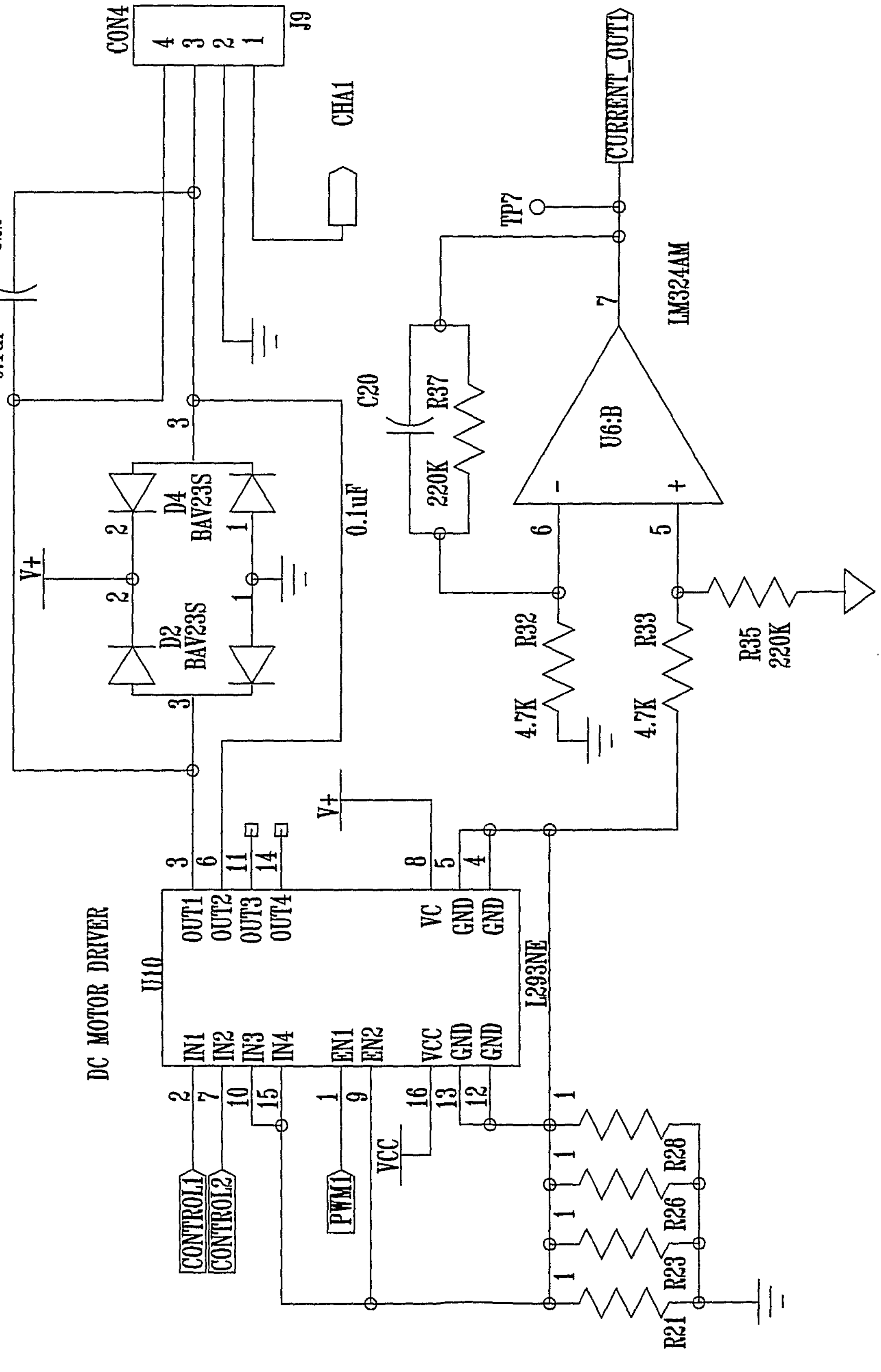

CON4
J8
4
3
2
1
CHA2
C21
0.1uF
CURRENT_OUT3
TP6
7
LM324AM
C19
R36
0.1uF
220K
U5:B
-
+
6
5
D3
BAV23S
D1
BAV23S
V+
R30
4.7K
R31
4.7K
R34
220K
DC MOTOR DRIVER
U9
L293NE
OUT1
OUT2
OUT3
OUT4
VC
GND
IN1
IN2
IN3
IN4
EN1
EN2
VCC
CONTROL3
CONTROL4
PWM2
R27
R25
R22
R20
1

FIG. 5D

FIG. 5E


CON4
J9
CHA1
C22
0.1uF
TP7
CURRENT_OUT1
LM324AM
C20
R37
220K
U6:B
D4
BAV23S
D2
BAV23S
V+
R32
4.7K
R33
4.7K
R35
220K
DC MOTOR DRIVER
U10
L293NE
OUT1
OUT2
OUT3
OUT4
VC
GND
IN1
IN2
IN3
IN4
EN1
EN2
VCC
CONTROL1
CONTROL2
PWM1
R21
R23
R26
R28

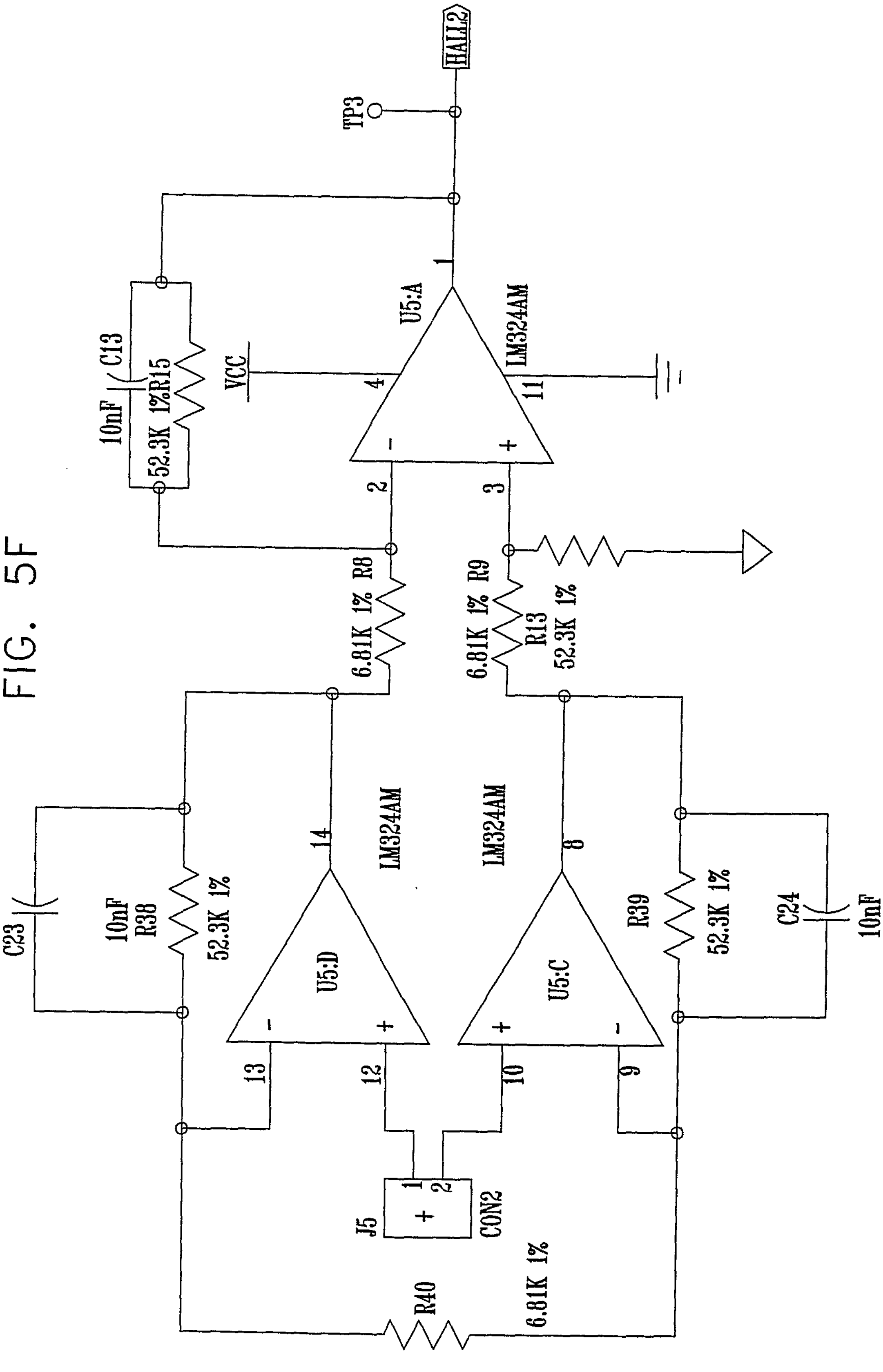

HALL2
TP3
U5:A
LM324AM
VCC
C13
10nF
R15
52.3K 1%
R8
6.81K 1%
R9
6.81K 1%
R13
52.3K 1%
U5:D
U5:C
LM324AM
LM324AM
C23
10nF
R38
52.3K 1%
R39
52.3K 1%
C24
10nF
J5
CON2
R40
6.81K 1%

FIG. 5F

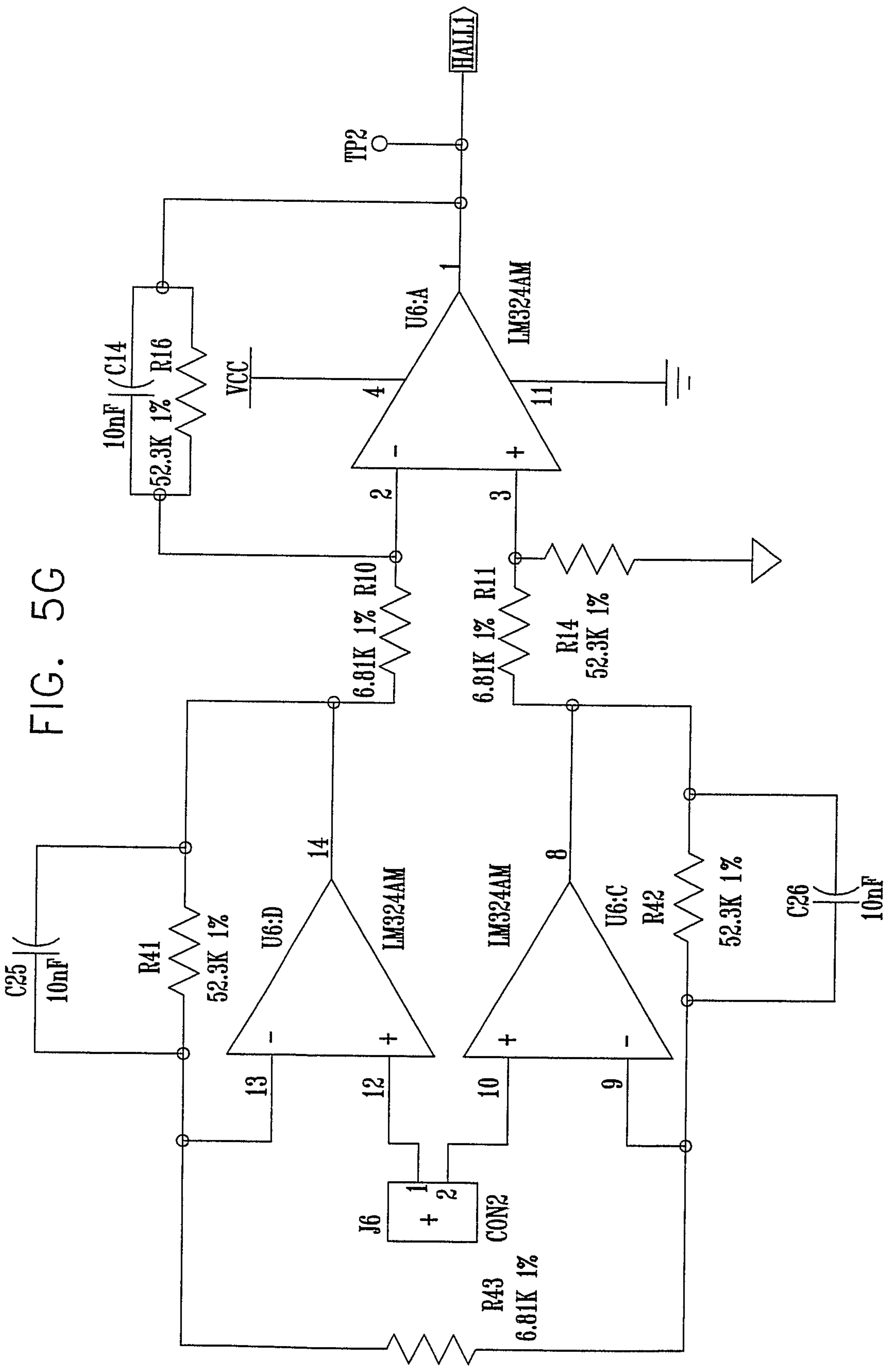

HALL1
TP2
U6:A
LM324AM
VCC
C14
10nF
R16
52.3K 1%
R10
6.81K 1%
R11
6.81K 1%
R14
52.3K 1%
U6:D
LM324AM
U6:C
LM324AM
R41
52.3K 1%
C25
10nF
R42
52.3K 1%
C26
10nF
J6
CON2
R43
6.81K 1%

FIG. 5G

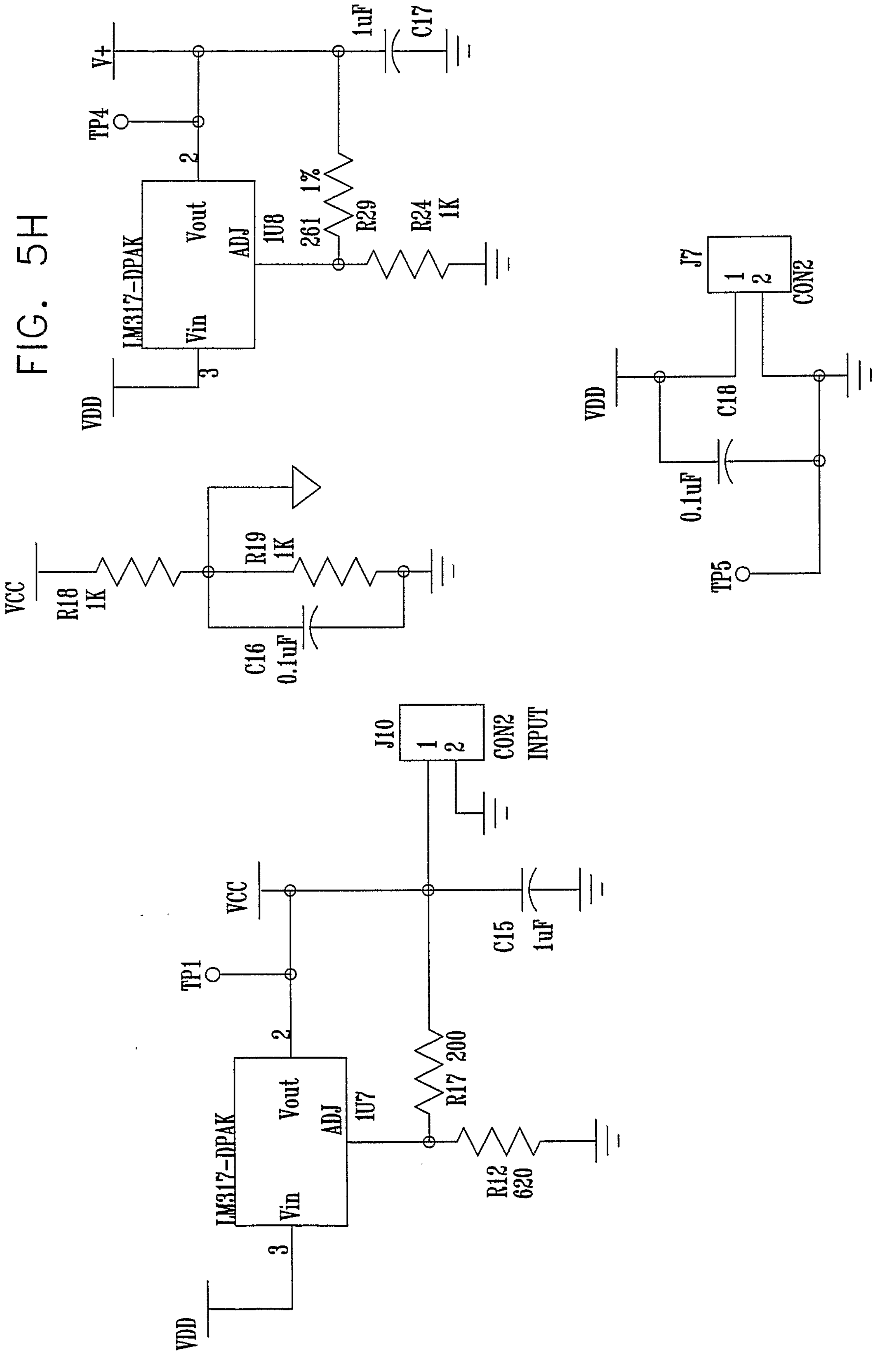

V+
1uF
C17
TP4
2
1%
LM317-DPAK
Vout
ADJ
1U8
261
R29
R24
1K
Vin
3
VDD
VCC
R18
1K
R19
1K
C16
0.1uF
J7
1
2
CON2
C18
0.1uF
TP5
J10
CON2
INPUT
C15
1uF
TP1
R17
200
1U7
R12
620

