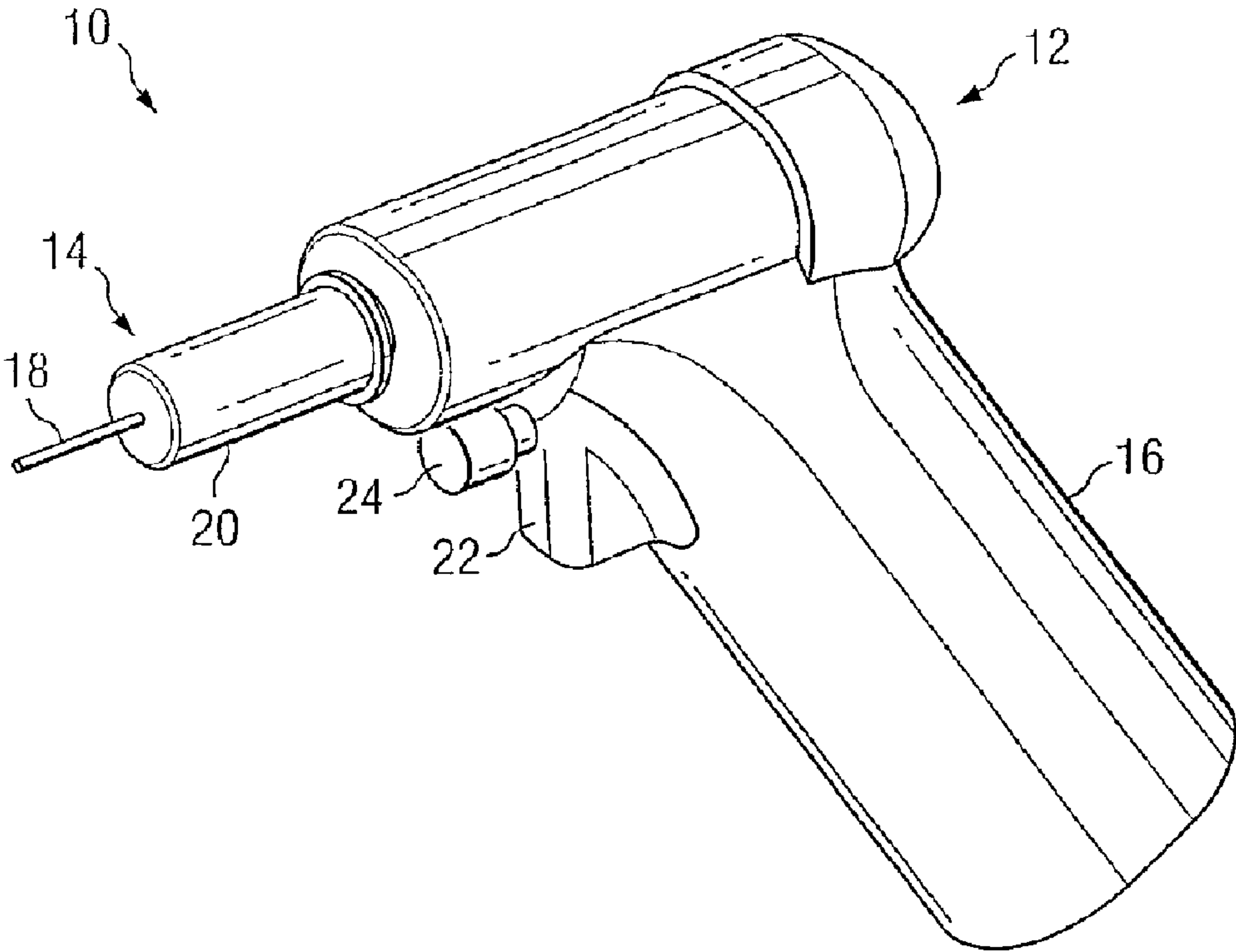




(22) **Date de dépôt/Filing Date:** 2003/05/30
(41) **Mise à la disp. pub./Open to Public Insp.:** 2003/12/11
(45) **Date de délivrance/Issue Date:** 2018/11/13
(62) **Demande originale/Original Application:** 2 485 910
(30) **Priorité/Priority:** 2002/05/31 (US60/384,756)