FIG. 5H

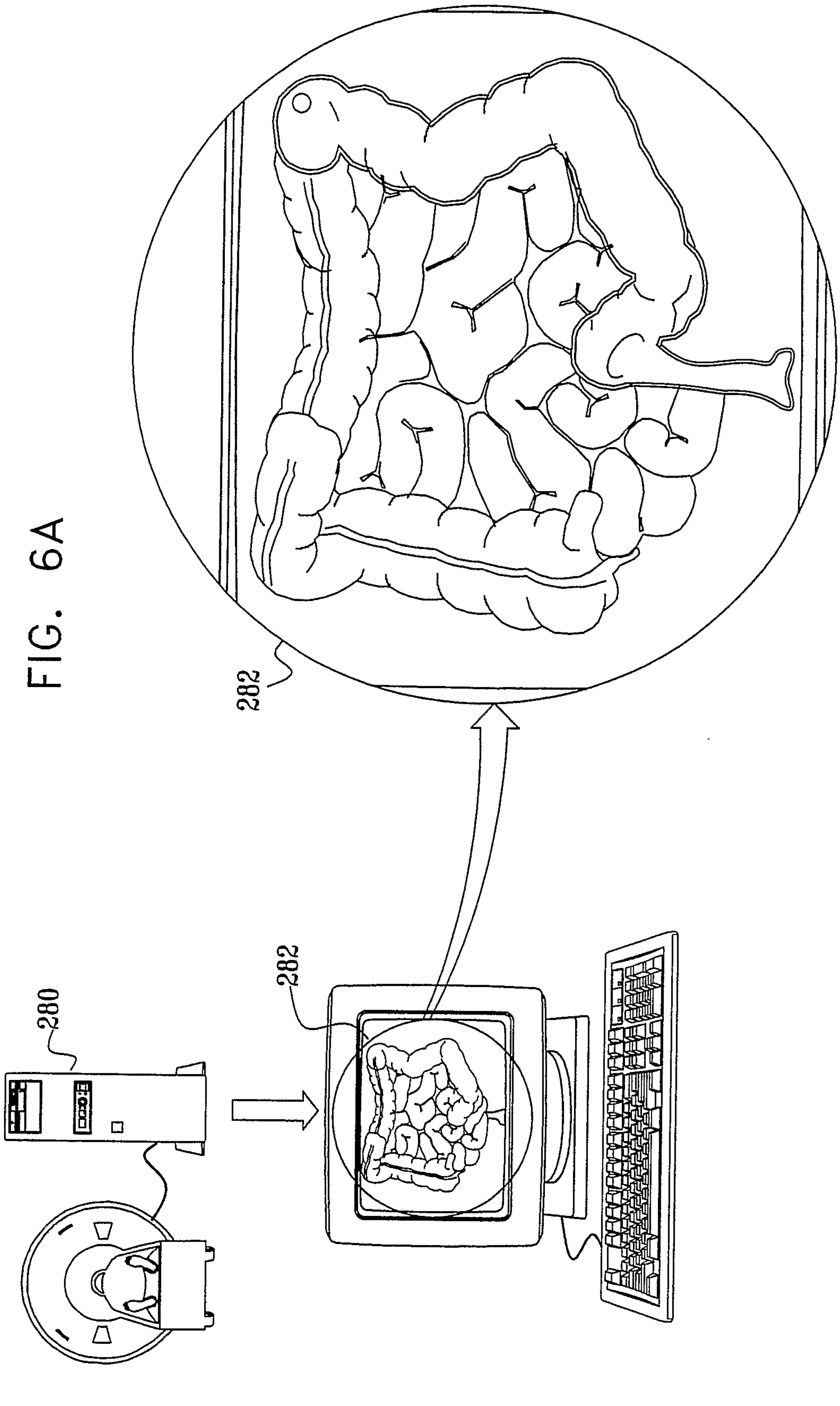


FIG. 6A

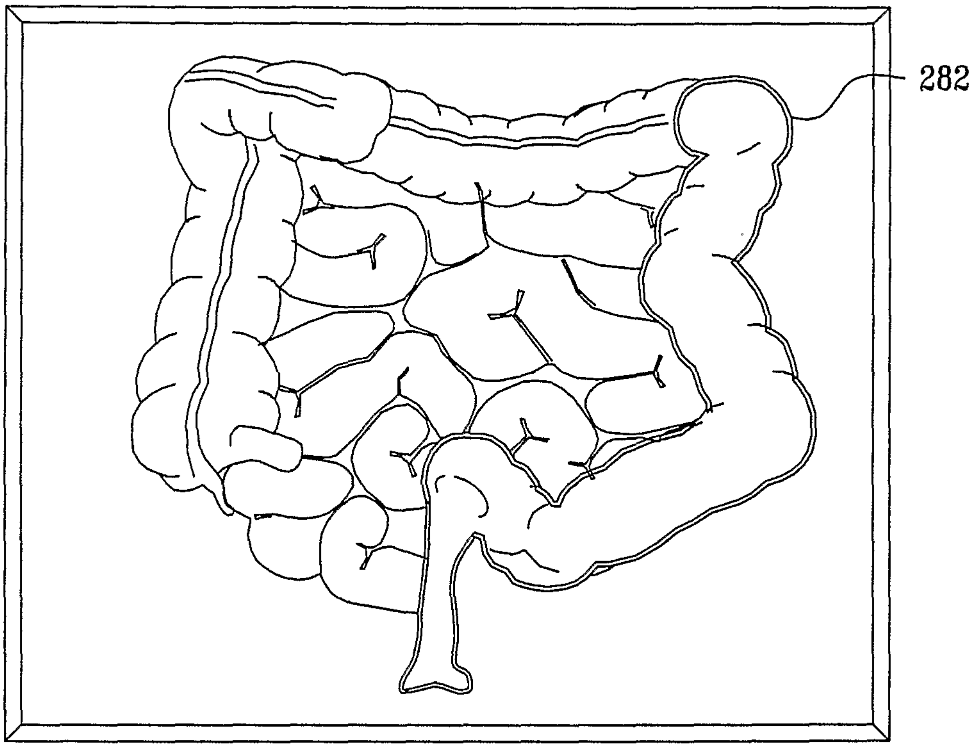
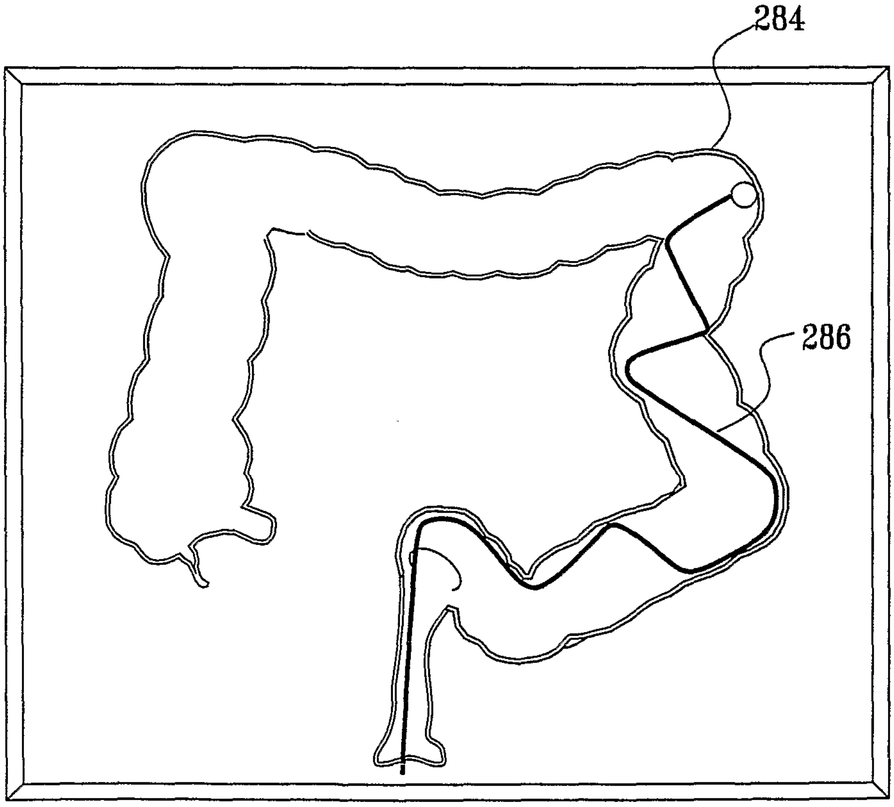


FIG. 6B



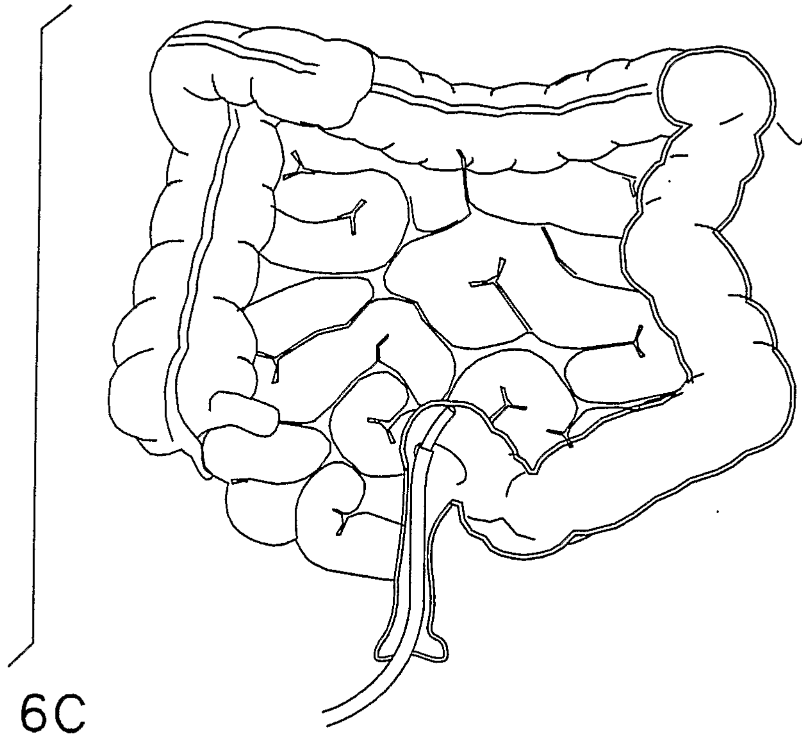
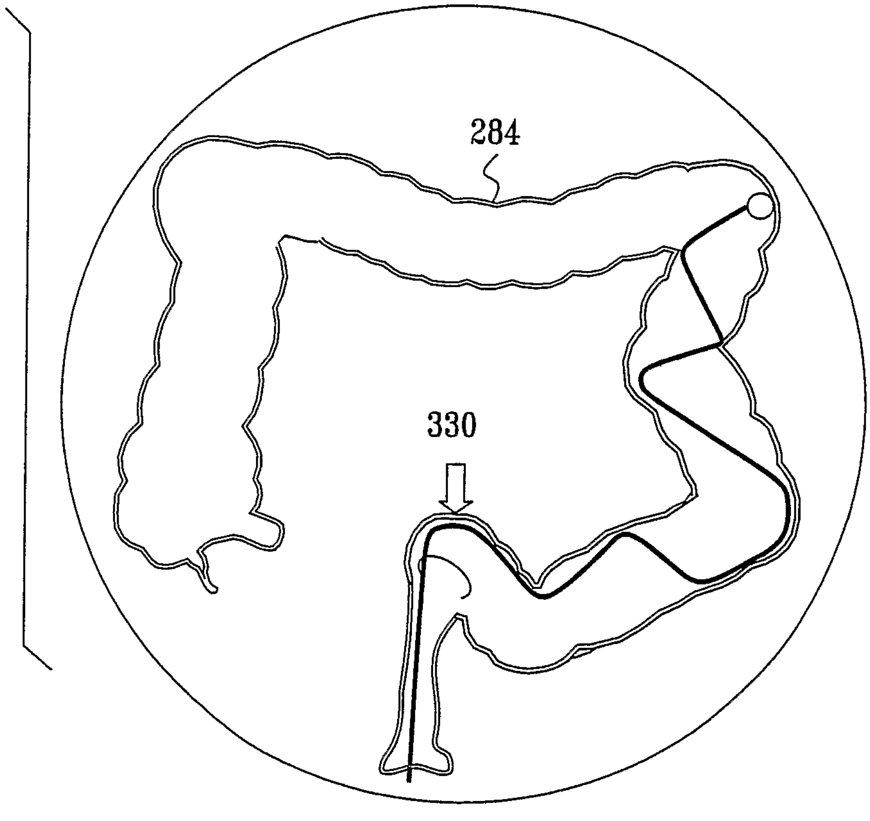


FIG. 6C



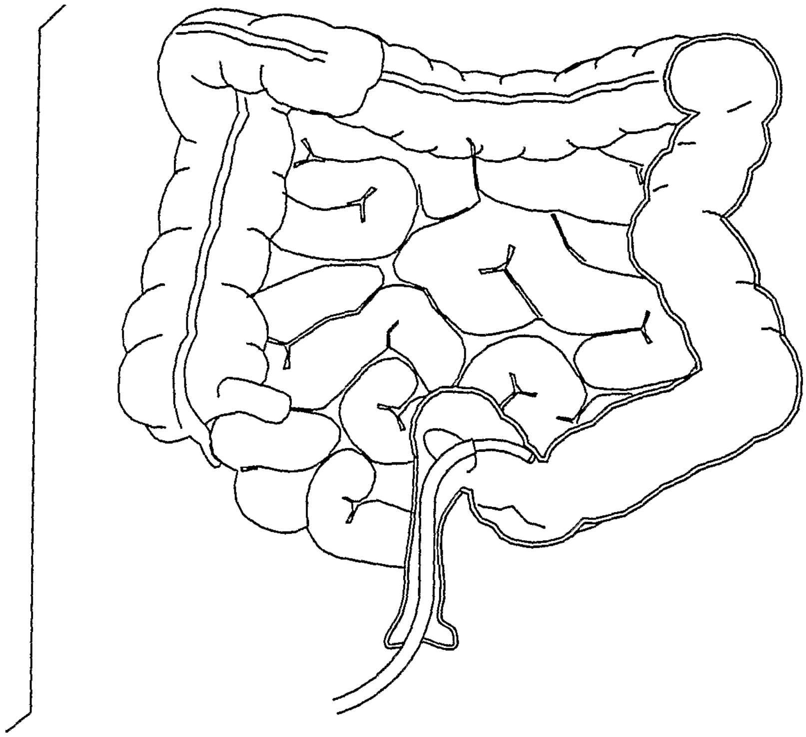
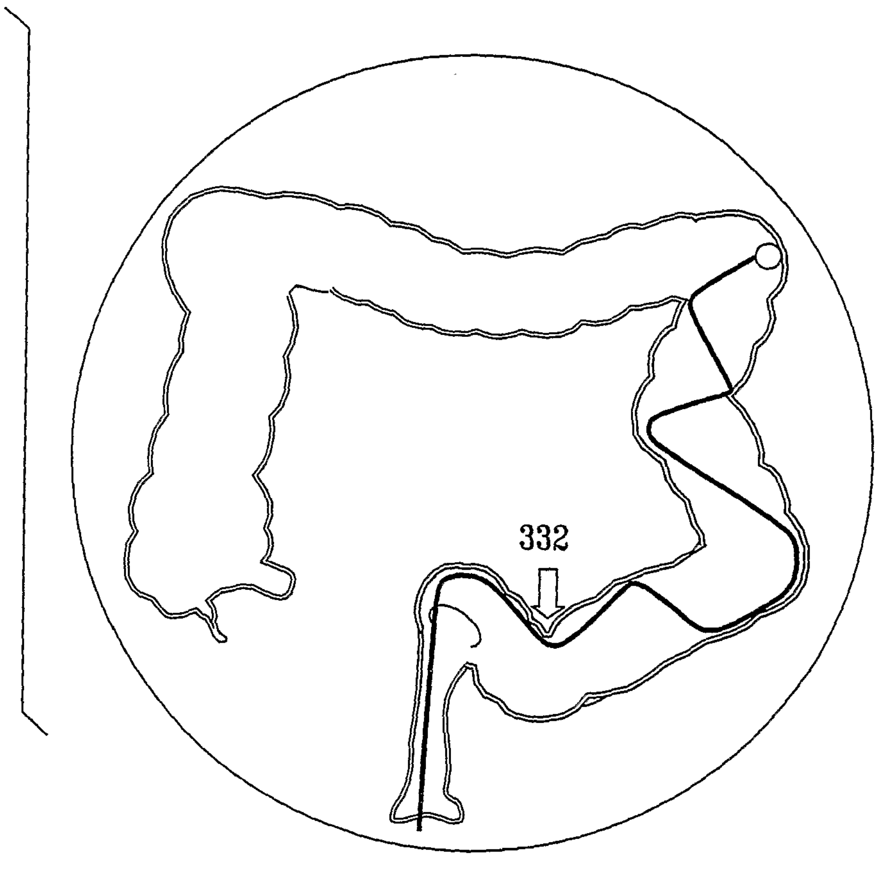


FIG. 6D



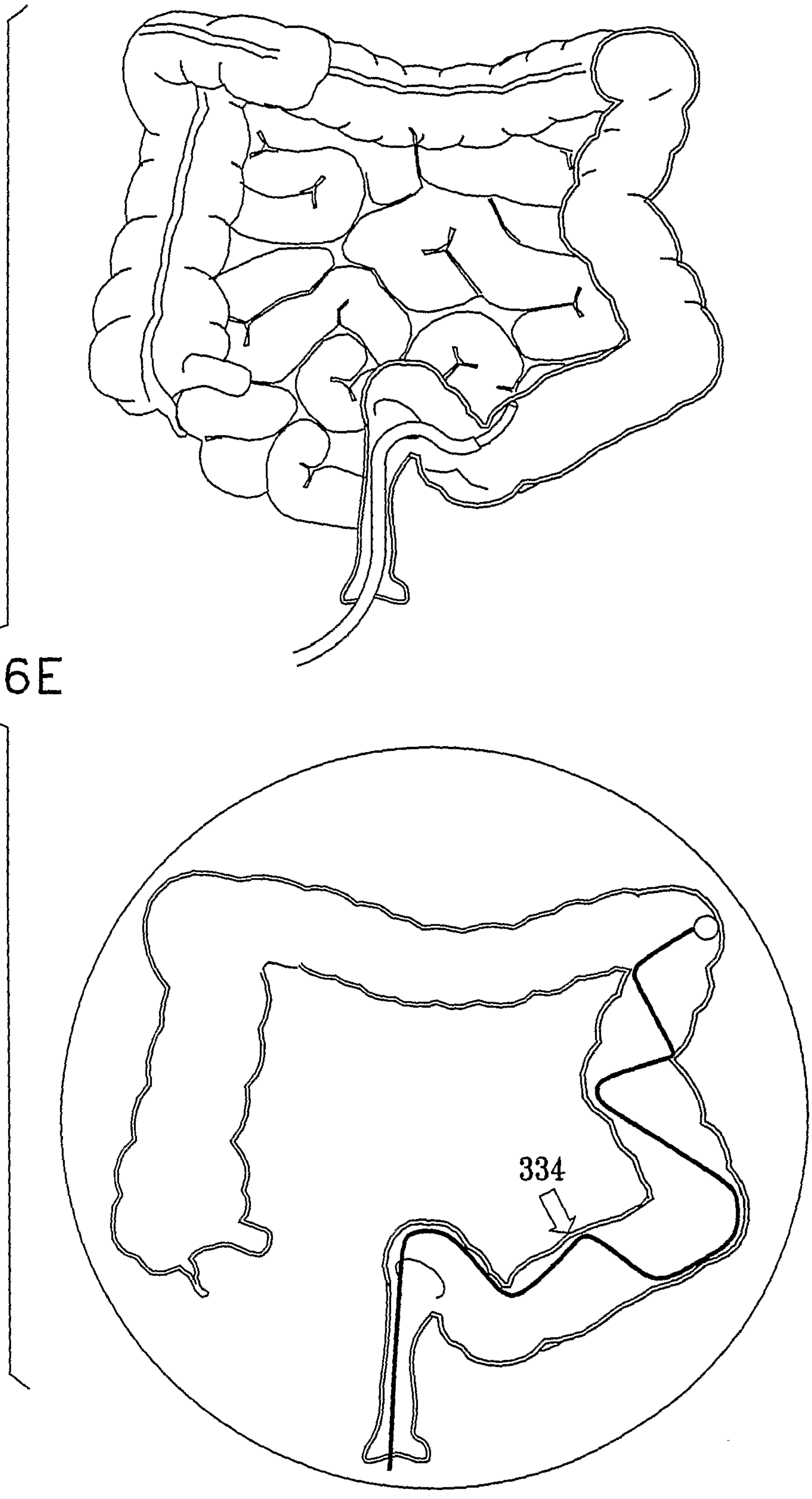


FIG. 6E

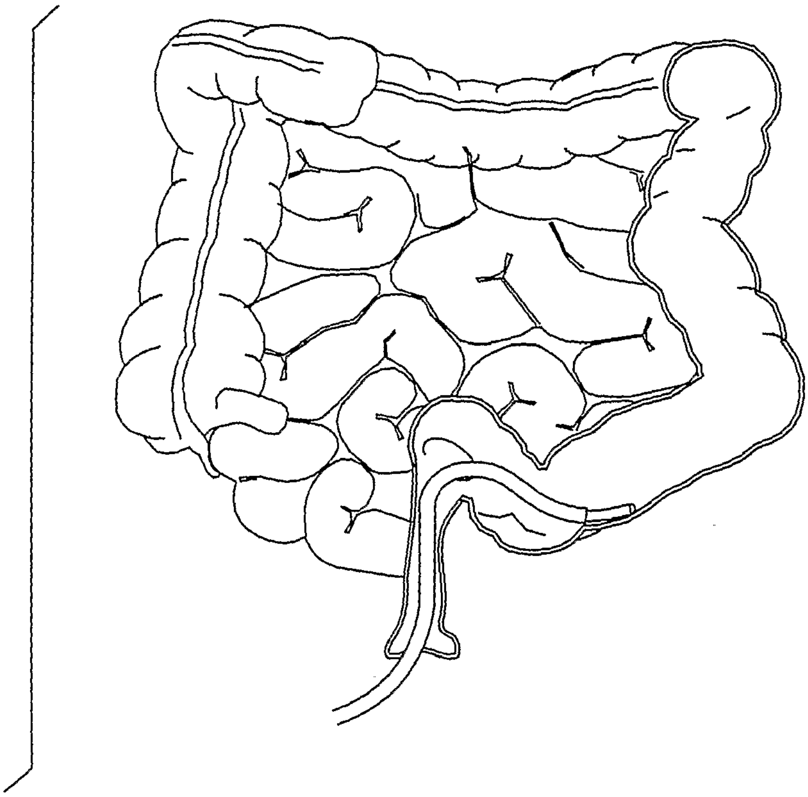
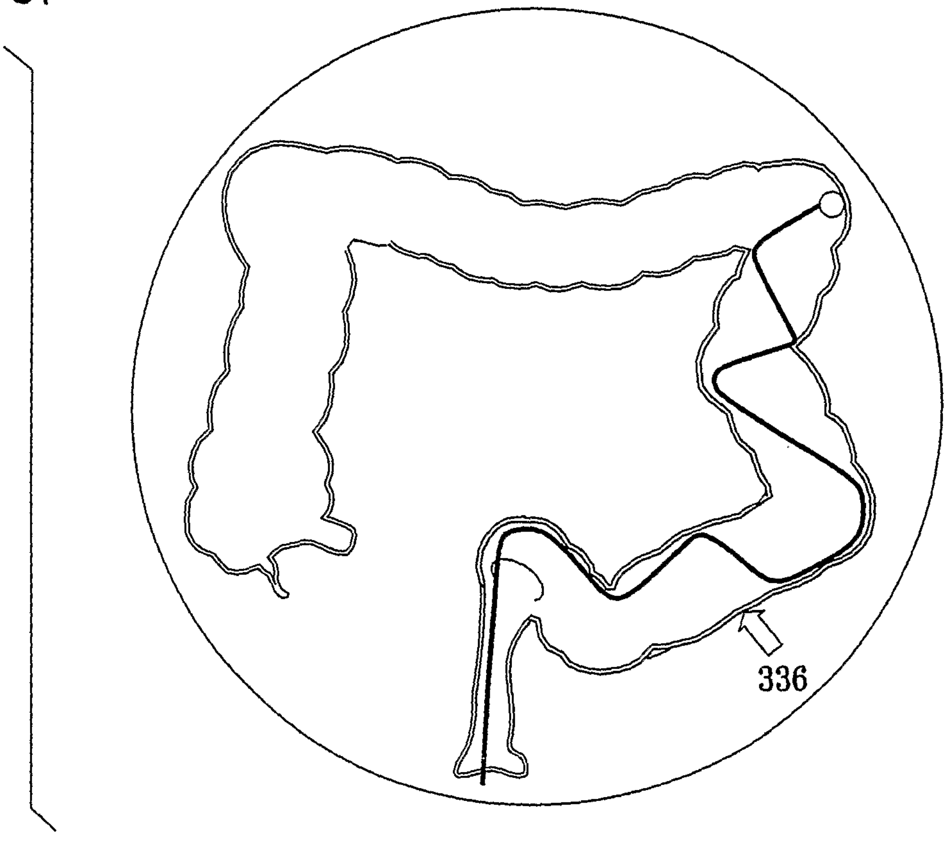


FIG. 6F



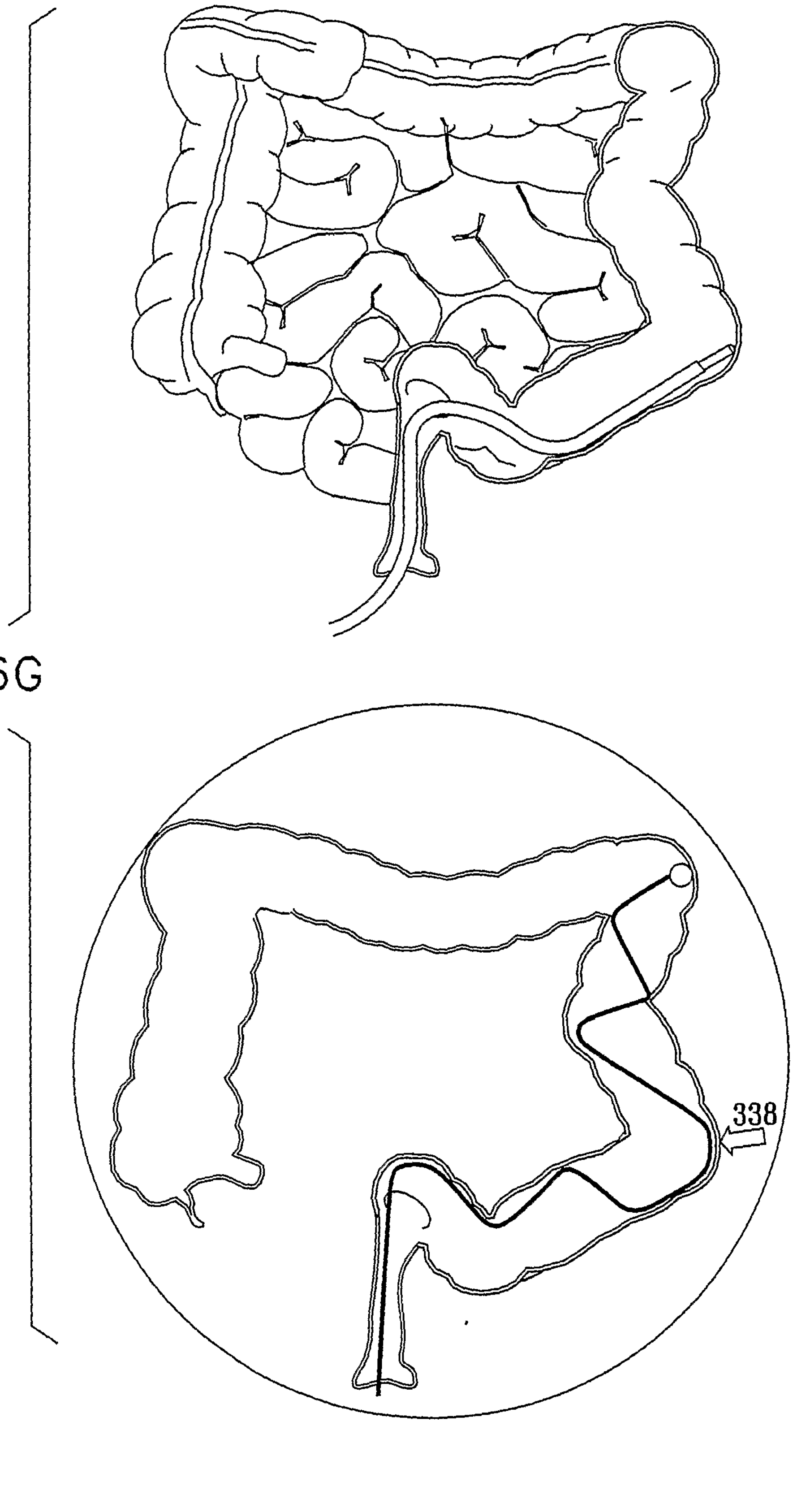


FIG. 6G

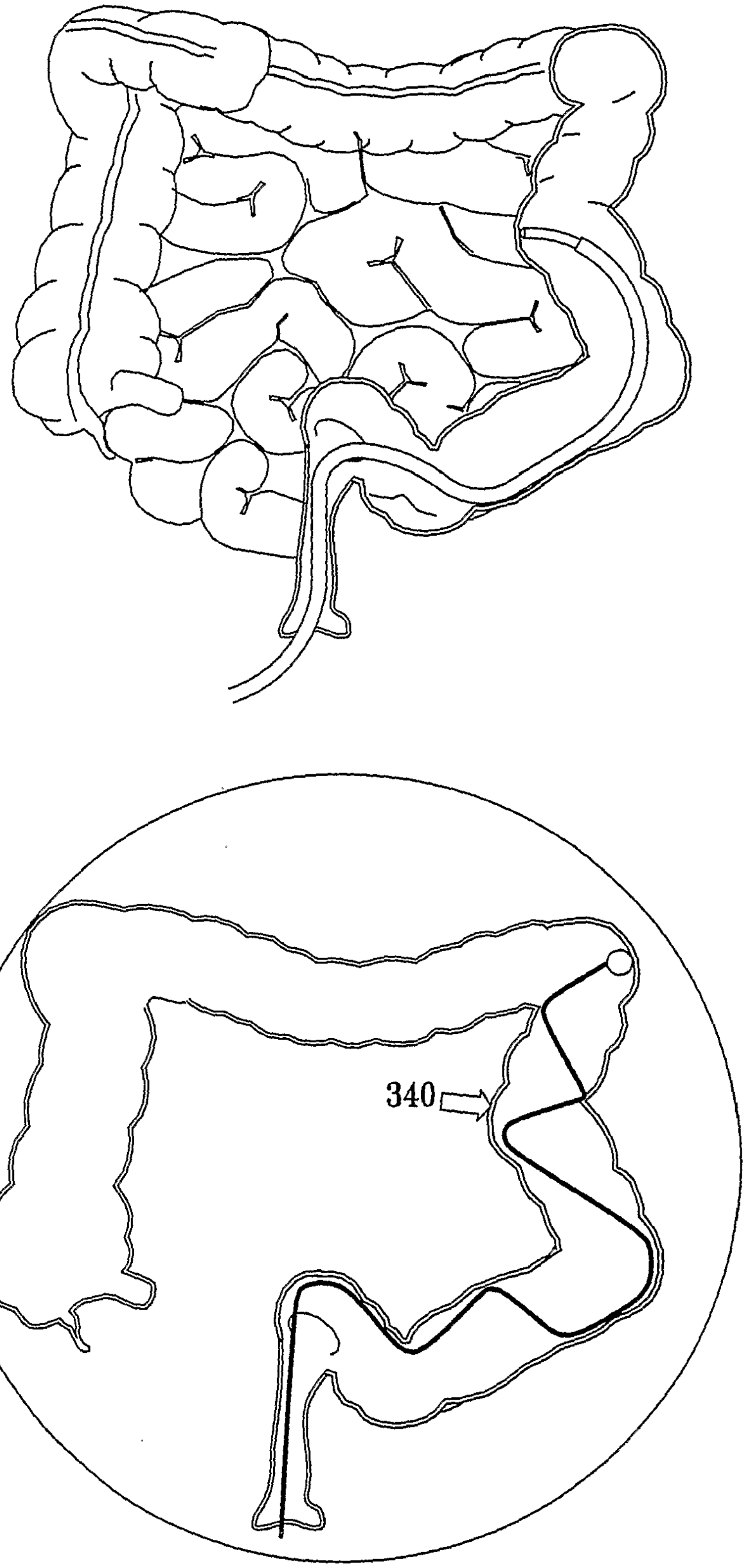


FIG. 6H

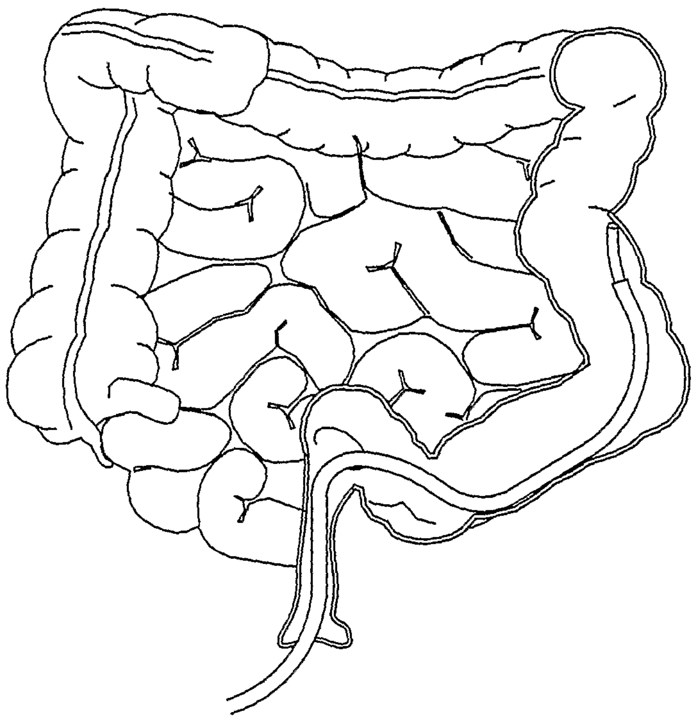
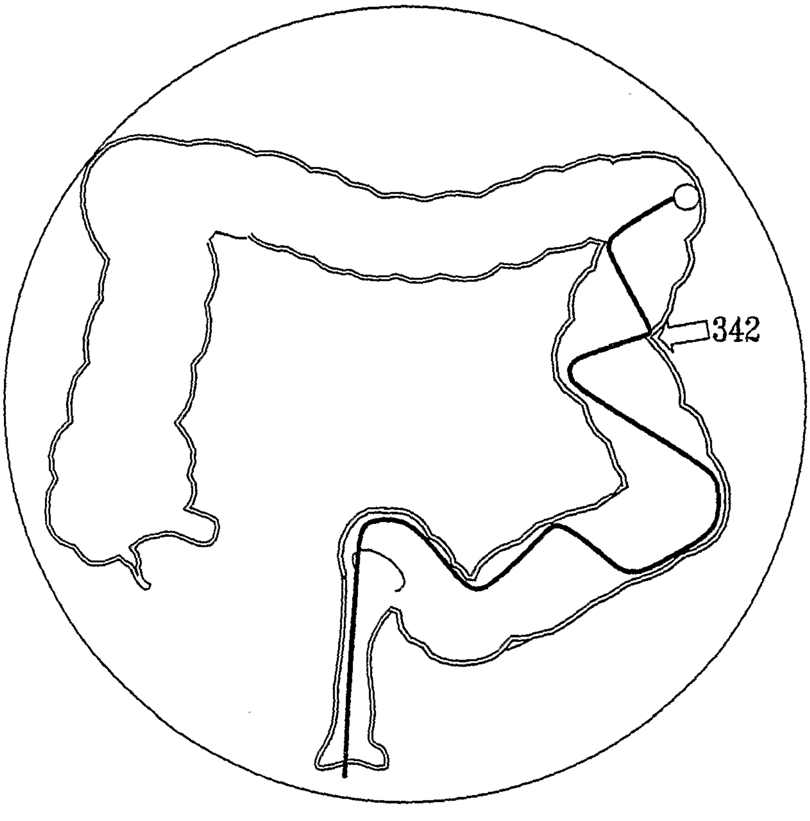


FIG. 61



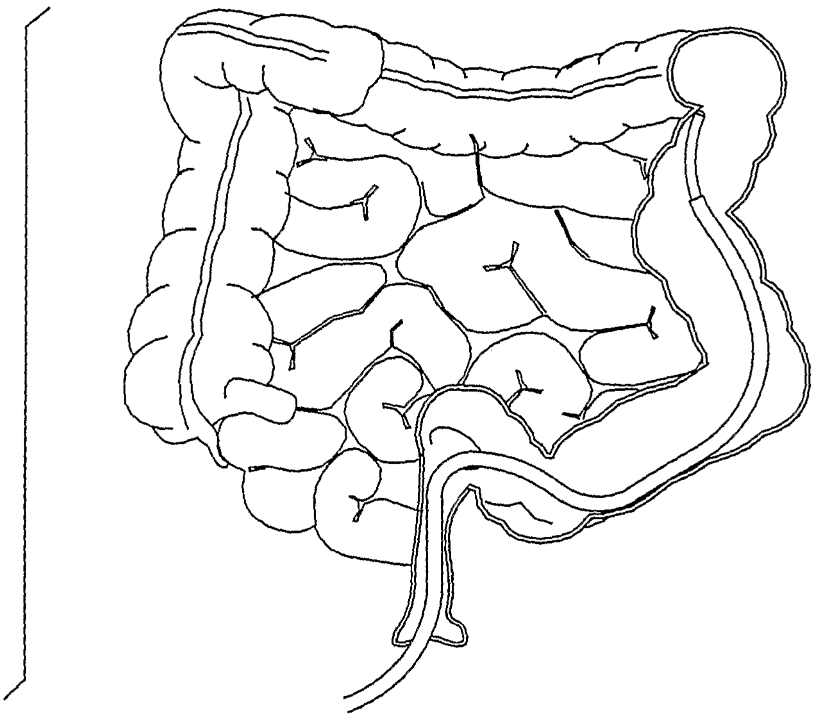
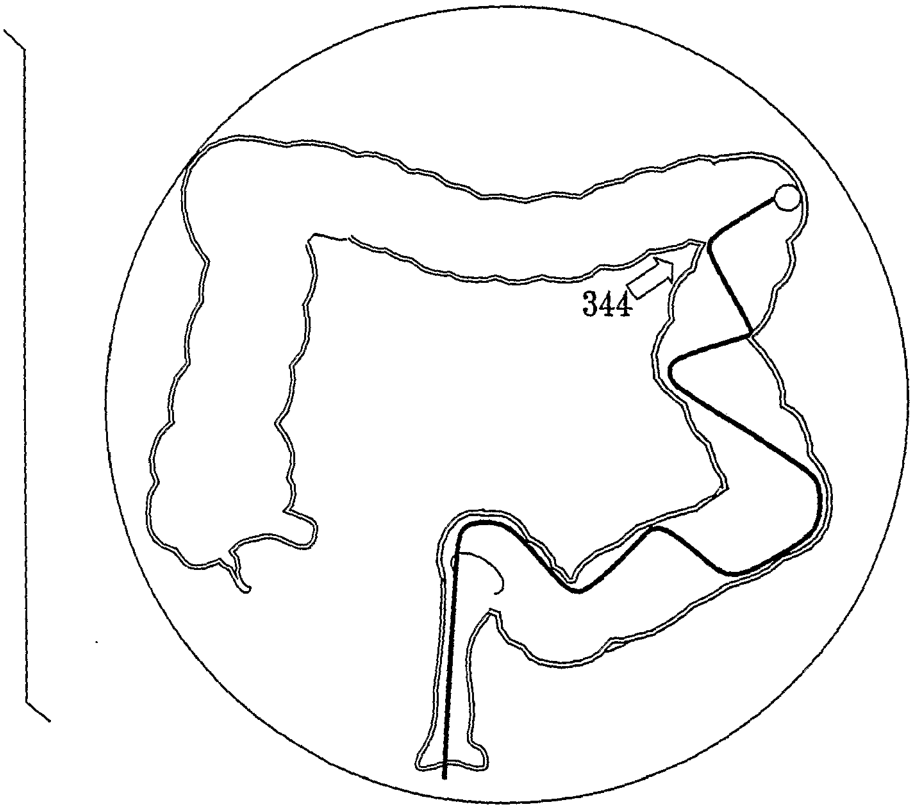


FIG. 6J



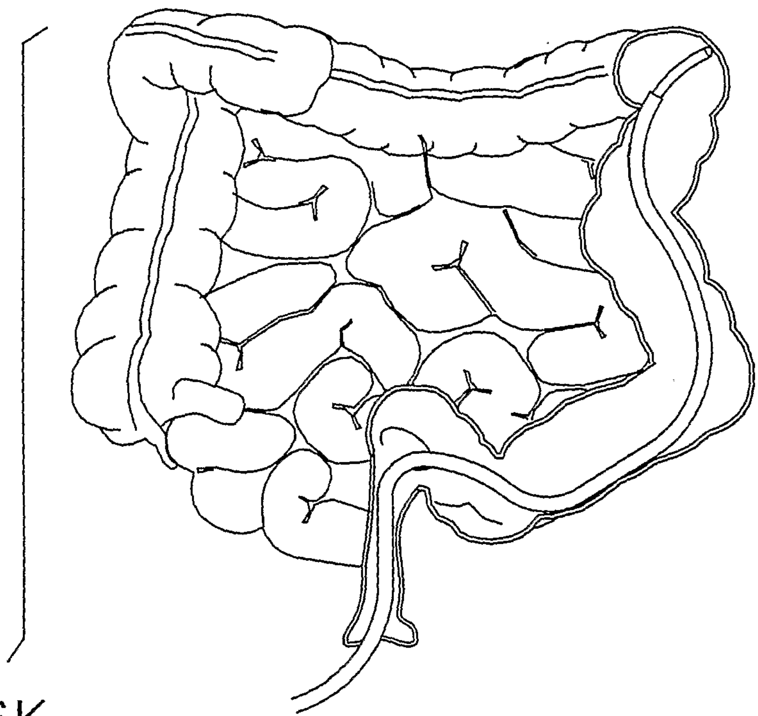


FIG. 6K

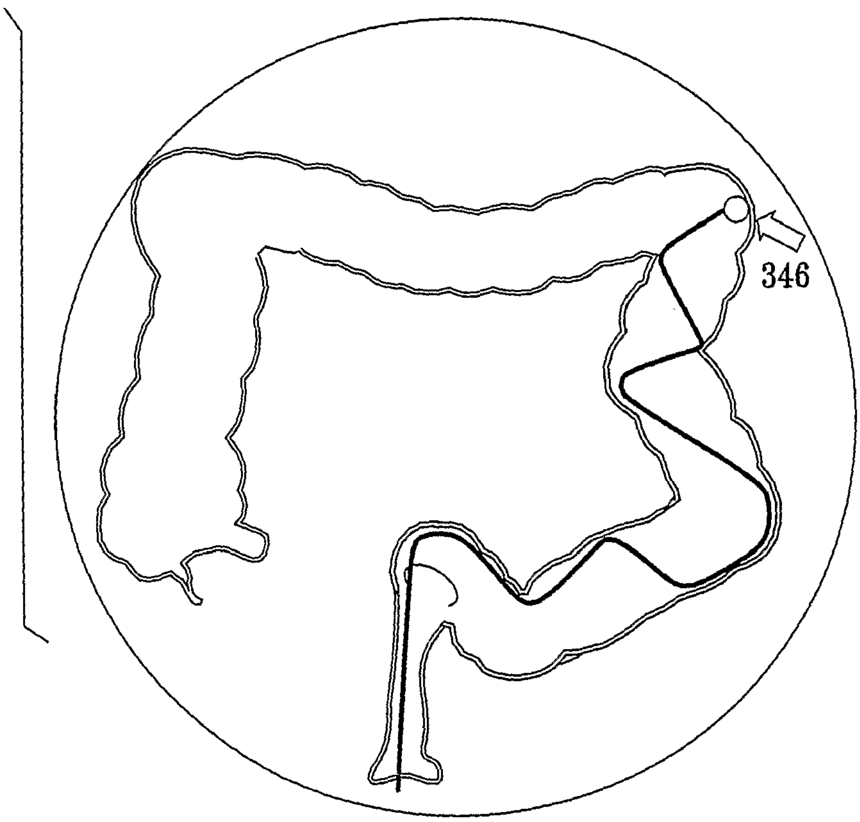


FIG. 7

290

ROW NO. (294)	INITIAL BEND		INITIAL INSERTION (295)	INITIAL SENSOR MEASUREMENTS (296)				INSERT DISTANCE (297)	FINAL SENSOR MEASUREMENTS (298)			
	FRONT	RIGHT		FRONT	BACK	RIGHT	LEFT		FRONT	BACK	RIGHT	LEFT
1	0	-45	0.5	0	0	0	3	5	9	9	9	9
2	0	45	0.1	0	0	0	4	2.5	0	0	0	0
3	0	-110	0.1	0	0	0	2	1	0	0	0	3
4	0	45	1.0	0	0	4	0	6	0	0	7	0
5	0	20	0.5	0	0	4	0	4	3	3	7	7
6	0	-60	1.0	0	0	0	0	3	9	9	9	9
7	0	45	2.5	0	0	0	0	1	0	0	2	0
8	0	0	2.5	0	0	0	0	1	0	0	0	3
9	0	45	2.5	0	0	0	0	1	9	9	9	9