(51) **Cl.Int./Int.Cl.** **A61B 17/16** (2006.01),
A61B 17/32 (2006.01), **A61B 17/34** (2006.01),
A61M 39/10 (2006.01), **A61M 5/14** (2006.01),
A61M 5/34 (2006.01)
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(54) **Titre : PROCÉDE ET DISPOSITIF POUR ACCÉDER A LA MOELLE OSSEUSE**
(54) **Title: APPARATUS AND METHOD TO ACCESS BONE MARROW**



(57) **Abrégé/Abstract:**
A penetrator assembly for penetrating a bone marrow comprising: a hub having a first end, a second end, a passage extending from the first end to the second end, and a flange extending radially outward from the second end; an outer penetrator extending from the second end of and in fixed relation to the hub, the outer penetrator defining a longitudinal channel in communication with the passage of the hub; a connector having a first end and a second end that is configured to be coupled to the first end of the hub, the first end configured to be releasably coupled to a drive shaft of a driver such that the driver can rotate the connector and the hub to drill the outer penetrator into a bone and associated bone marrow; where the flange is configured to stabilize the hub against tissue overlying the bone when the outer penetrator is disposed in the bone.

ABSTRACT

A penetrator assembly for penetrating a bone marrow comprising: a hub having a first end, a second end, a
5 passage extending from the first end to the second end, and
a flange extending radially outward from the second end; an
outer penetrator extending from the second end of and in
fixed relation to the hub, the outer penetrator defining a
longitudinal channel in communication with the passage of
10 the hub; a connector having a first end and a second end
that is configured to be coupled to the first end of the
hub, the first end configured to be releasably coupled to a
drive shaft of a driver such that the driver can rotate the
connector and the hub to drill the outer penetrator into a
15 bone and associated bone marrow; where the flange is
configured to stabilize the hub against tissue overlying the
bone when the outer penetrator is disposed in the bone.

APPARATUS AND METHOD TO ACCESS BONE MARROW

This is a division of co-pending Canadian Patent Application Serial No. 2,485,910, from PCT/US03/17203, filed
5 May 30, 2003.

TECHNICAL FIELD

The present invention is related in general to a medical device to access the bone marrow and specifically to an
10 apparatus and method for penetrating the bone marrow with a powered drill and inserting a penetrator or needle.

BACKGROUND OF THE INVENTION

Every year, millions of patients are treated for life-threatening emergencies in the United States. Such
15 emergencies include shock, trauma, cardiac arrest, drug overdoses, diabetic ketoacidosis, arrhythmias, burns, and status epilepticus just to name a few. For example, according to the American Heart Association, more than 1,500,000 patients suffer from heart attacks (myocardial infarctions)
20 every year, with over 500,000 of them dying from its devastating complications.

An essential element for treating all such emergencies is the rapid establishment of an intravenous (IV) line in order to administer drugs and fluids directly into the
25 circulatory system. Whether in the ambulance by paramedics, or in the emergency room by emergency specialists, the goal is the same - to start an IV in order to administer life-saving drugs and fluids. To a large degree, the ability to successfully treat such critical emergencies is dependent on
30 the skill and luck of the operator in accomplishing vascular access. While it is relatively easy to start an IV on some patients, doctors, nurses and paramedics often experience great difficulty establishing IV access in approximately 20

percent of patients. These patients are probed repeatedly with sharp needles in an attempt to solve this problem and may require an invasive procedure to finally establish an intravenous route.

5 A further complicating factor in achieving IV access occurs "in the field" e.g. at the scene of an accident or during ambulance transport where it is difficult to see the target and excessive motion make accessing the venous system very difficult.

10 In the case of patients with chronic disease or the elderly, the availability of easily-accessible veins may be depleted. Other patients may have no available IV sites due to anatomical scarcity of peripheral veins, obesity, extreme dehydration or previous IV drug use.