292

FIG. 8

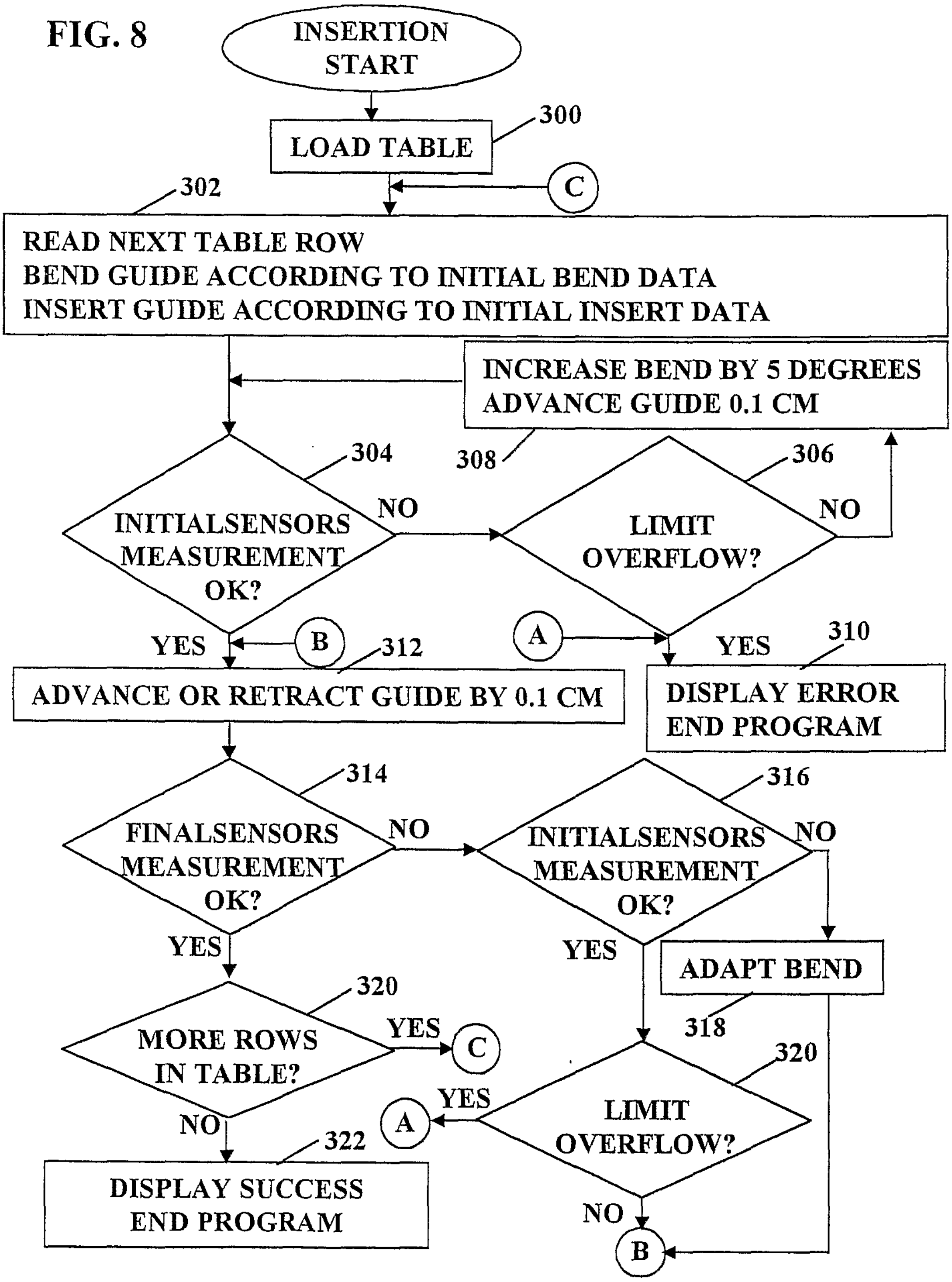

INSERTION START
LOAD TABLE
300
C
302
READ NEXT TABLE ROW
BEND GUIDE ACCORDING TO INITIAL BEND DATA
INSERT GUIDE ACCORDING TO INITIAL INSERT DATA
INCREASE BEND BY 5 DEGREES
ADVANCE GUIDE 0.1 CM
304
308
306
INITIALSENSORS MEASUREMENT OK?
NO
LIMIT OVERFLOW?
NO
YES
B
312
A
YES
310
ADVANCE OR RETRACT GUIDE BY 0.1 CM
DISPLAY ERROR END PROGRAM
314
316
FINALSENSORS MEASUREMENT OK?
NO
INITIALSENSORS MEASUREMENT OK?
NO
YES
YES
ADAPT BEND
320
318
MORE ROWS IN TABLE?
YES
C
320
YES
A
LIMIT OVERFLOW?
NO
322
DISPLAY SUCCESS END PROGRAM
NO
B

FIG. 9A

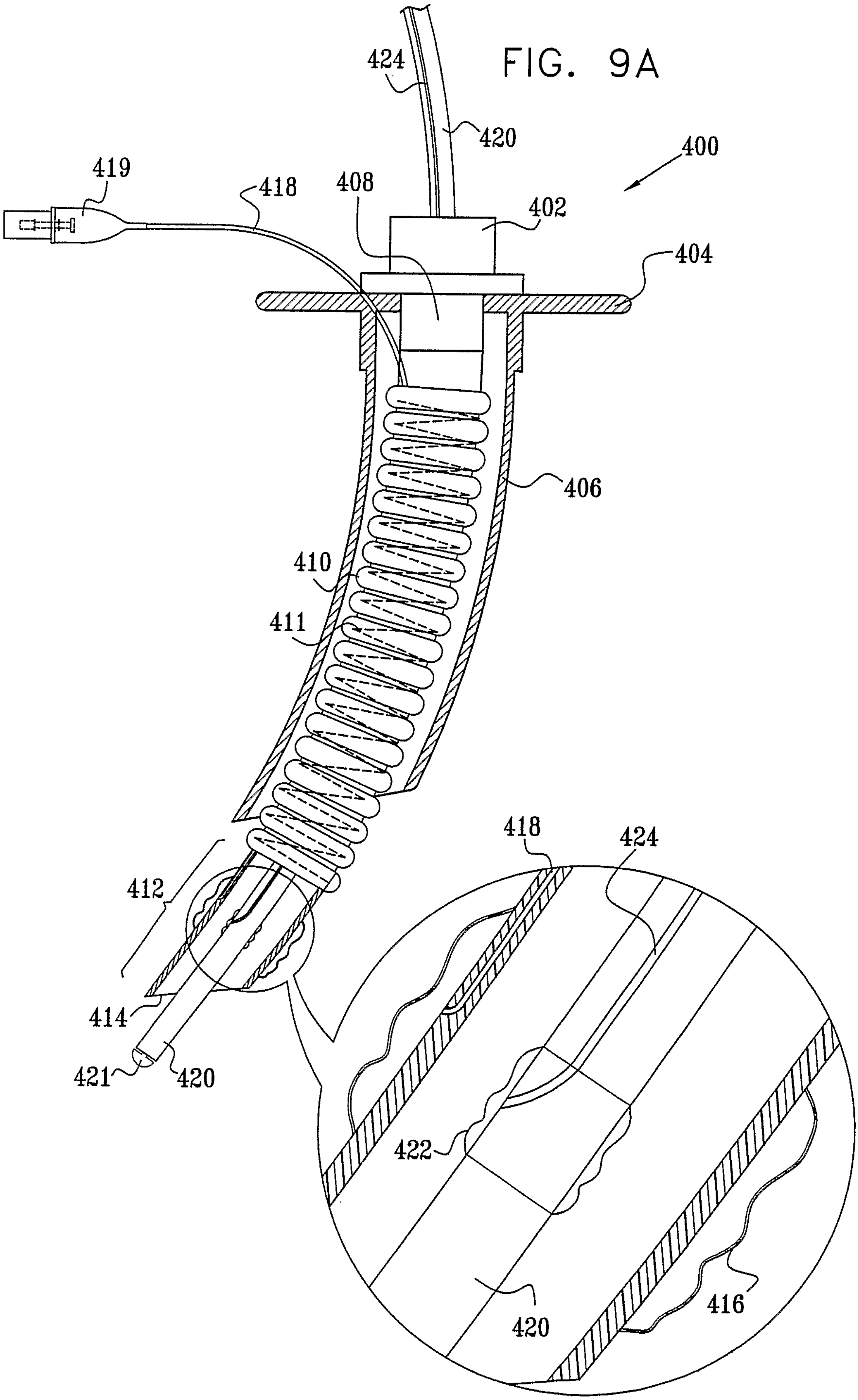

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FIG. 9B

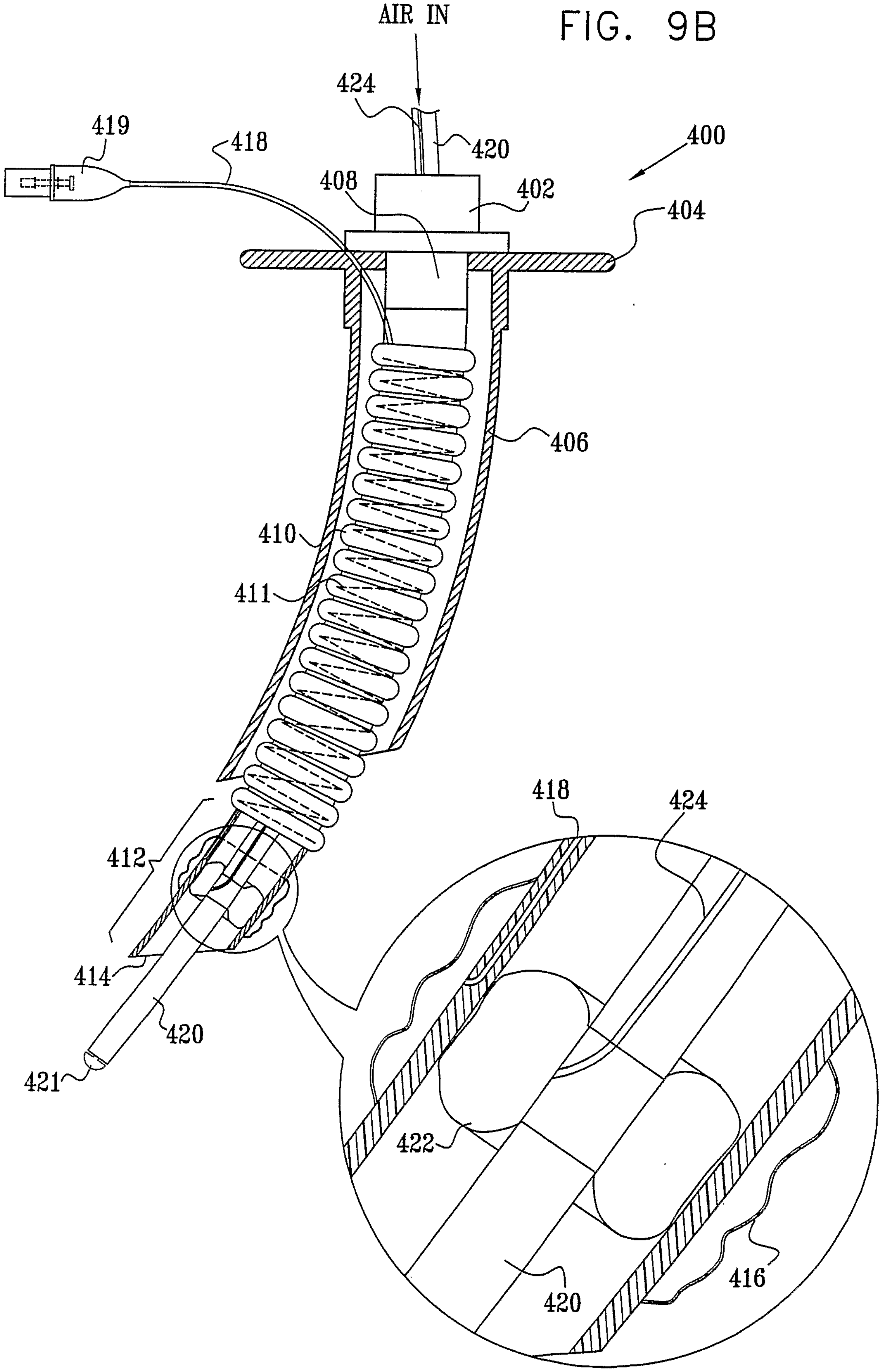
AIR IN
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FIG. 9C

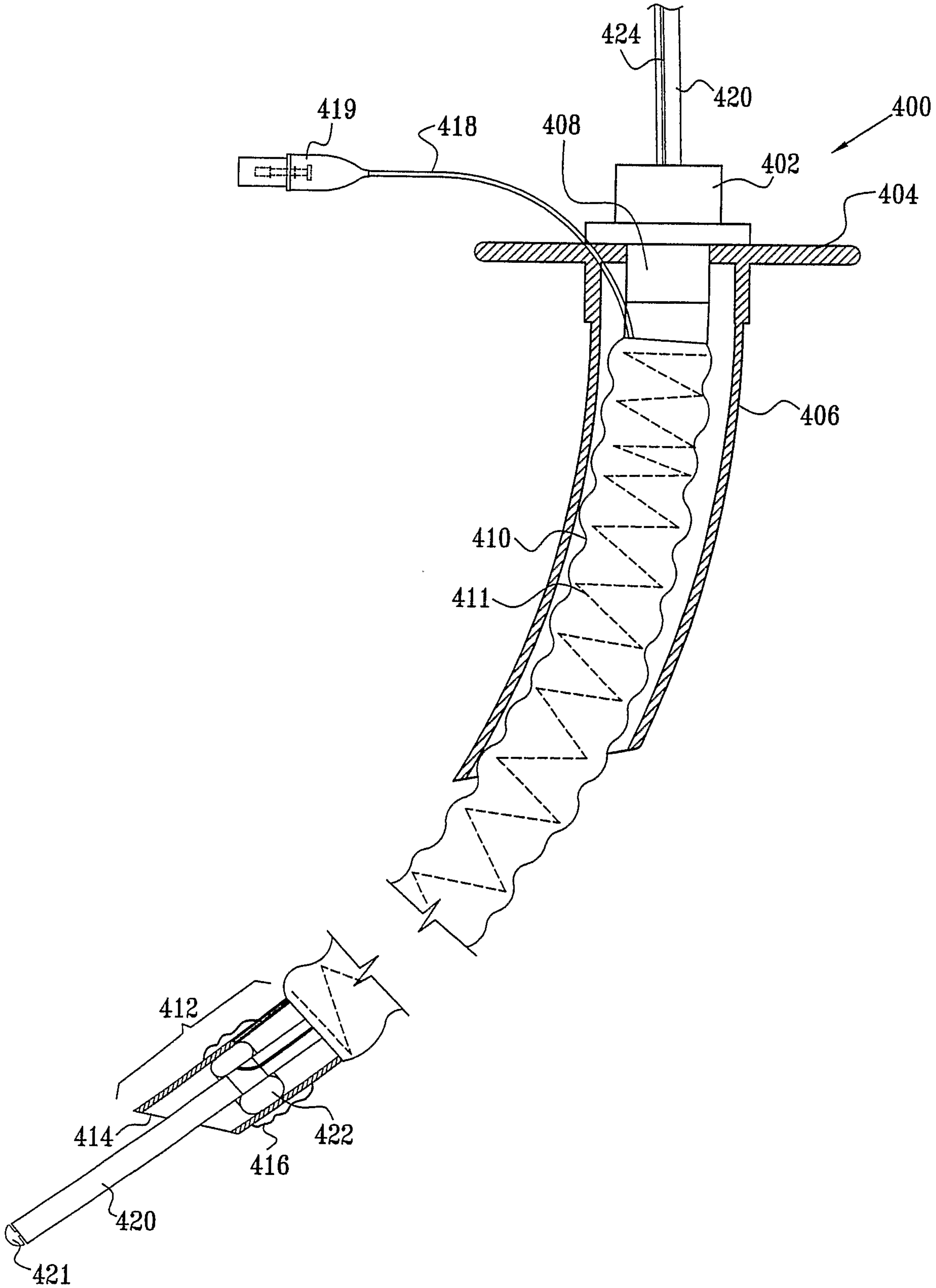
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FIG. 9D

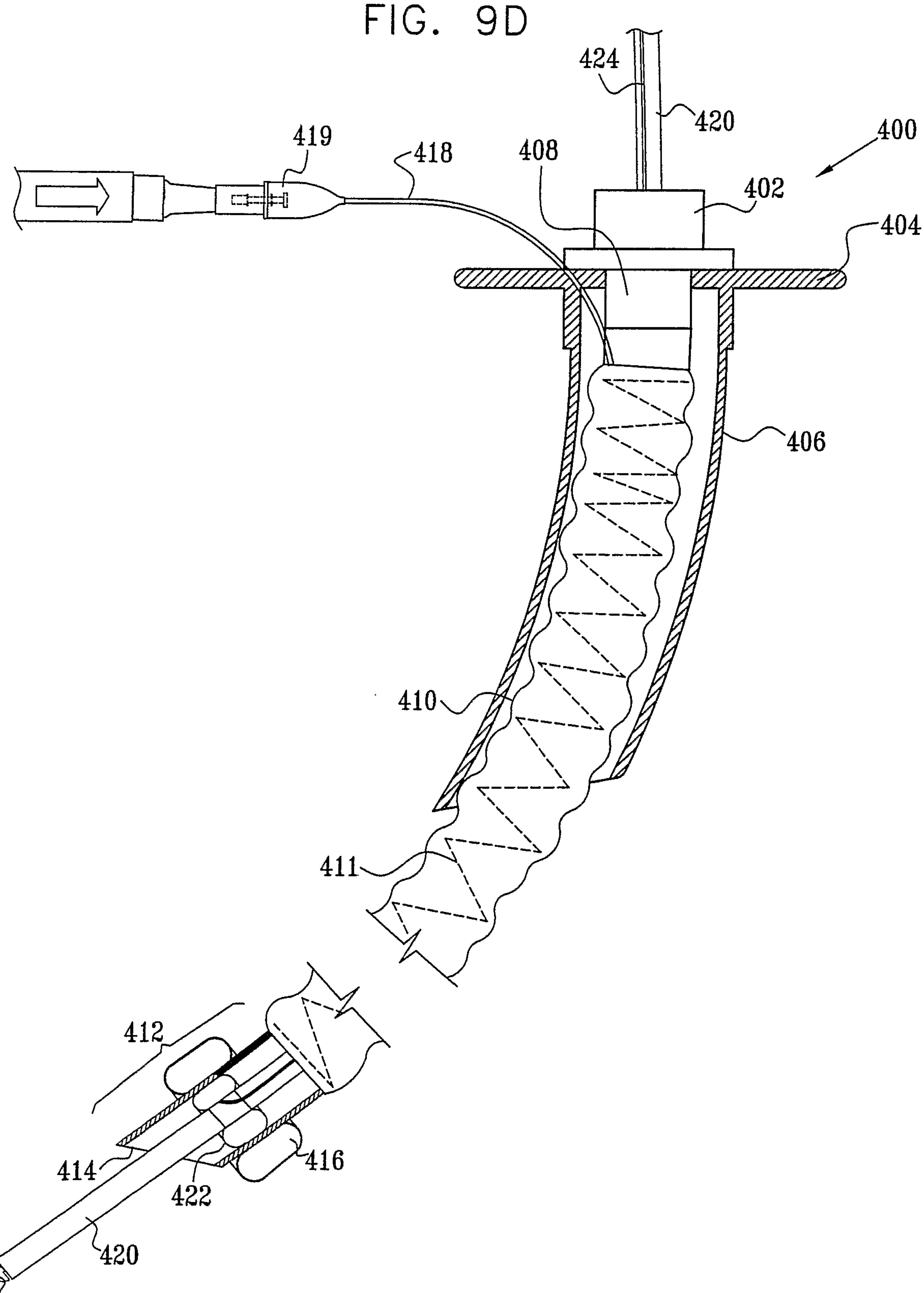
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FIG. 9E