15 For these patients, finding a suitable site for administering lifesaving drugs becomes a monumental and frustrating task. While morbidity and mortality statistics are not generally available, it is known that many patients with life-threatening emergencies have died
20 of ensuing complications because access to the vascular system with life-saving IV therapy was delayed or simply not possible. For such patients, an alternative approach is required.

SUMMARY OF THE INVENTION

25 In accordance with teachings of the present invention, an apparatus and method for gaining rapid access to the bone marrow is provided.

Certain exemplary embodiments can provide a penetrator assembly for penetrating a bone marrow comprising: a hub having a first end, a second end, a passage extending from the first end to the second end, and a flange extending radially outward from the second end; an outer penetrator extending from the second end of and in fixed relation to the hub, the outer penetrator defining a longitudinal channel in communication with the passage of the hub; a connector having a first end and a second end that is configured to be coupled to the first end of the hub, the first end configured to be releasably coupled to a drive shaft of a driver such that the driver can rotate the connector and the hub to drill the outer penetrator into a bone and associated bone marrow; where the flange is configured to stabilize the hub against tissue overlying the bone when the outer penetrator is disposed in the bone.

Certain exemplary embodiments can provide a penetrator assembly for penetrating a bone marrow comprising: a hub having a first end, a second end, a passage extending from the first end to the second end, and a flange extending radially outward from the second end; an outer penetrator extending from the second end of and in fixed relation to the hub, the outer penetrator defining a longitudinal channel in communication with the passage of the hub; a connector having a first end and a second end that is configured to be coupled to the first end of the hub, the first end configured to be releasably coupled to a drive shaft of a driver such that the driver can rotate the connector and the hub to drill the outer penetrator into a

bone and associated bone marrow, the first end of the connector comprises a connector receptacle configured to receive a portion of the drive shaft; and a magnetic disc disposed in the connector receptacle to resist separation
5 of the connector from the drive shaft.

Certain exemplary embodiments can provide a system for penetrating a bone marrow, the system comprising: a housing; a penetrator assembly operable to penetrate the bone marrow, the penetrator assembly including a removable
10 inner trocar and an outer penetrator; a first connector operable to releasably attach the penetrator assembly to a drill shaft, the drill shaft operable to connect the penetrator assembly to a gear assembly; a gear assembly operable to engage and rotate the drill shaft; a motor
15 operable to engage the gear assembly and drive the penetrator assembly into the bone marrow by rotation of the drill shaft; a power supply and associated circuitry operable to power the motor; a second connector operable to connect the outer penetrator to at least one section of
20 tubing; and the second connector comprising a right angle connector.

Certain exemplary embodiments can provide a system for penetrating a bone marrow, the system comprising: a housing; a penetrator assembly operable to penetrate the
25 bone marrow; a first connector operable to releasably attach the penetrator assembly to a drill shaft; a gear assembly operable to engage and rotate the drill shaft; a power supply and associated circuitry operable to power the

motor; and a second connector operable to connect a portion of the penetrator assembly to at least one section of tubing; where the drill shaft is operable to connect the penetrator assembly to the gear assembly; and where the
5 motor is operable to engage the gear assembly and drive the penetrator into the bone marrow by rotation of the drill shaft.

Certain exemplary embodiments can provide an apparatus comprising: a penetrator assembly operable for insertion
10 into bone marrow; and a right angle connector operable to couple the penetrator assembly to a source of intravenous fluid.

Certain exemplary embodiments can provide an apparatus for connecting a penetrator after insertion into bone
15 marrow to a source of intravenous fluids, the apparatus comprising a right angle connector and at least one section of tubing.

In another embodiment an apparatus for penetrating a bone marrow is provided that includes a housing and a
20 penetrator assembly. The penetrator assembly is operable to penetrate the bone marrow, having a removable inner trocar and an outer penetrator. A connector operable to releasably attach the penetrator assembly to a drill shaft is included. The drill shaft is operable to connect the
25 penetrator assembly to a gear assembly. The gear assembly is operable to engage and rotate the drill shaft. A motor operable to engage the gear assembly and drive the penetrator into the bone marrow by rotation of the drill shaft and a power supply and associated circuitry operable
30 to power the motor are also included.

2d

reduction gear assembly and drive the penetrator assembly into the bone marrow by rotation of the drill shaft; and a power supply and associated circuitry operable to power the motor.

- 5 In one embodiment of the invention an apparatus for penetrating a bone marrow is provided that includes a housing and a penetrator assembly. The penetrator assembly is operable to penetrate the bone marrow, having a removable inner trocar and an outer penetrator. A

In another embodiment an apparatus for penetrating a bone marrow is provided that includes a housing and a penetrator assembly, operable to penetrate the bone marrow. A connector operable to releasably attach the penetrator assembly to a drill shaft, the drill shaft operable to connect the penetrator assembly to a reduction gear assembly is included. A reduction gear assembly operable to engage and rotate the drill shaft and a motor operable to engage the reduction gear assembly and drive the penetrator into the bone marrow by rotation of the drill shaft are also included. A power supply and associated circuitry operable to power the motor are also provided.

In another embodiment a penetrator assembly operable to provide access to a bone marrow comprising an outer penetrator and a removable inner trocar operable to penetrate the bone marrow is provided. A connector operable to releasably attach the penetrator assembly to a power drill is also included.

In another embodiment a penetrator assembly operable to provide access to a bone marrow comprising an outer penetrator and a removable inner trocar operable to penetrate the bone marrow is provided. The inner trocar includes a handle, the handle including a grasping means that allows a user to grasp and manipulate the device. The outer penetrator includes a handle, the handle including a grasping means, and also includes a flange operable to engage an insertion site proximate the bone marrow. A connector operable to releasably attach the penetrator assembly to a power drill is also provided. The inner trocar is operable to releasably engage the connector.

In another embodiment a method of accessing a bone marrow is provided that includes inserting a penetrator assembly into the bone marrow by means of a powered apparatus, detaching the powered apparatus from the penetrator, removing an inner trocar from an outer penetrator of the assembly and attaching a right angle connector to the outer penetrator.

In another embodiment a method of accessing a bone marrow is provided that includes inserting a penetrator assembly into the bone marrow by means of a powered apparatus, detaching the powered apparatus from the penetrator, removing an inner trocar from an outer penetrator of the assembly and attaching an adapter suitable to convey medications or fluids to the bone marrow.

In yet another embodiment a method of manufacturing an apparatus operable to penetrate a bone marrow is provided that includes manufacturing a housing having a connector operable to releasably attach a penetrator assembly to a drill shaft, a drill gear assembly, a gear assembly operable to engage and rotate the drill shaft, a motor operable to engage the gear assembly and drive a penetrator assembly into the bone marrow and a power supply and associated circuitry operable to power the motor and manufacturing a penetrator assembly operable to releasably attach to the connector.

In a further embodiment, a kit for use in penetrating a bone marrow in an extremity is provided that includes a carrying case, an apparatus for penetrating the bone marrow including a housing and penetrator assemblies operable to penetrate the bone marrow, a removable inner trocar and an outer penetrator forming portions of at least one of the penetrator assemblies, at least one connector operable to releasably attach the penetrator assemblies to a drill shaft, a gear assembly operable to engage and rotate the drill shaft, a motor operable to engage the reduction gear assembly and drive at least one of the penetrator assemblies into the bone marrow and a power supply and associated circuitry to power the motor and a strap operable to immobilize the outer penetrator to a site in an extremity.

BRIEF DESCRIPTION OF THE DRAWINGS

A more complete and thorough understanding of the present embodiments and advantages thereof may be acquired by referring to the following description taken in conjunction with the accompanying drawings, in which like reference numbers indicate like features, and wherein:

FIGURE 1A is a schematic drawing showing an isometric view of one embodiment of the present invention;

FIGURE 1B is a schematic drawing showing an isometric view of one embodiment of the present invention;

FIGURE 2A is a schematic drawing showing an isometric view of one embodiment of the present invention;

FIGURE 2B is a schematic drawing showing an isometric view of one embodiment of the present invention;