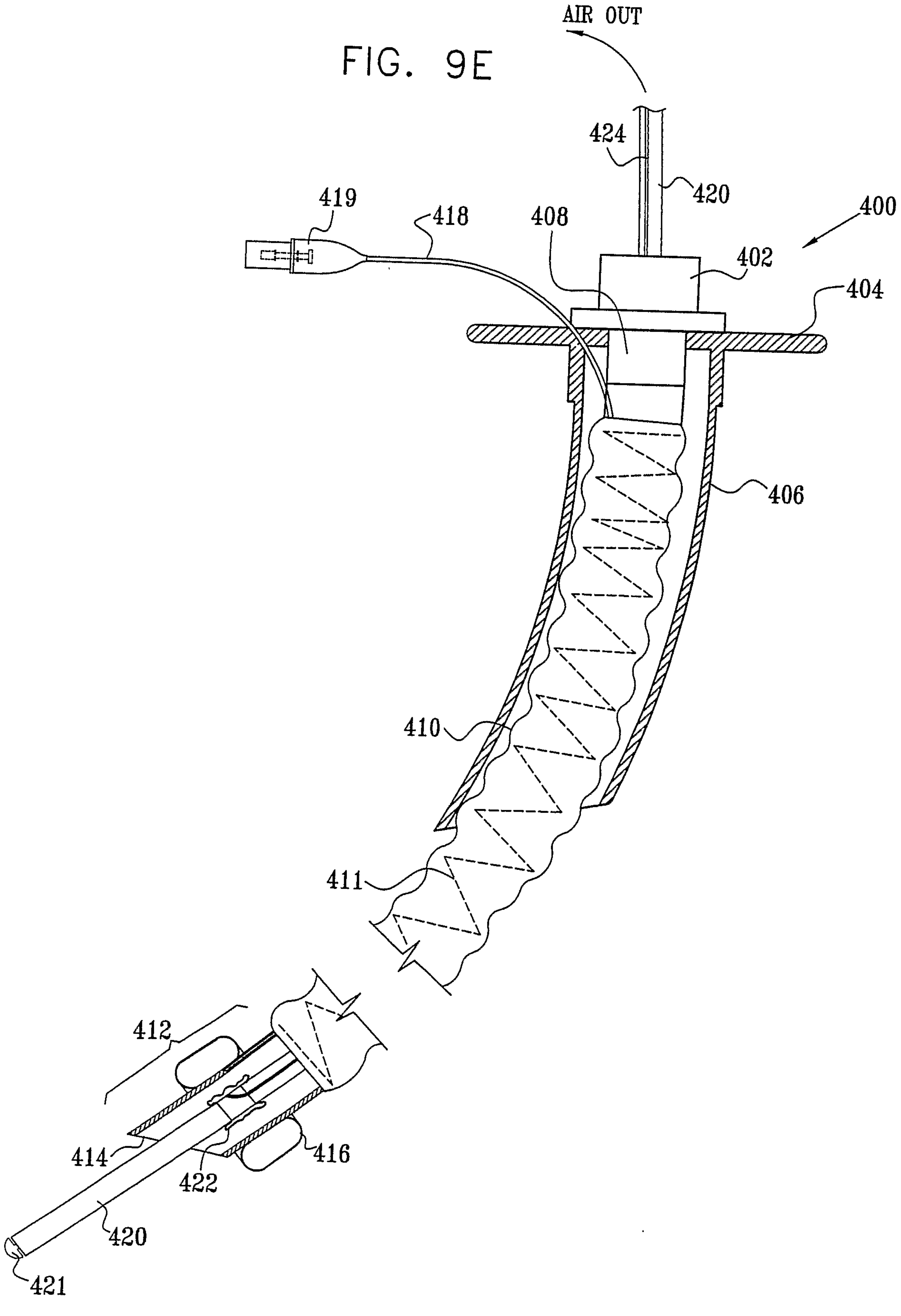
AIR OUT
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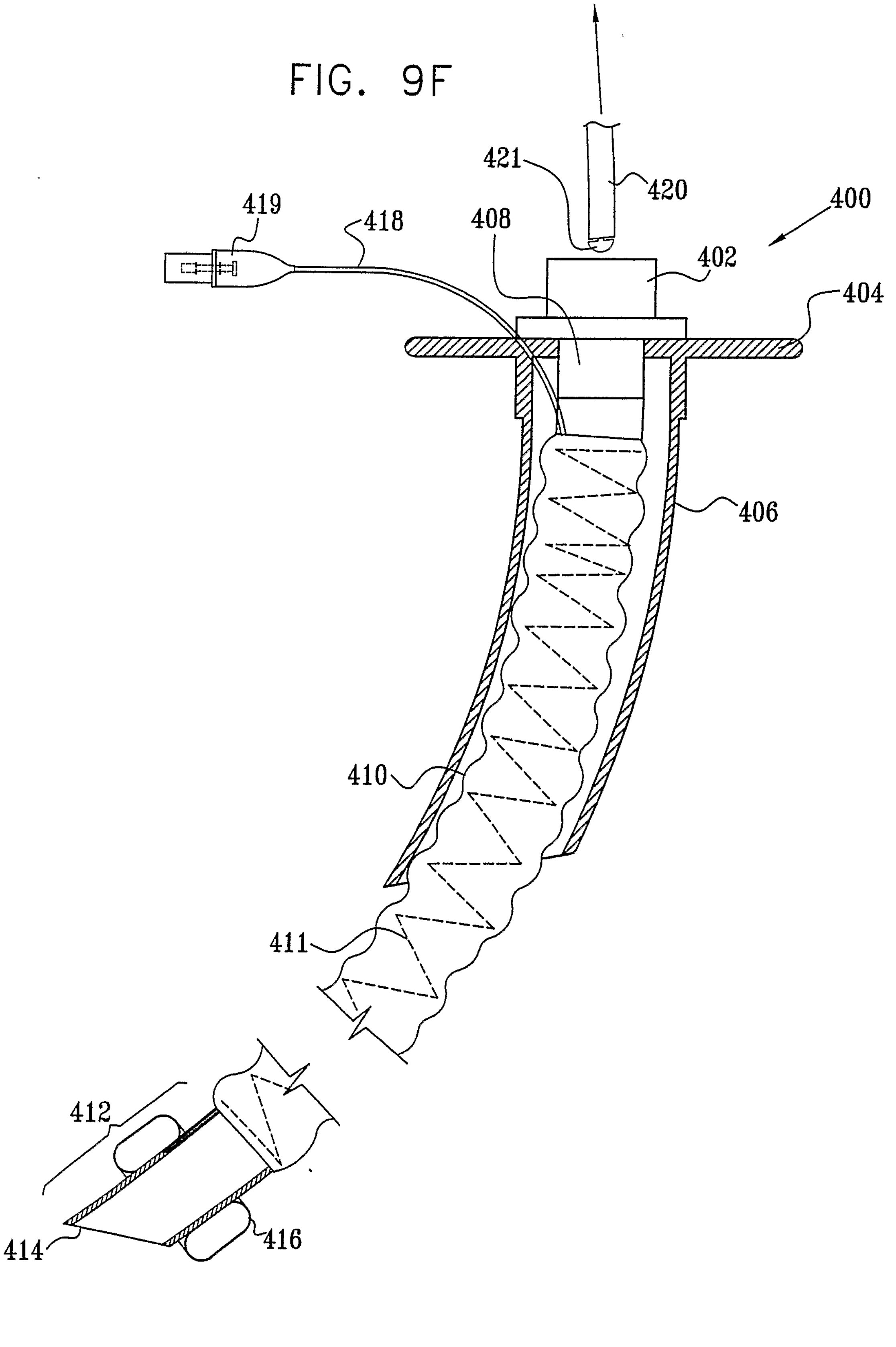
FIG. 9F



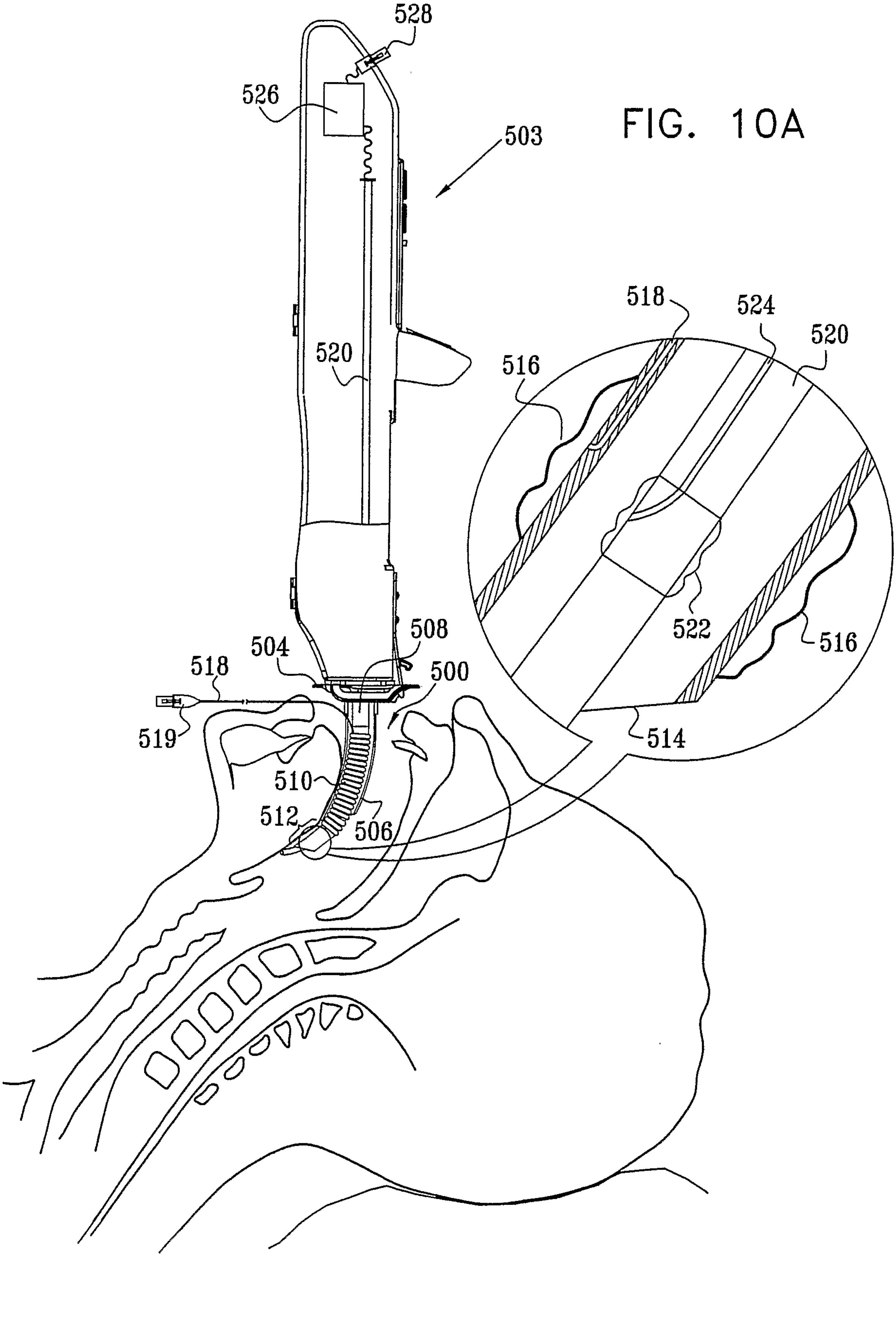

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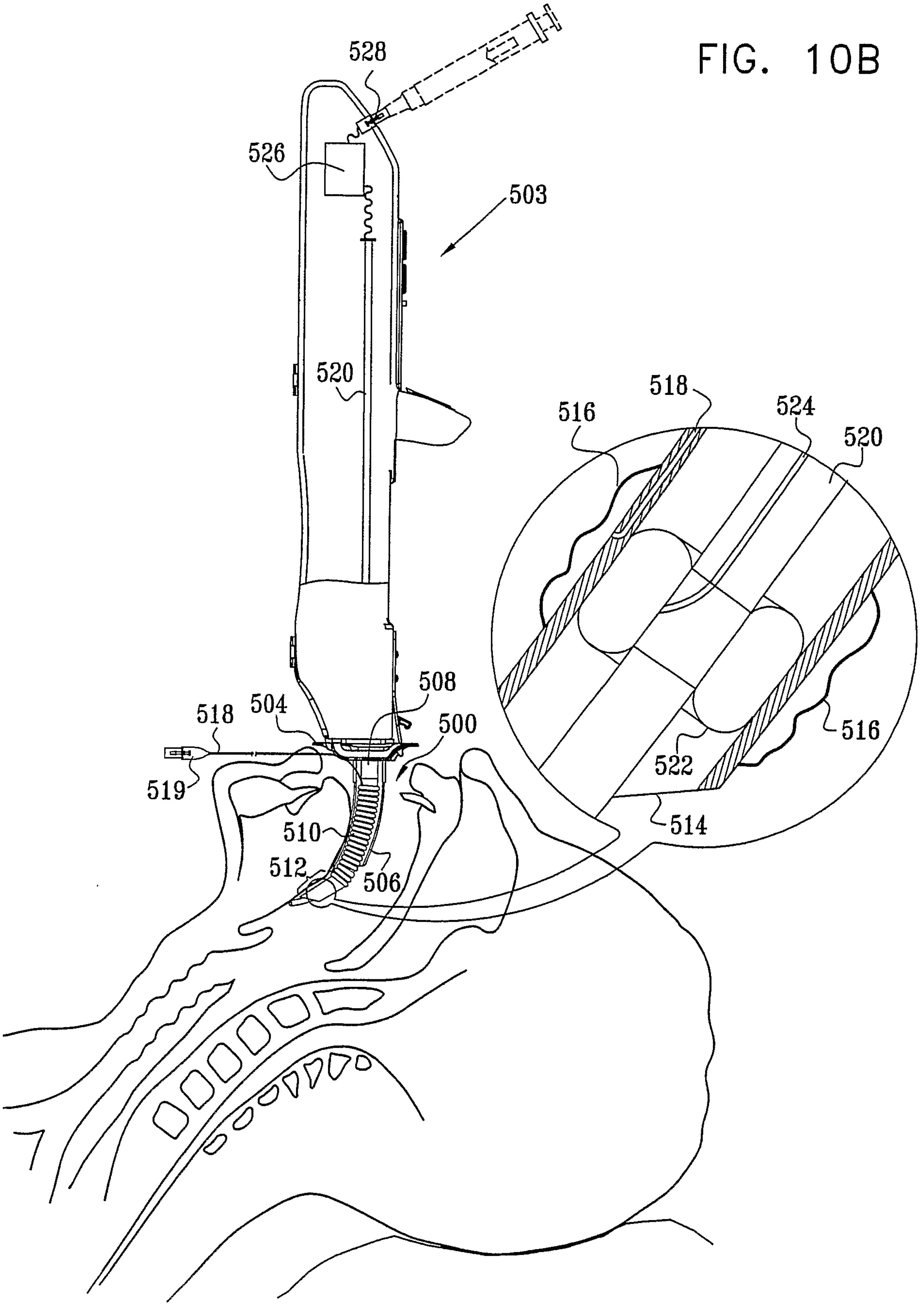
FIG. 10A

FIG. 10B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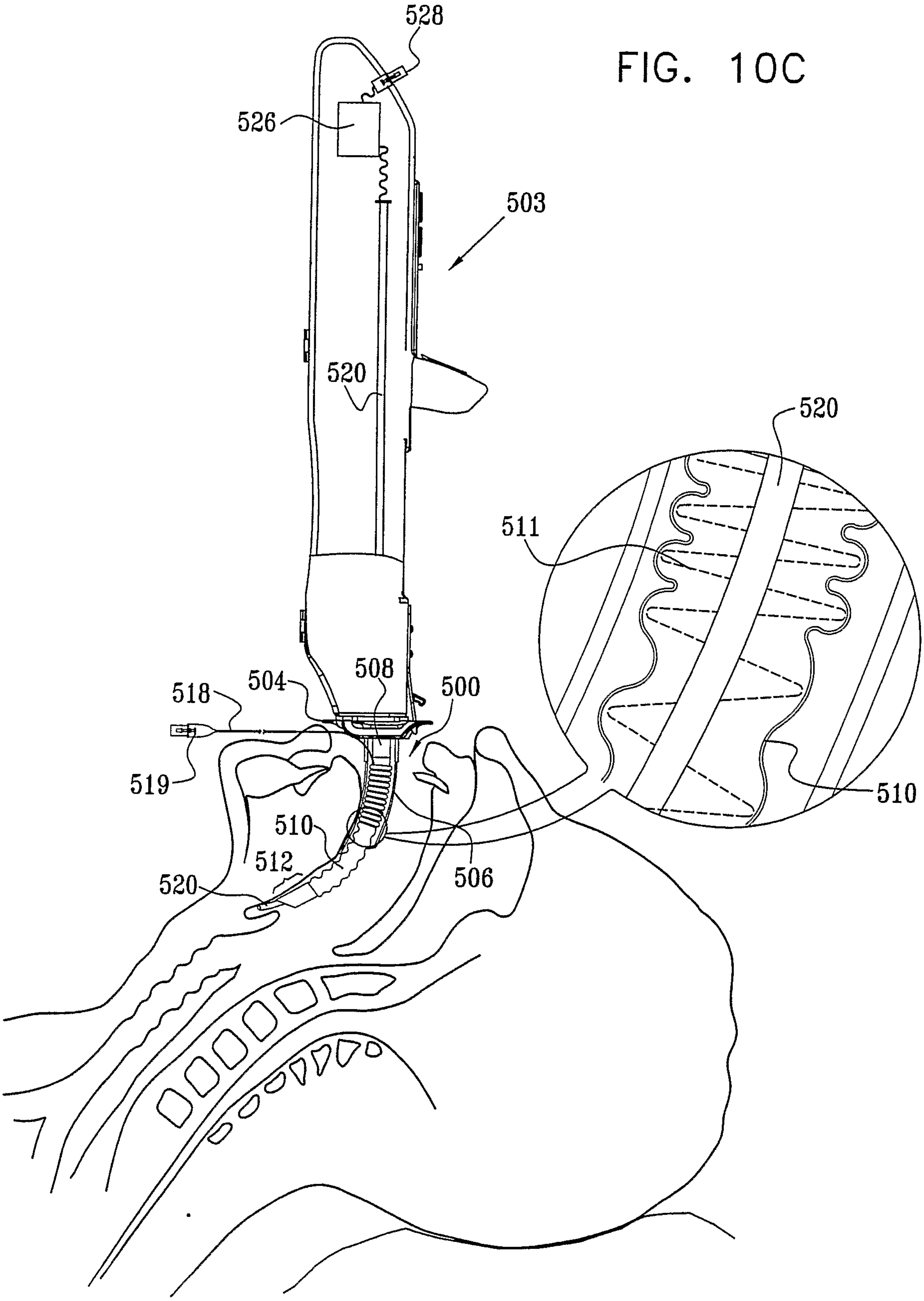

FIG. 10C

FIG. 10D

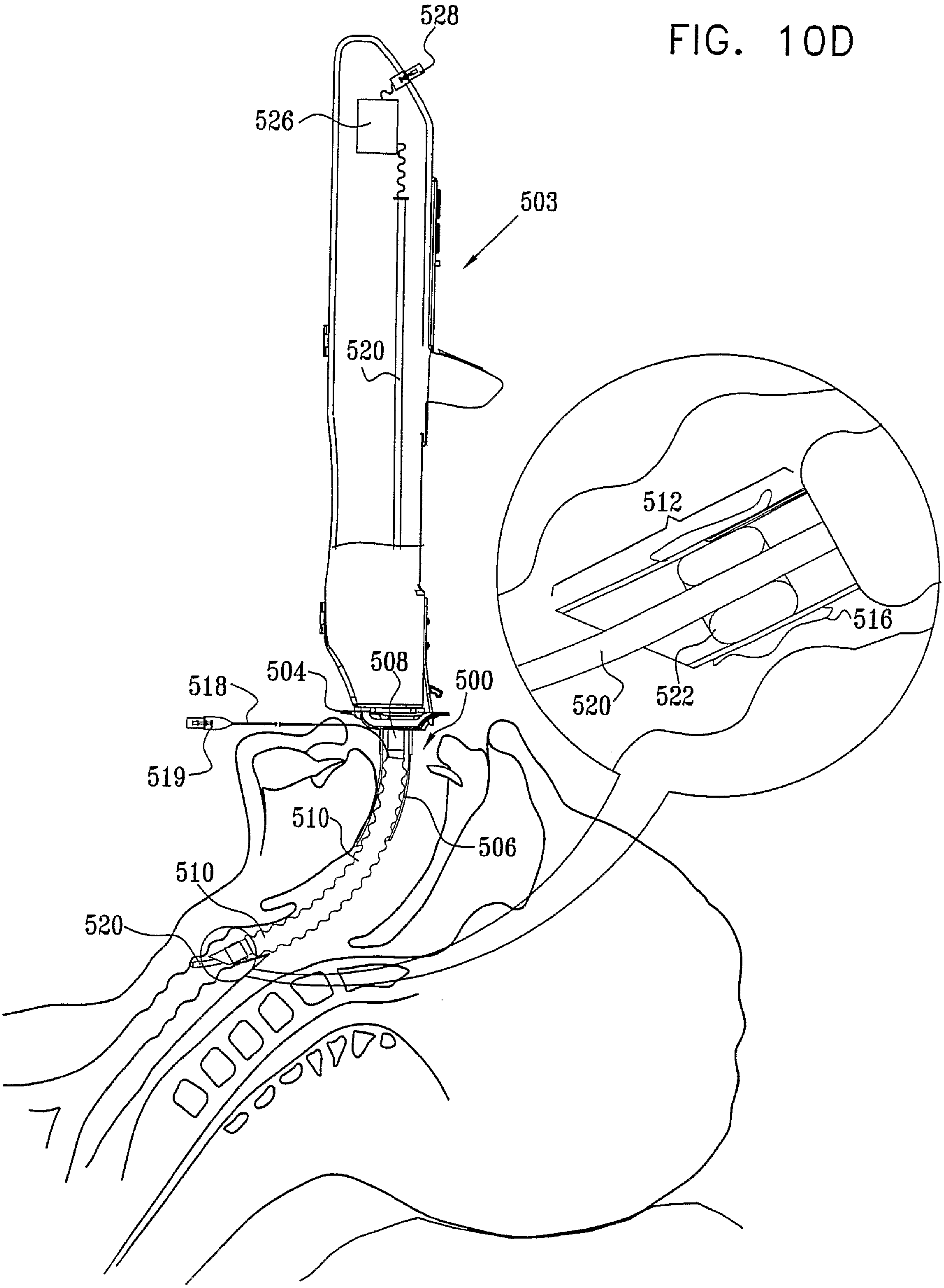
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FIG. 10E