FIGURE 3A-C illustrates a side and cross-sectional view of one embodiment of the present invention;

FIGURE 4A-C illustrates various alternate embodiments of a reduction gear mechanism that may be included in an embodiment of the present invention;

FIGURE 5A-C illustrates one embodiment of a penetrator assembly of the present invention;

FIGURES 6A-C illustrate various alternate embodiments of a penetrator assembly connector of the present invention;

FIGURE 7A illustrates one embodiment of a penetrator assembly of the present invention;

FIGURE 7B illustrates a cross-sectional view of one embodiment of a penetrator assembly of the present invention;

FIGURE 7C illustrates one embodiment of an inner trocar in cross section of the present invention;

FIGURE 7D illustrates one embodiment of an outer penetrator in cross section of the present invention.

FIGURE 7E-G illustrate examples of release mechanisms of the present invention.

FIGURE 8A illustrates one embodiment of a tip of a penetrator assembly of the present invention;

FIGURE 8B illustrates one embodiment of a tip of a penetrator assembly of the present invention;

FIGURE 9 illustrates one embodiment of a kit to access the bone marrow of the present invention; and

FIGURE 10 illustrates one embodiment of a connector to attach to an outer penetrator of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Preferred embodiments of the invention and its advantages are best understood by reference to FIGURES 1A-10 wherein like numbers refer to same and like parts.

10 Various examples of an apparatus operable to access the bone marrow in accordance with the present invention are shown generally in FIGURES 1A and 1B at 10. Apparatus 10 as shown in FIGURES 1A and 1B generally includes housing 12 and penetrator assembly 14. Housing
15 12 includes handle 16 that is sized and contoured to fit the hand of an operator. Handle 16 may include on/off switch 22 and safety 24. Penetrator assembly 14 includes outer penetrator 18, inner trocar (not expressly shown) and penetrator assembly connector 20.

20 FIGURE 2A and 2B illustrate an alternate embodiment of the present invention. Apparatus 10a generally includes housing 12 and penetrator assembly 14a. Housing 12 includes handle 16 that is sized and contoured to fit the hand of an operator. Handle 16 may include an on/off
25 switch 22. Penetrator assembly 14a includes outer penetrator 18, inner trocar(not expressly shown) and penetrator assembly connector 20. Penetrator assembly 14a may include penetrator shield 26. An outer penetrator may include either a trocar, a needle, a
30 cannula, a hollow tube, a drill bit or a hollow drill bit.

FIGURES 3A and 3B illustrate yet another embodiment of the present invention. Apparatus 10b generally includes housing 12 and a penetrator assembly (not expressly shown). Housing 12 includes handle 16 and
5 on/off switch 22. Penetrator assembly may include penetrator (not expressly shown) and a connector, for example a pentagonal connector 20 as shown in figure 3A. As shown in FIGURE 3B, housing 12 encloses motor 30, power supply 32, for example four or more AA batteries,
10 motor connecting wires 34 between power supply 32 and motor 30 and switch connecting wires 36 between on/off switch 22 and power supply 32. The power supply to the apparatus may be any suitable number of AA batteries or any other type of battery, a source of direct current, a
15 source of alternating current or a source of air or gas power. The motor may be reciprocating or rotational. Thruster bearing 45, for example a washer, may be located adjacent to housing 12 where drill shaft 40 exits housing 12. Thruster bearing 45 prevents the thrust or
20 penetration force of drilling from being placed on gear assembly 38 as penetrator is drilled into bone. FIGURE 3C shows one embodiment of the invention where drill shaft 40 may be separated into two interdigitating pieces at 42 in order to allow the two ends of drill shaft 40 to slide
25 in and out as bone is penetrated to avoid applying excessive force to a gear assembly.

In FIGURE 3B gear assembly 38 is coupled to motor 30. Gear assembly 38 may be a reduction gear assembly such as that shown in figure 3B that functions to reduce
30 the revolutions per minute (RPMs) between the motor and drill shaft 40 and to increase drill shaft torque.

Depending on the type of motor employed in the invention, gear assembly may or not be of the reduction type.

By way of example and not limitation, a reduction gear assembly, for example a worm gear assembly is shown
5 in more detail in FIGURE 4A and may include first connector 43 that connects shaft 44 of motor 30 to worm gear 46. Worm gear 46 may engage spur gear 47. Reduction gear assembly 38 may be used to decrease the RPMs between the motor and penetrator assembly to provide
10 an optimum RPM at the point of insertion of penetrator assembly into bone. Reduction gear assembly 38 may also be used to increase the torque of drill shaft and drilling power.

FIGURE 4B illustrates one embodiment of reduction gear assembly 38 wherein a first spur gear 47 engages a
15 second spur gear 49. FIGURE 4C illustrates an alternate embodiment of reduction gear assembly 38 wherein spur gear 47 is offset from mitered gear 48 that may be preferable in some embodiments of the present invention.
20 Other gears may be used in a reduction gear assembly, for example a planetary gear (not expressly shown) that may be used alone or in combination with a worm gear or a spur gear. In one embodiment of the current invention, gear assembly may be any suitable gear arrangement and is
25 not limited to a reduction gear assembly.

FIGURES 5A-5C illustrate one embodiment of a penetrator assembly 55 operable to penetrate a bone marrow, having a removable inner trocar 50 and an outer
penetrator 52. Also shown in FIGURE 5A is a penetrator
30 shield 26 that may be used to shield penetrator assembly 55 from inadvertent engagement and also serves to preserve needle sterility. In some embodiments outer

penetrator 52 may be a type of needle or cannula. FIGURE 5B illustrates outer penetrator 52 may include a male connecting piece 56 operable to engage a complementary female connecting piece 54 of inner trocar 50. Adjacent to male connecting piece 56 is connecting piece locking mechanism 58 that locks into position on female connecting piece 54. Alternatively outer penetrator may include a female connecting piece suitable to engage a complementary male connecting piece of an inner trocar. Luer lock attachment 57 is coupled to male connecting piece 56 for connection to an intravenous tubing or syringe after the outer penetrator is positioned in the bone marrow. Male connecting piece 56 and female connecting piece 54 may also be of the luer-lock type. Inner trocar 50 includes stylet 53 that keeps outer penetrator 52 from getting plugged with debris created during drilling. Stylet 53 acts in combination with cannula portion 51 of outer penetrator. Outer penetrator 52 may include flange 60 that abuts or interfaces the skin of an insertion site and may be used to stabilize a penetrator assembly at the time of insertion. Penetrator assembly 55 may include various types of connectors, such as connector 62 that may be used to connect penetrator assembly 55 to a powered drill. Connector 62 may be pentagonal as shown in FIGURES 5A and 5C.

In one embodiment, the invention may include a specialized connector between the penetrator assembly and a powered drill. The connector performs at least two functions, a connecting function and a releasing function. The connecting function may be performed by various mechanisms such as a pentagonal male-female fitting or various lock-and-key mechanisms such as one

that may include a combination or series of grooves and ridges or bars that match and interlock on a connector.

The releasing function may be performed by an O-ring connection, a magnetic connector, a chuck release
5 mechanism, or a ball and detent mechanism with and without a spring. In one embodiment the releasing function may occur by means of a trigger mechanism whereby a trigger comes in contact with a holding mechanism and releases a penetrator or needle. In
10 another embodiment a connecting mechanism may also include a trigger or retractable shield rod that slides up and contacts a holding mechanism or clamp that breaks away and releases a penetrator or needle after contact (not expressly shown).

15 FIGURES 6A-C illustrate alternate embodiments of connectors operable to releasably attach penetrator assembly 55 to powered drill apparatus 10. FIGURE 6A illustrates penetrator assembly connector 62 wherein connector 62 is formed to fit into a connector receptacle
20 64 and releasably lock into place. In this example, connector 62 and connector receptacle 64 are pentagonal shaped. Advantages of this embodiment may be the ease of attachment and removal of penetrator assembly 55 from powered drill apparatus 10. Penetrator assembly
25 connector 62 may be formed from metal or plastic.