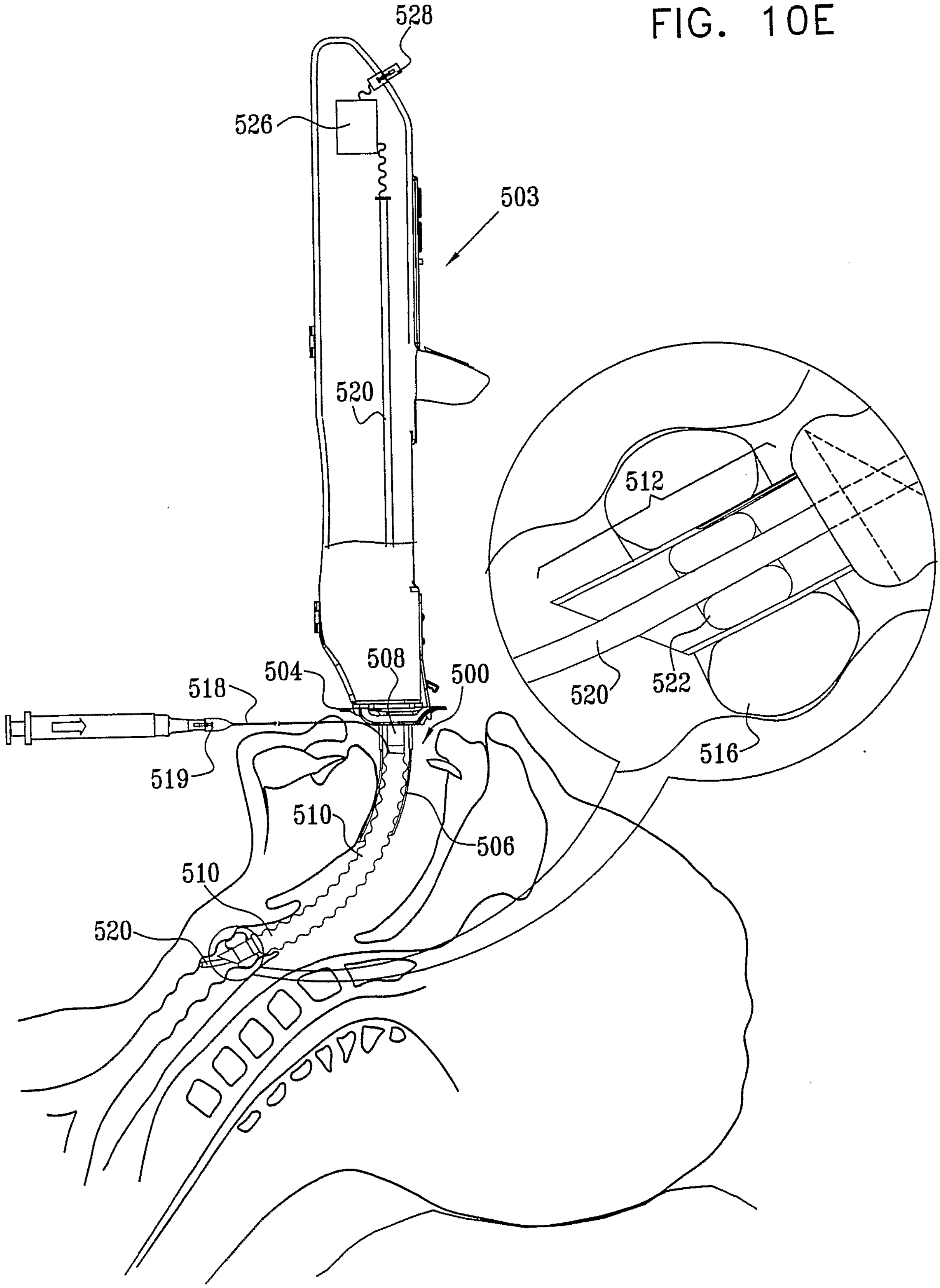
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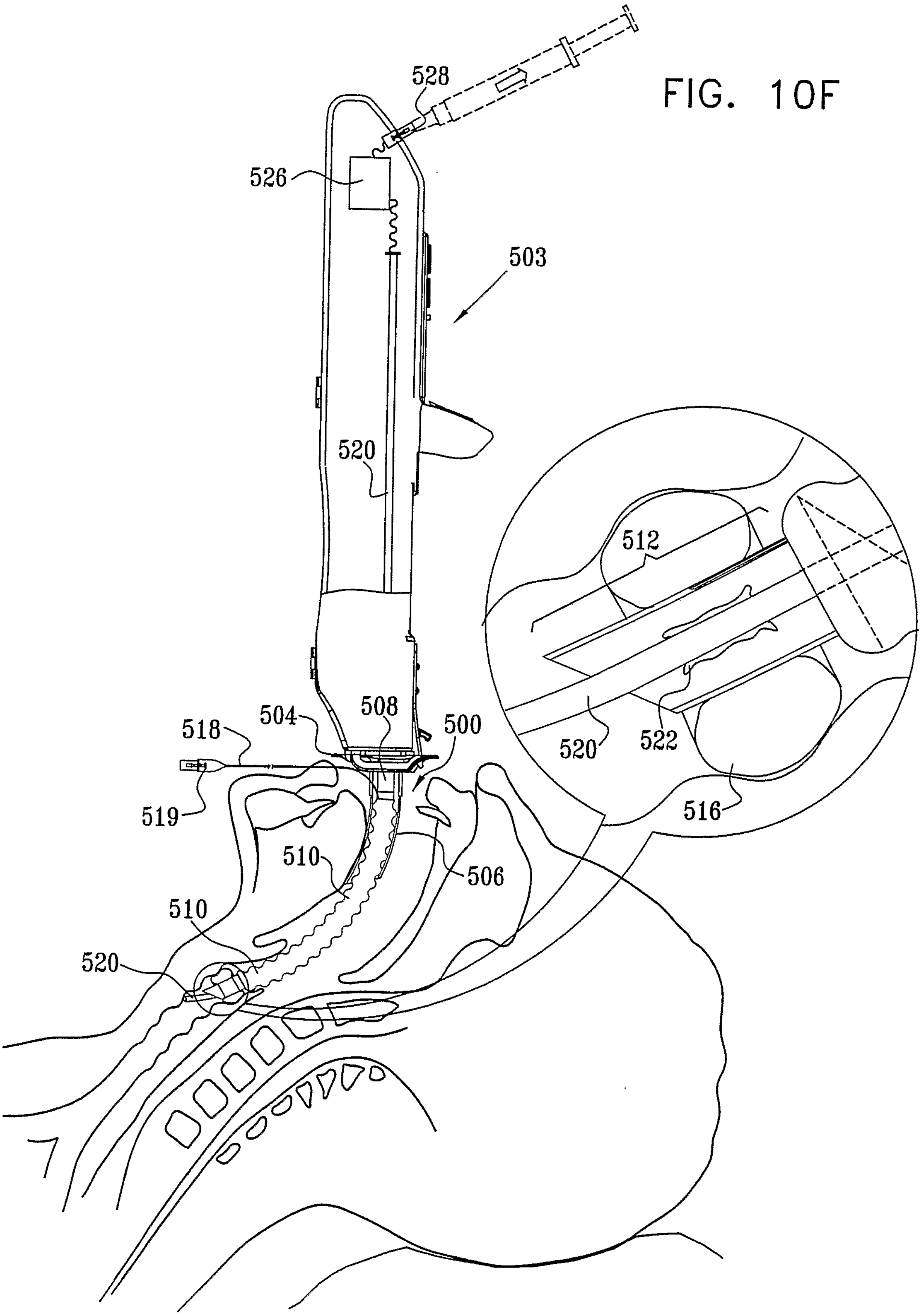
FIG. 10F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520

FIG. 10G

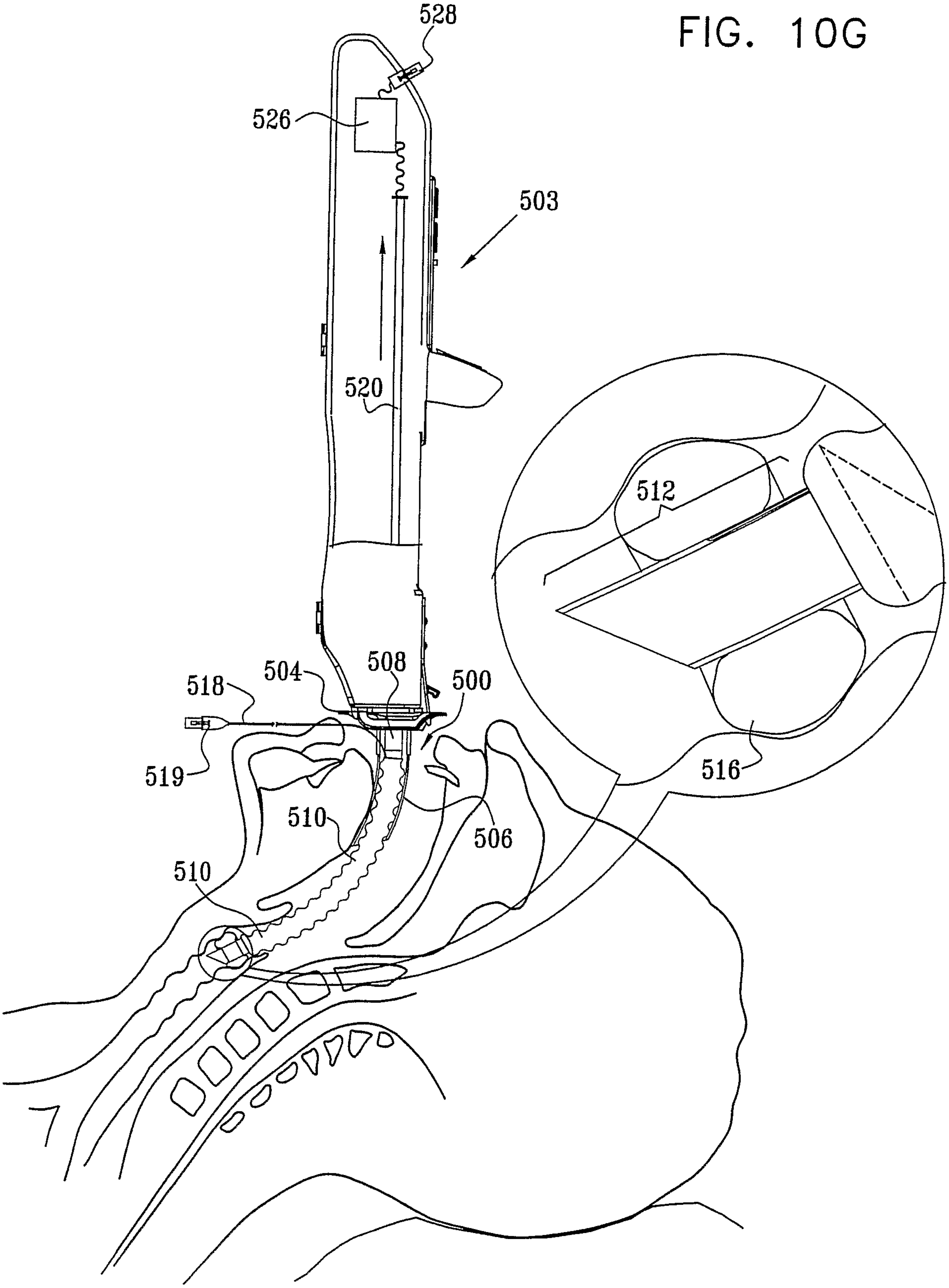
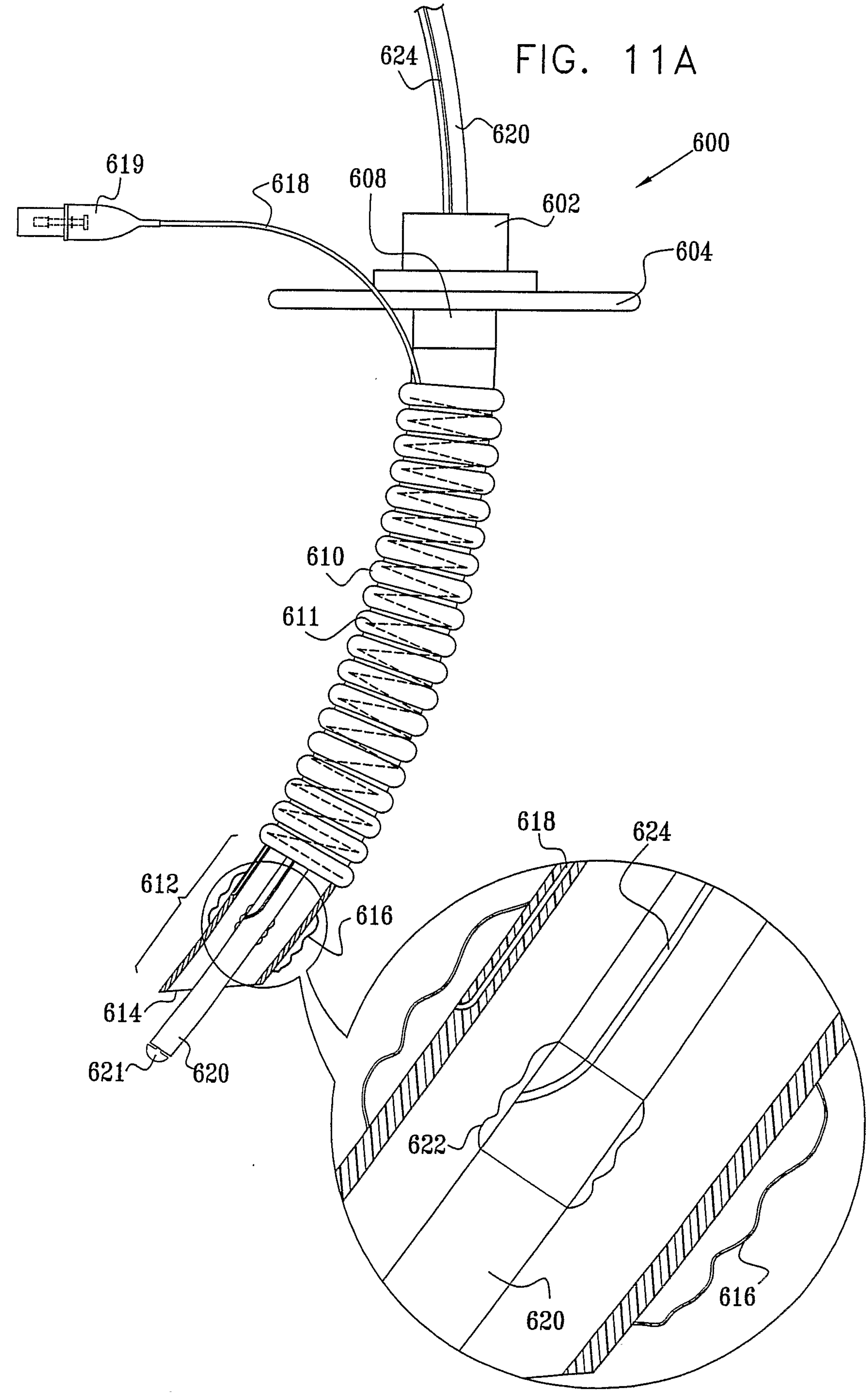


FIG. 11A



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618
624
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621
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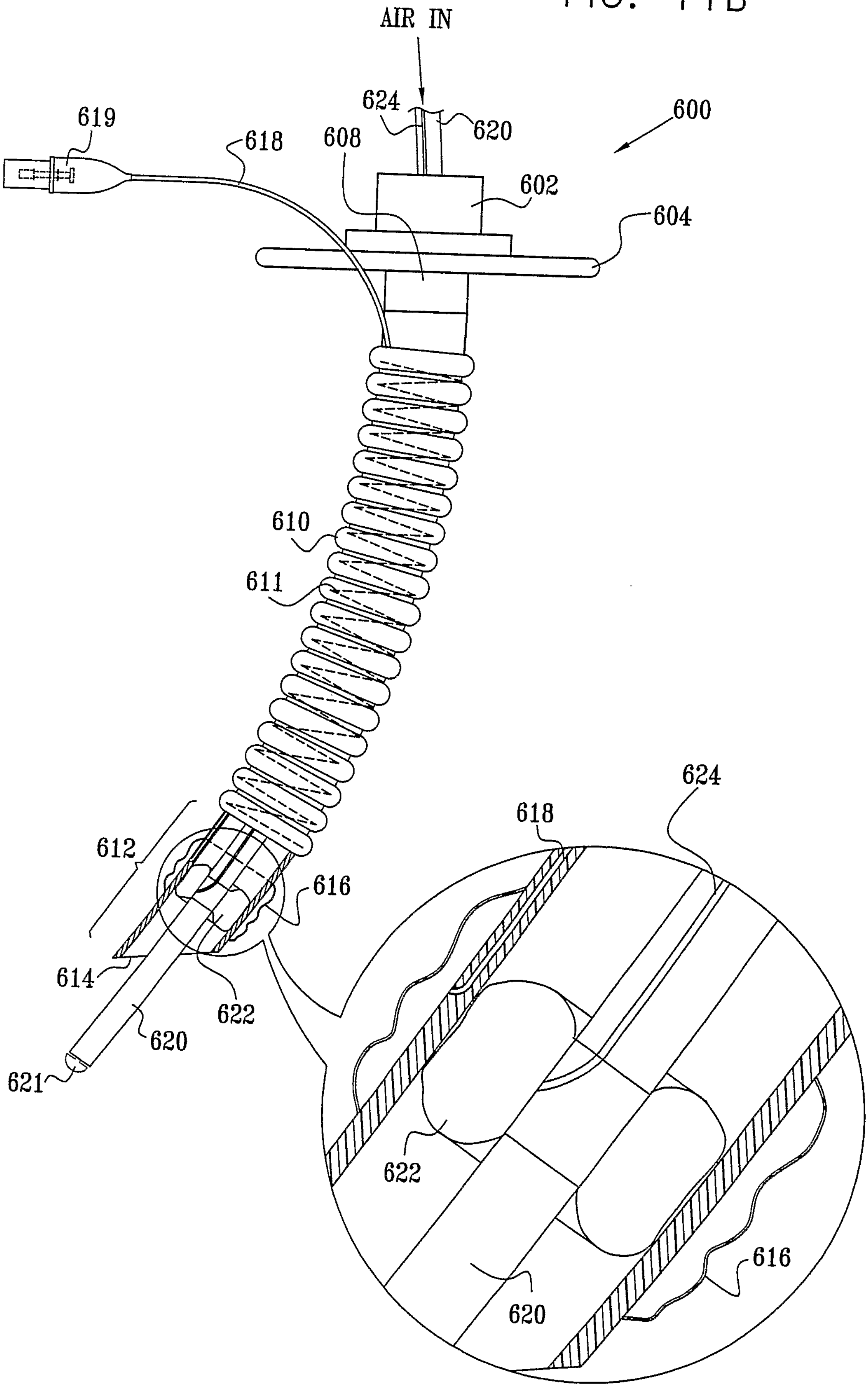
622
620
616

FIG. 11B


AIR IN
624
620
600
619
618
608
602
604
610
611
612
616
614
622
620
621
618
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622
620
616