FIGURE 6B illustrates an alternate embodiment of penetrator assembly connector wherein a female pentagonal receptacle 65 is operable to engage pentagonal connecting piece 66 attached to powered drill apparatus 10. FIGURE
30 6C illustrates a further embodiment of a penetrator assembly connector wherein penetrator assembly connector 68 is a proprietary design having a pattern of ridges or

bars 70 that engage a matching pattern of slots 71 on a connecting receptacle 72. Example penetrator assembly connectors may include any type of lock and key design or a pentagonal design. Penetrator assembly connectors of any type may be held in place by either a magnet, an O-ring connector or a ball and detent mechanism with or without a spring (not expressly shown).

In one embodiment, the penetrator assembly may include an outer penetrator such as a cannula, needle or hollow drill bit which may be of various sizes. Needles may be small (for pediatric patients), medium (for adults) and large (for over-sized adults). Penetrator, cannulas or needles may be provided in various configurations depending on the clinical purpose for needle insertion. For example, there may be one configuration for administering drugs and fluids and an alternate configuration for sampling bone marrow or for other diagnostic purposes although one needle configuration may be suitable for both purposes. Needle configuration may vary depending on the site chosen for insertion of a needle.

FIGURES 7A-7D illustrate one embodiment of a penetrator assembly 80 that includes a removable inner trocar 82 and an outer penetrator 84. FIGURE 7B illustrates a cross-sectional view of one embodiment of a penetrator assembly having a removable inner trocar 82 and an outer penetrator 84. Outer penetrator 84 includes flange 86 and flange groove 88. Flange 86 may be used to stabilize penetrator assembly 80 against the skin of an insertion site. Flange groove 88 is operable to engage plastic penetrator cover 94. The surface of outer penetrator may include a series of discs formed along a

longitudinal axis, a series of ridges or some other grasping means. This surface allows an operator to grasp the outer penetrator with two fingers and easily disengage the inner trocar 82 from outer penetrator 84.

5 Outer penetrator 84 includes a penetrator cannula 96 that is hollow when stylet 100 is removed.

In FIGURE 7C inner trocar 82 includes handle 98 that may have a surface such as a series of discs formed along a longitudinal axis of the trocar, or a series of ridges
10 or some other grasping means. Handle 98 allows an operator to easily grasp and manipulate inner trocar 82 and disengage it from outer penetrator 84. Inner trocar 82 also includes stylet 100. Stylet 100 exits an end of penetrator cannula 96 when inner trocar 82 is inserted
15 into outer penetrator 84. Stylet 100 includes a cutting tip and is operable to penetrate bone marrow. In one embodiment of the invention, inner trocar 82 may include metal disc 95 to allow a magnetic connection between penetrator assembly and powered drill. Receptacle 97 may
20 also engage a penetrator assembly male-type connector piece operable to connect penetrating assembly to a powered drill, or any other suitable connector.

FIGURES 7E-7G illustrate example release mechanisms that may be coupled to a connector and included in
25 penetrator assembly 80. FIGURE 7E illustrates one embodiment of a magnetic release mechanism where magnetic disc 70 is included in inner trocar 82. In this embodiment magnetic disc 70 is at the base of open area or receptacle 97. In alternative embodiments a magnetic
30 disc could be included with a pentagonal connector or a lock and key connector or any other suitable connector.

FIGURE 7F illustrates another embodiment of a release mechanism where O-ring 72 is included in trocar 98 as part of a connector. In this embodiment O-ring 72 is in the wall of receptacle 97. O-ring 72 is able to engage a lock and key connector, a pentagonal connector or any other suitable connector.

FIGURE 7G illustrates yet another embodiment of a release mechanism using ball and detent mechanism 74. In this embodiment ball and detent mechanism 74 is in the wall of receptacle 97. Ball and detent mechanism 74 is able to engage a lock and key connector, a pentagonal connector or any other suitable connector.

FIGURE 8A illustrates an embodiment of an outer penetrator needle 110 and inner stylet 112. Cutting tip 114 of outer penetrator needle 110 and tip of inner stylet 112 are operable to penetrate bone marrow. In one embodiment of the invention the outer penetrator needle and the inner stylet are ground together as one unit in the manufacturing process to ensure that the two pieces are an exact fit and act as a single drilling unit.