FIG. 11C

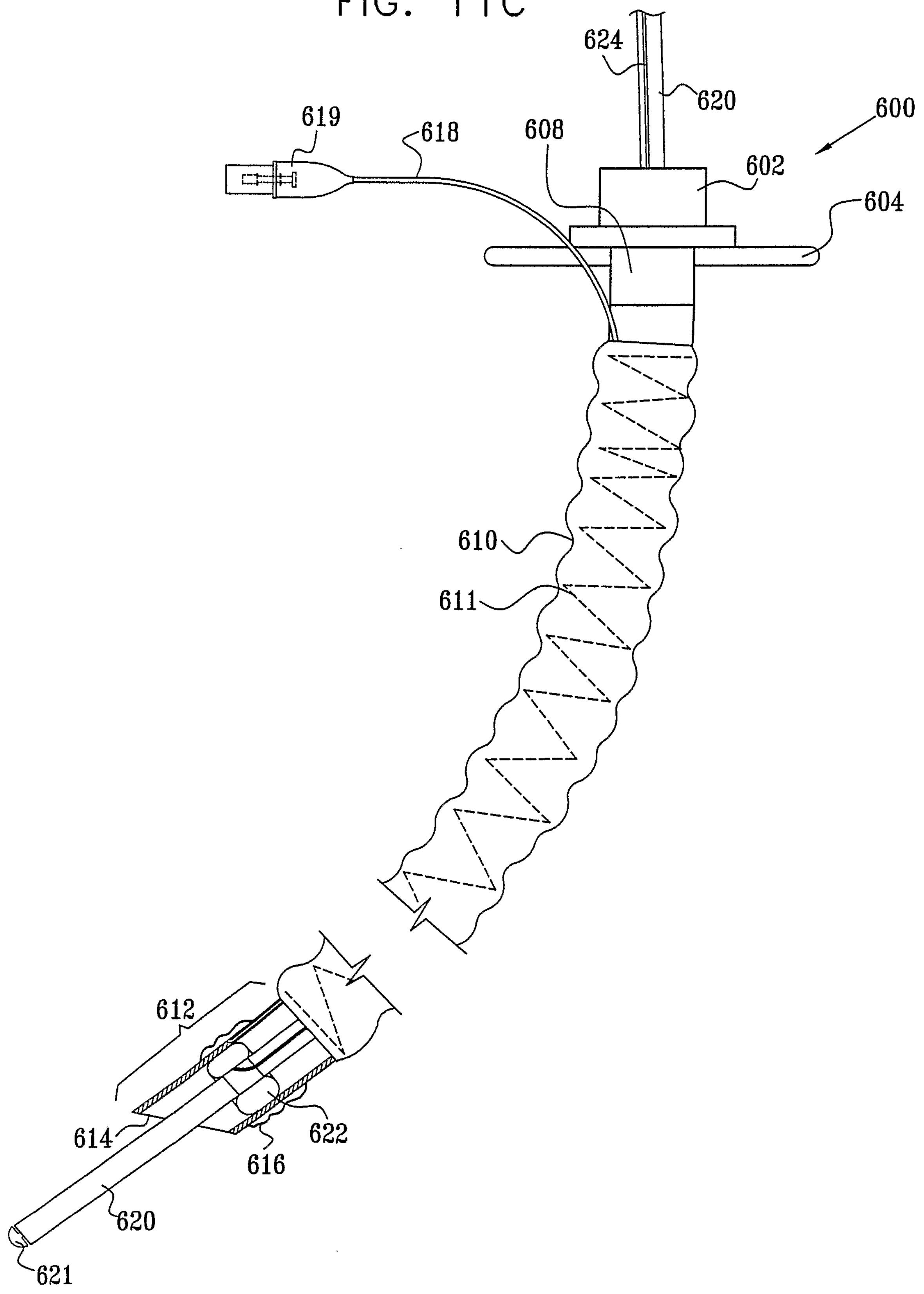
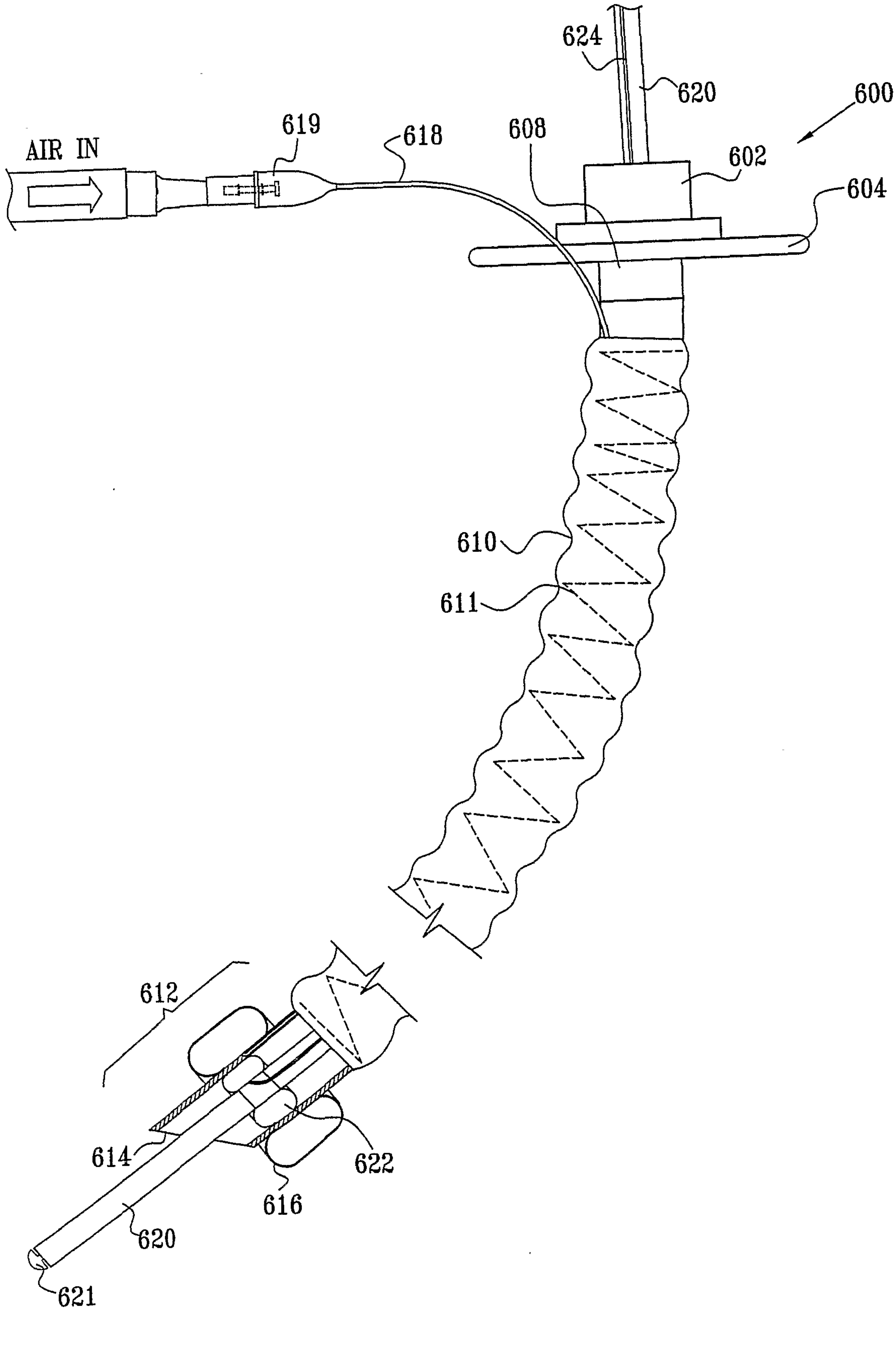


FIG. 11D


624
620
600
AIR IN
619
618
608
602
604
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612
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622
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620
621

FIG. 11E

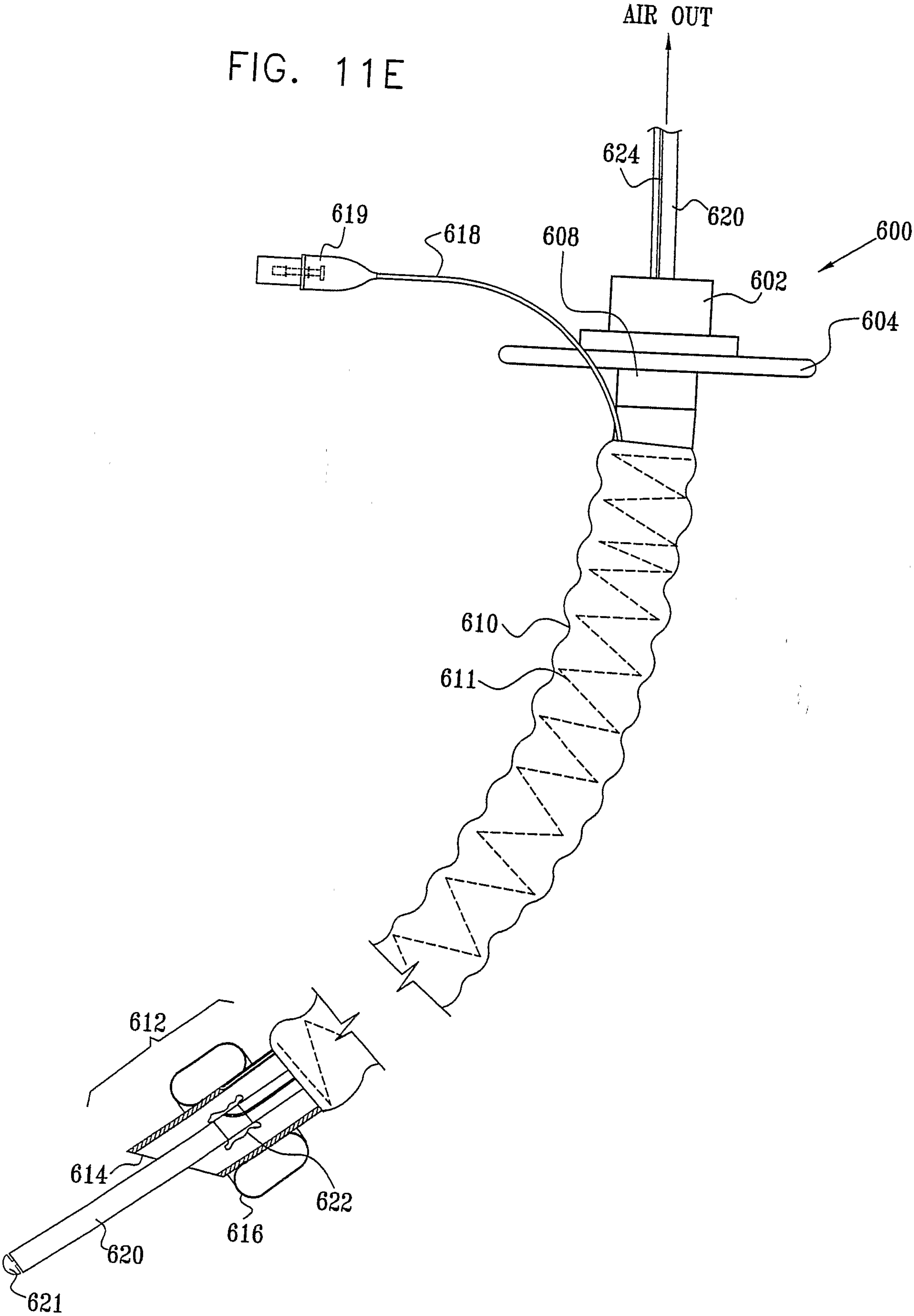
AIR OUT
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FIG. 11F

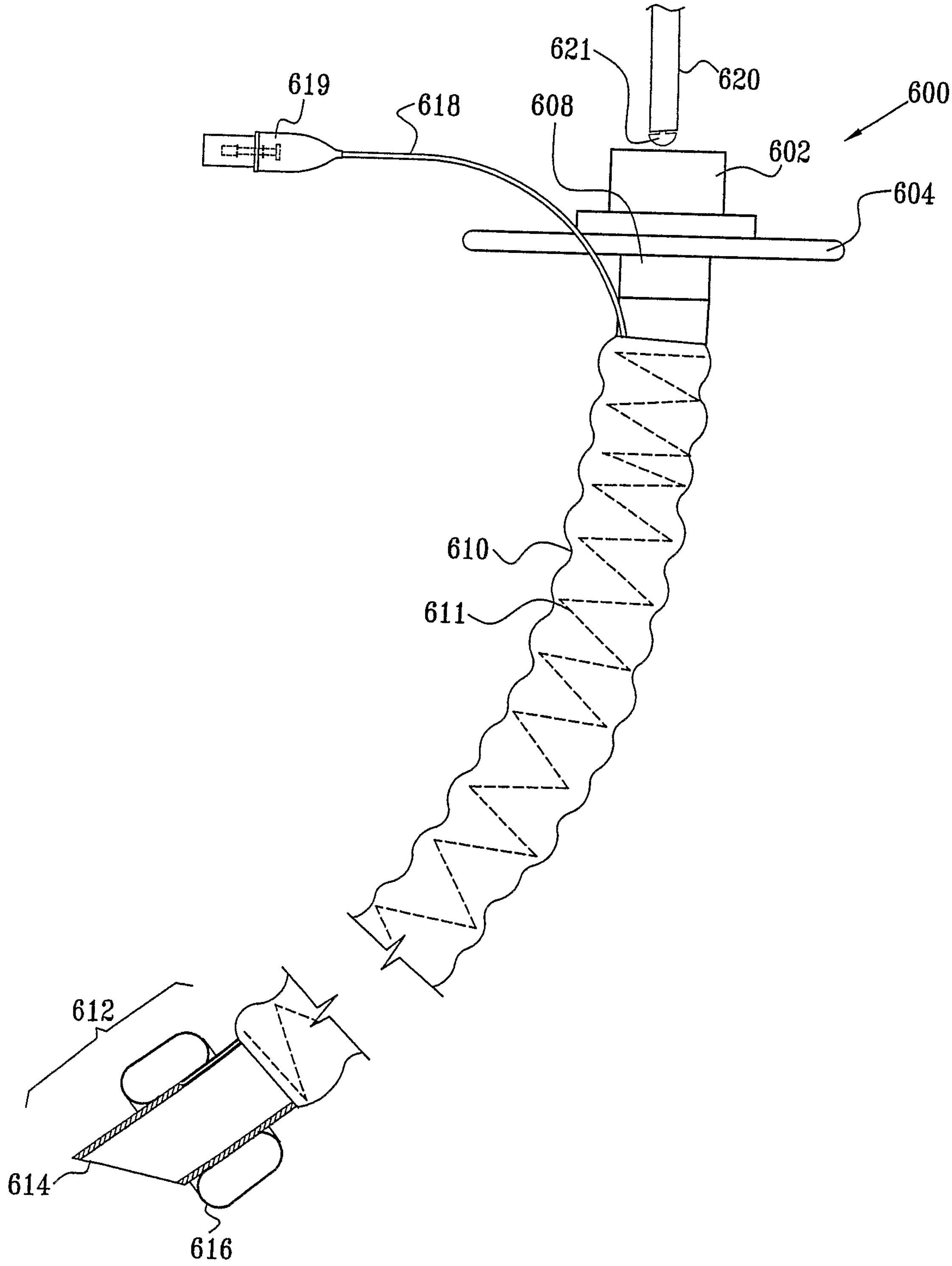
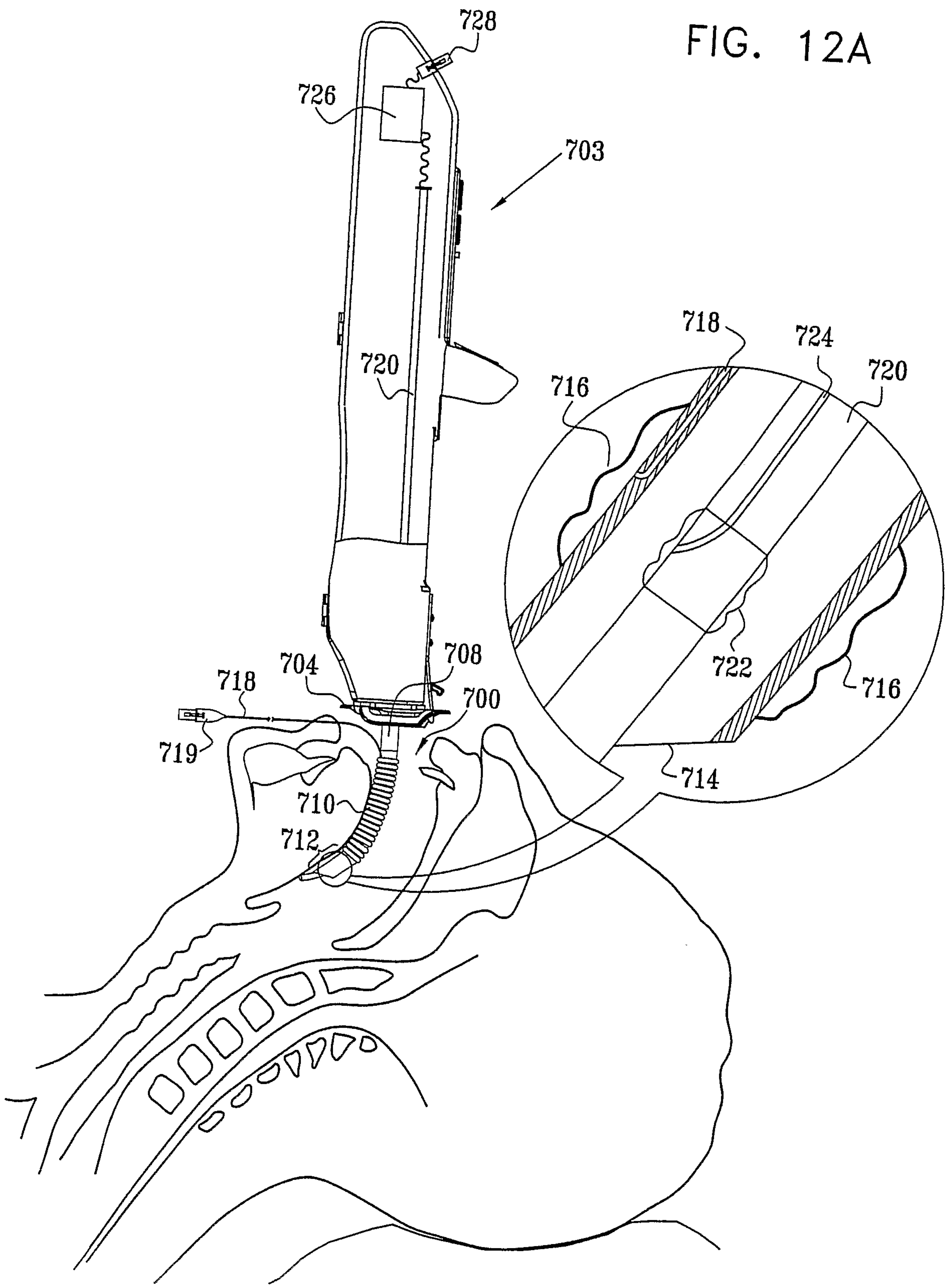


FIG. 12A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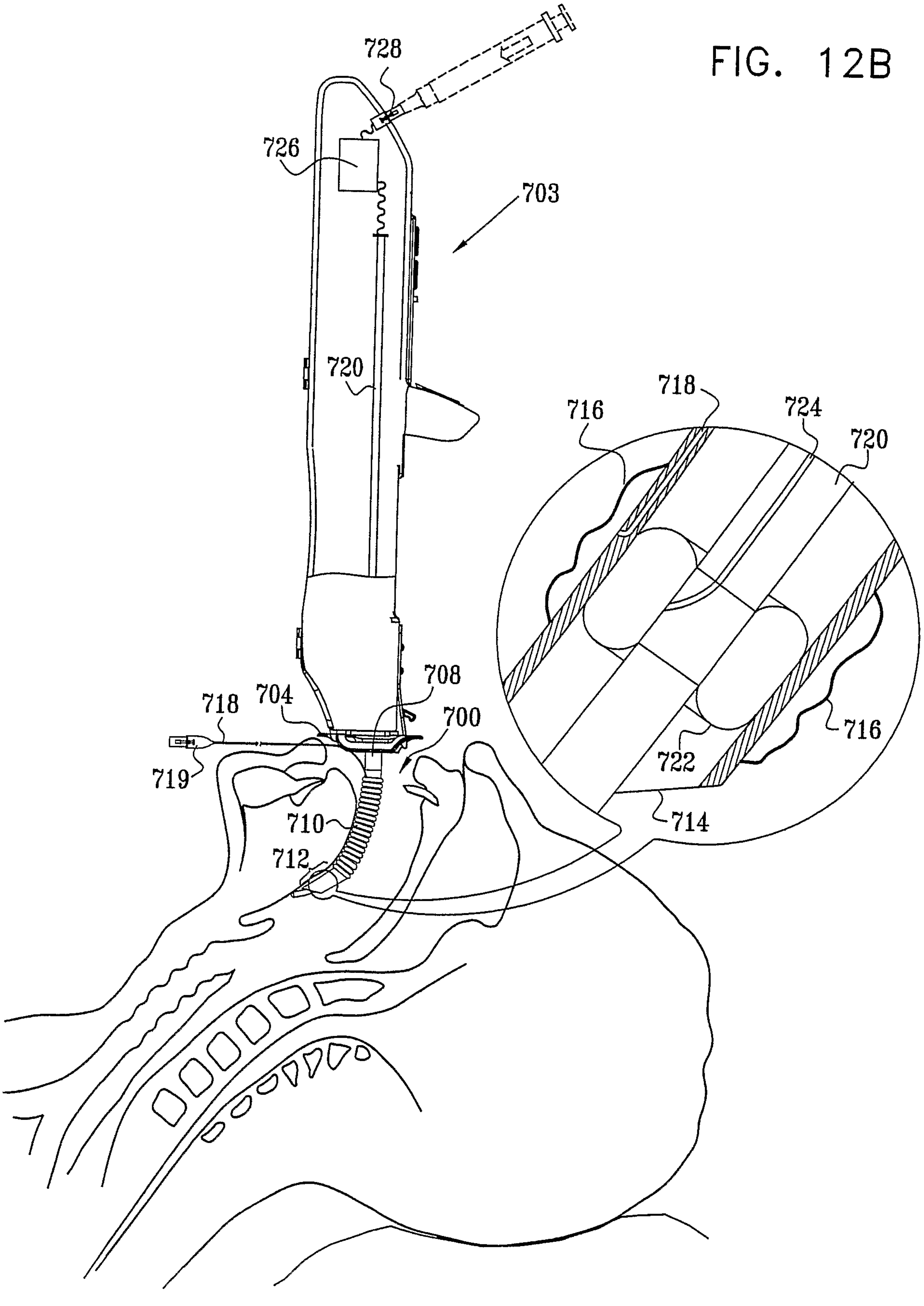
728
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722
714
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710
712

FIG. 12B

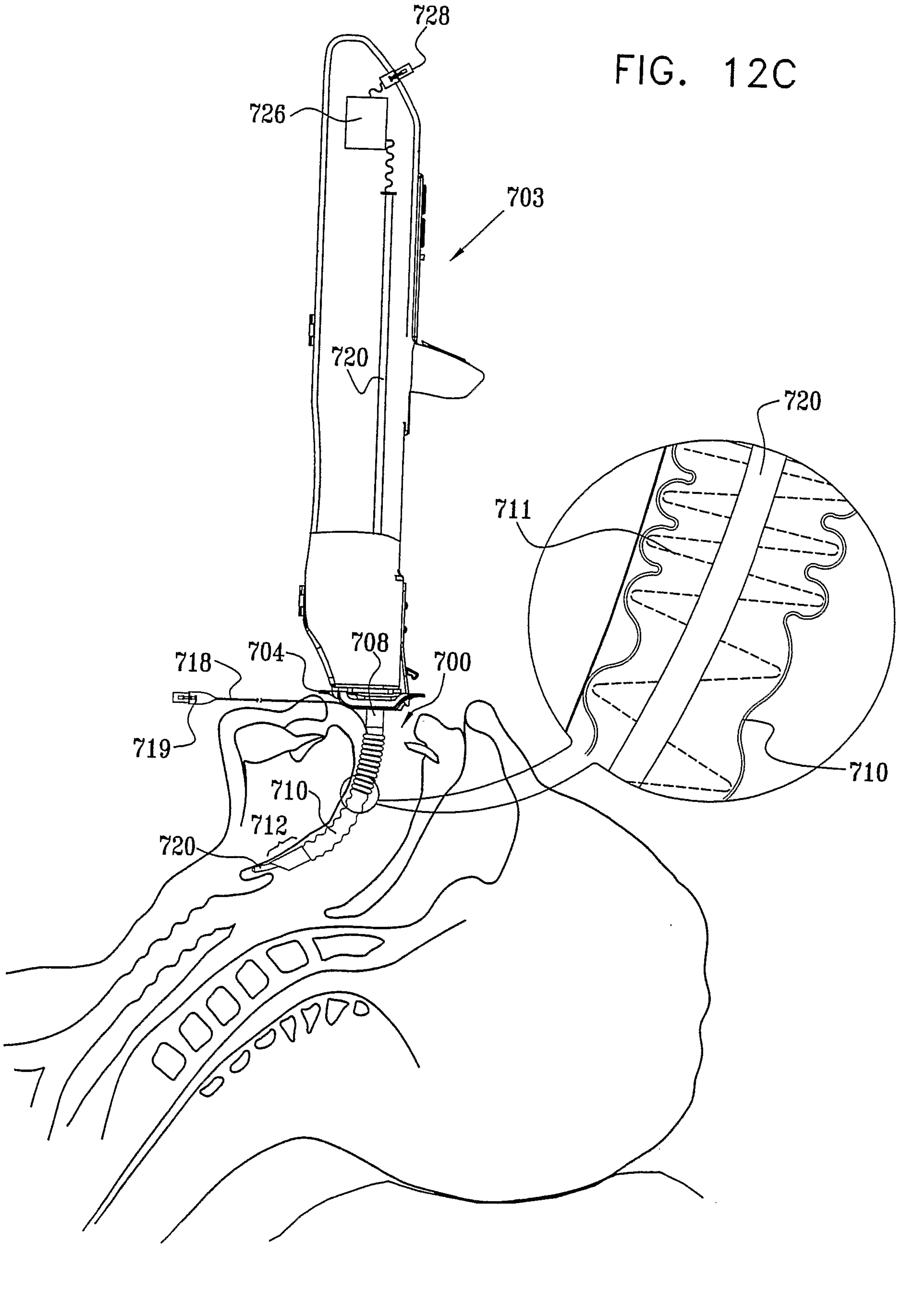


FIG. 12C

FIG. 12D

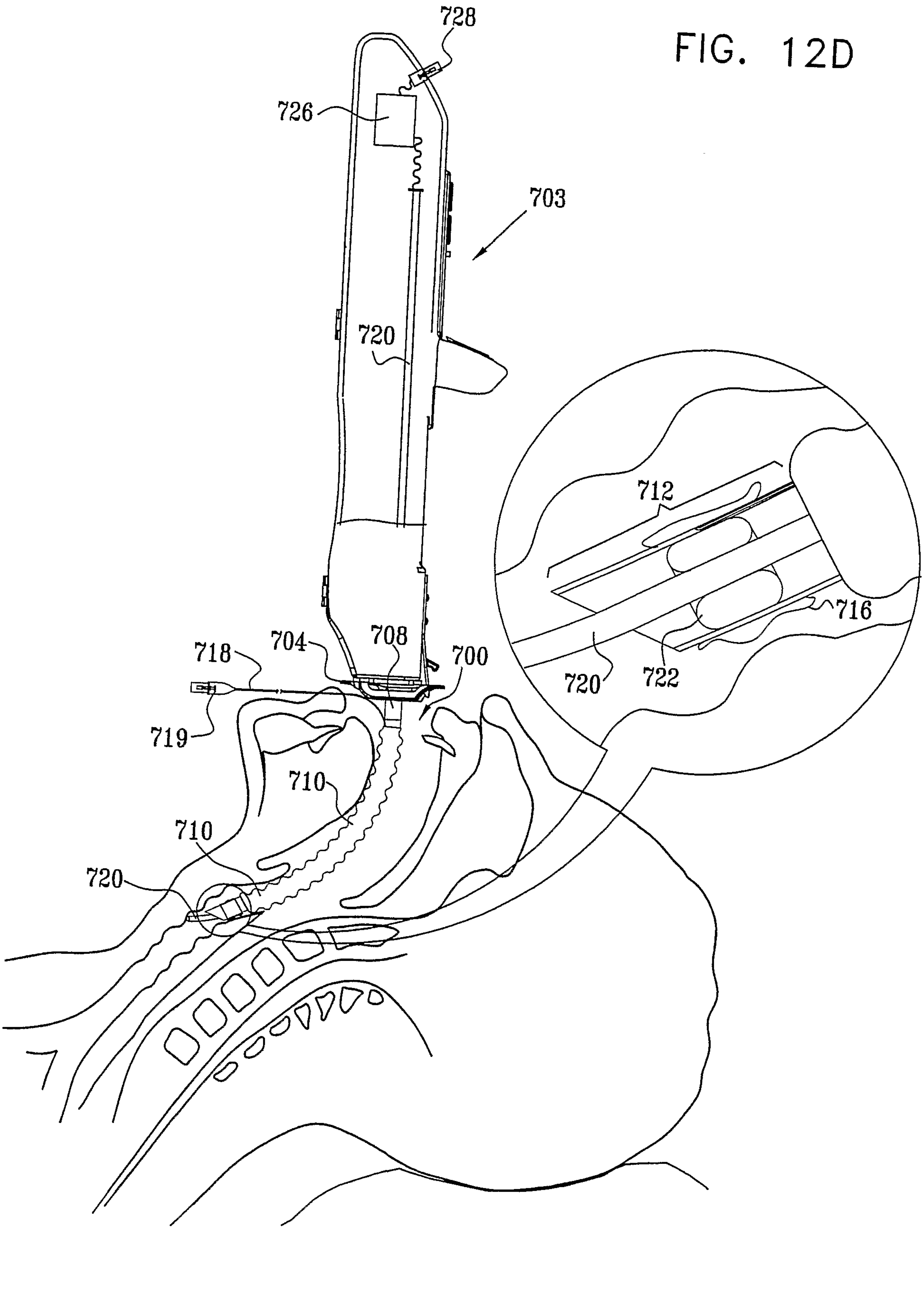
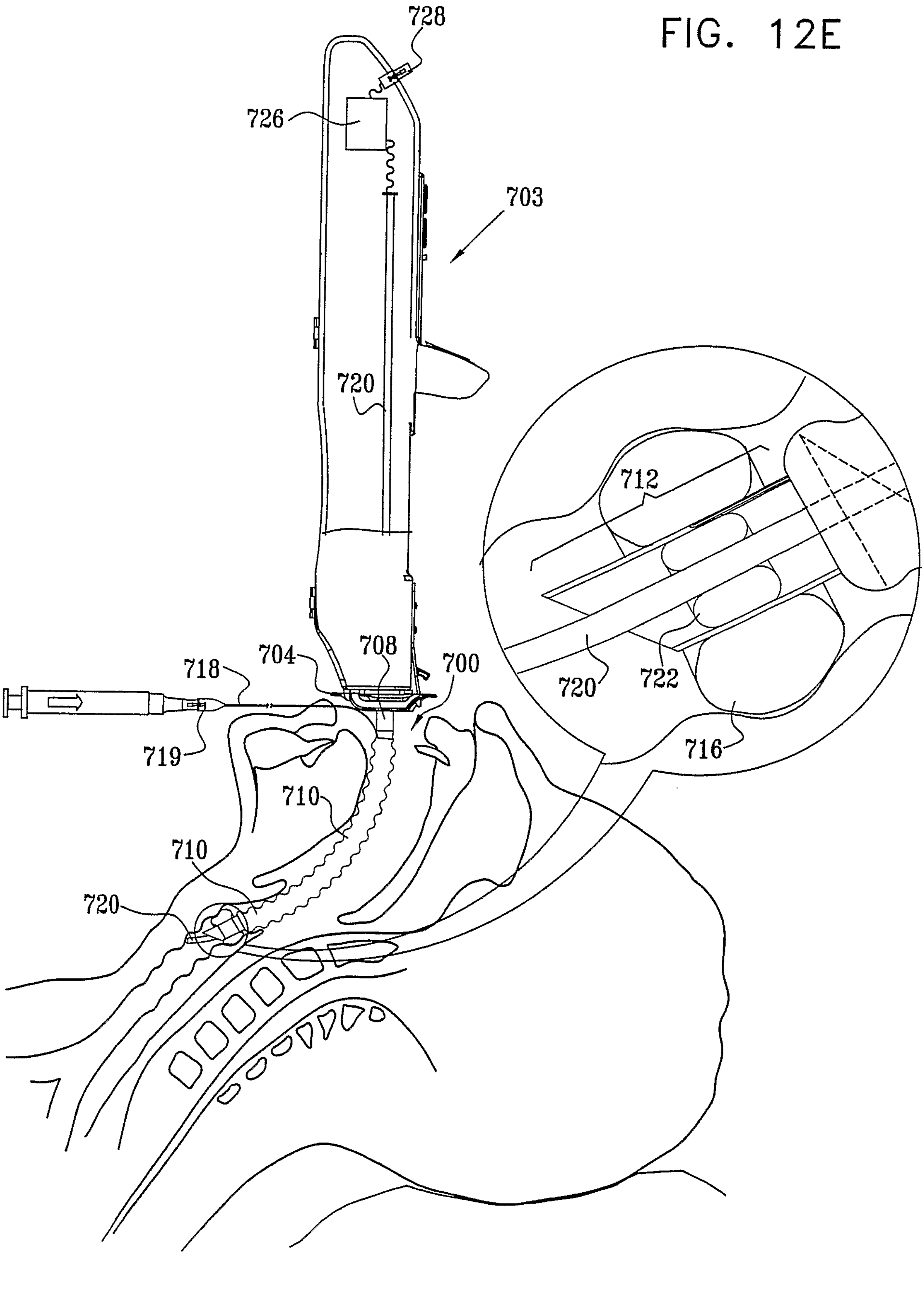


FIG. 12E



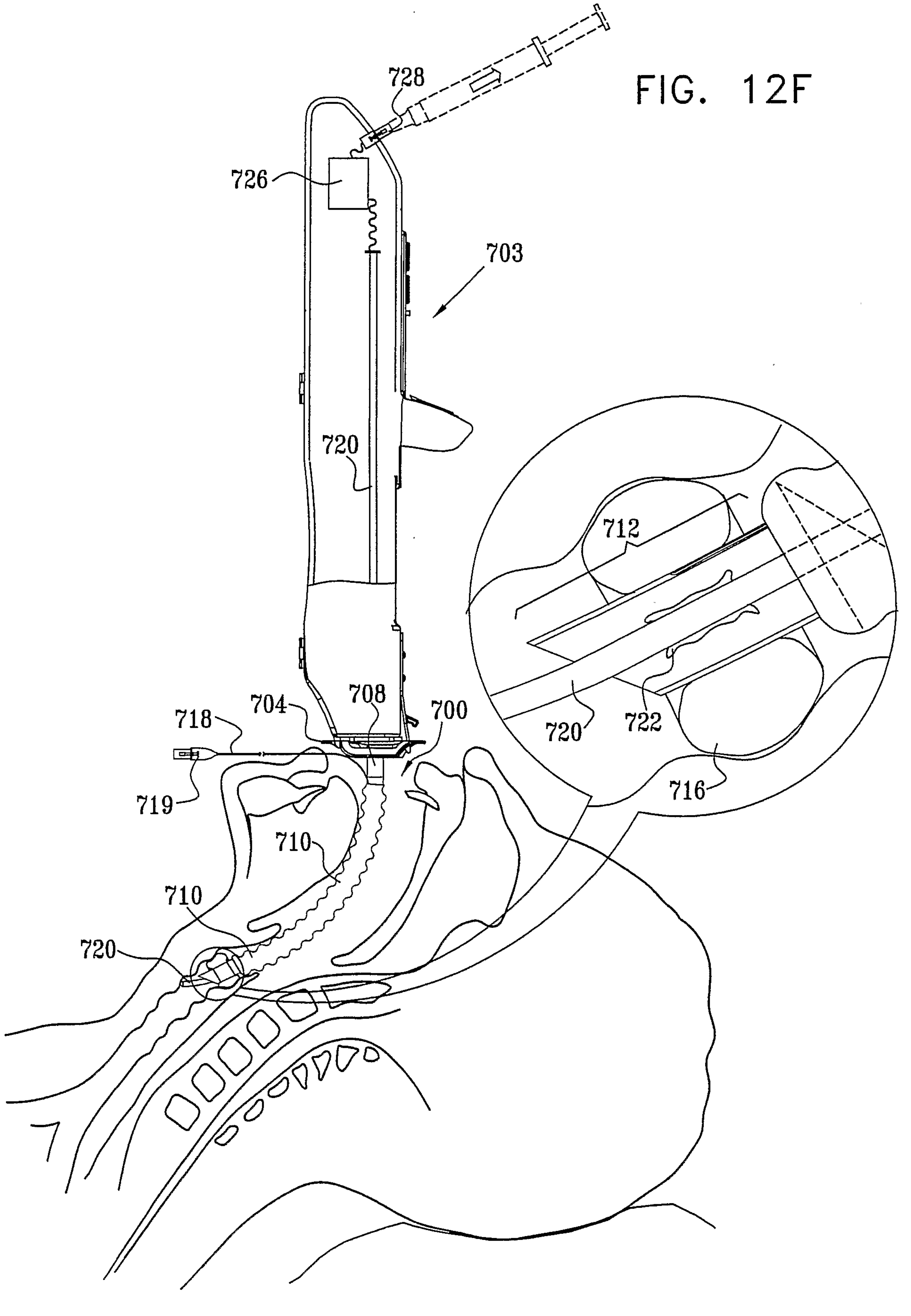
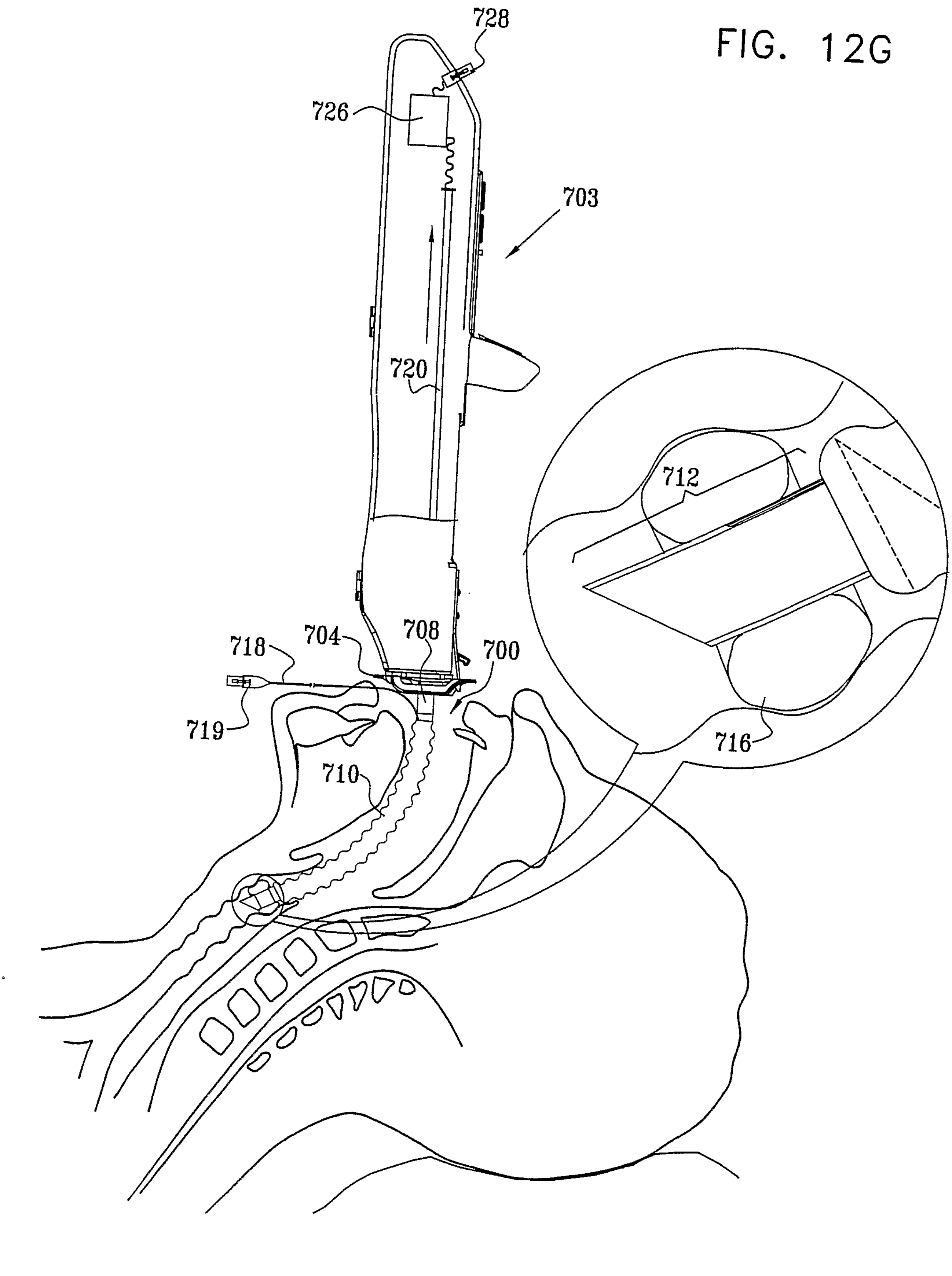


FIG. 12F

FIG. 12G



INTERNATIONAL SEARCH REPORT

International application No.
PCT/IL02/00347

A. CLASSIFICATION OF SUBJECT MATTER
IPC(7) : A61M 16/00
US CL : 128/207.14
According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
U.S. : 128/207.14, 200.26, 200.24, 204.18; 606/108; 604/95.01

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 4,827,925 A (VILASI) 09 MAY 1989, see entire document.	1-8 AND 71-78
A	US 5,184,603 A (STONE) 09 FEBRUARY 1993, see entire document.	1-8 AND 71-78
A	US 5,282,472 A (COMPANION, et al.) 01 FEBRUARY 1994, see entire document.	1-8 AND 71-78
A	US 5,571,114 A (DEVANABOYINA) 05 NOVEMBER 1996, see entire document.	1-8 AND 71-78
A	US 6,096,004 A (MEGLAN, et al.) 01 AUGUST 2000, see entire document.	1-8 AND 71-78
A,P	US 6,332,865 B1 (BORODY, et al.) 25 DECEMBER 2001, see entire document.	1-8 AND 71-78
A,P	US 6,398,755 B1 (BELEF, et al.) 04 JANUARY 2002, see entire document.	1-8 AND 71-78

☐ Further documents are listed in the continuation of Box C. ☐ See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search 23 September 2002 (23.09.2002)	Date of mailing of the international search report 04 APR 2003
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. (703)305-3230	Authorized officer Glenn K Dawson Telephone No. 703-308-0858

Form PCT/ISA/210 (second sheet) (July 1998)

INTERNATIONAL SEARCH REPORT

International application No.

PCT/IL02/00347

Box I Observations where certain claims were found unsearchable (Continuation of Item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claim Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claim Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☒ Claim Nos.: 9-70 and 79-142
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of Item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

patsnap

专利名称(译)	可伸缩管		
公开(公告)号	[EP1461104A1](EP1461104A1)	公开(公告)日	2004-09-29
申请号	EP2002728003	申请日	2002-05-02
[标]申请(专利权)人(译)	INTUMED		
申请(专利权)人(译)	INTUMED LTD.		
当前申请(专利权)人(译)	INTUMED LTD.		
[标]发明人	BESHARIM SHLOMO BESHARIM ELIYAHU		
发明人	BESHARIM, SHLOMO BESHARIM, ELIYAHU		
IPC分类号	A61M16/04 A61B1/267 A61M25/01		
CPC分类号	A61M16/0411 A61M16/0488 A61M16/049		
优先权	PCT/IL2001/001121 2001-12-05 WO		
其他公开文献	EP1461104A4		
外部链接	Espacenet		

摘要(译)

一种自动操作的医疗插入装置（12）和方法，包括可插入元件（18），其适于插入体内的生物体内，表面跟随元件（20），与可插入元件物理相关并且布置成遵循生物体内的物理表面，驱动子系统（15），其可操作以至少部分地自动地沿着物理表面引导可插入元件;以及导航子系统（274），其可操作以至少部分地基于感知来控制驱动子系统。沿着存储在导航子系统中的参考路径的元素后面的表面的位置。