FIGURE 8B illustrates another embodiment of an outer penetrator needle 96 and an inner stylet 100. Cutting tip 102 of inner stylet 100 is operable to penetrate bone marrow. Inner stylet may also include a longitudinal groove 104 that runs along the side of stylet 100 that allows bone chips and tissue to exit an insertion site as a penetrator assembly is drilled deeper into bone. Outer penetrator or needle 96 includes cutting tip 106 that facilitates insertion of outer penetrator or needle 96 and minimizes damage to outer penetrator or needle 96 as penetrator assembly 55 is inserted into bone marrow. In one embodiment of the invention the outer penetrator

needle and the inner stylet are ground together as one unit in the manufacturing process to ensure that the two pieces are an exact fit and act as a single drilling unit.

5 FIGURE 9 illustrates one embodiment of kit 120 to penetrate bone marrow. Kit 120 includes apparatus 10 for penetrating bone marrow, alternative sizes of penetrator assemblies 122, and strap 124 suitable to immobilize an outer penetrator on an extremity during insertion of
10 penetrator assembly 122. Carrying case 125 is also included.

Once an outer penetrator or needle is inserted into a bone, it may be connected to a source of intravenous fluids or medication. FIGURE 10 illustrates an example
15 of a connector that may be used to connect the outer penetrator of a penetrator assembly to tubing 130, for example an intravenous tubing for providing intravenous fluids or medications to a person. Outer penetrator 84 is inserted into the bone marrow of an extremity. Right
20 angle connector 132 is then used to connect intravenous tubing 130 to outer penetrator 84. Right angle connector has the advantage of allowing tubing to be connected to an outer penetrator or needle at an angle that will not kink or pinch off the lumen of the tubing. Other
25 connectors or adapters may also be used to connect an outer penetrator to an intravenous tubing, another kind of tubing or to a syringe for use in providing medication or fluids to a person or for use in withdrawing a sample of blood from the bone marrow.

30 A method for providing access to the bone marrow includes using a powered drill, capable of reciprocal or rotational motion, to insert a penetrator assembly that

includes an outer penetrator and an inner trocar into a bone marrow cavity. The powered drill is then released from the penetrator assembly and the inner trocar is grasped and removed from the outer penetrator. A
5 connector present on the end of the outer penetrator, for example a luer lock connector, is then available for attachment to either an adapter, such as a right angle connector or directly to an intravenous tubing or syringe.

CLAIMS

1. A penetrator assembly for penetrating a bone marrow comprising:

5 a hub having a first end, a second end, a passage extending from the first end to the second end, and a flange extending radially outward from the second end;

an outer penetrator extending from the second end of and in fixed relation to the hub, the outer penetrator
10 defining a longitudinal channel in communication with the passage of the hub;

a connector having a first end and a second end that is configured to be coupled to the first end of the hub, the first end configured to be releasably coupled to a drive
15 shaft of a driver such that the driver can rotate the connector and the hub to drill the outer penetrator into a bone and associated bone marrow;

where the flange is configured to stabilize the hub against tissue overlying the bone when the outer penetrator
20 is disposed in the bone.

2. The penetrator assembly of claim 1, further comprising:

an inner penetrator extending from the second end of
25 the connector and configured to extend through the longitudinal channel of the outer penetrator when the connector is coupled to the hub.

3. The penetrator assembly of claim 2, where the inner penetrator extends from the second end of the connector by a distance that is longer than a length of the outer penetrator.

5

4. The penetrator assembly of claim 1, where the first end of the connector comprises a connector receptacle configured to receive a portion of the drive shaft.

10

5. The penetrator assembly of claim 4, where the connector receptacle has a cross-sectional perimeter defined by a plurality of adjacent lines of substantially equal length.

15

6. The penetrator assembly of claim 5, where the connector receptacle has a cross-sectional perimeter that is pentagonal.

20

7. The penetrator assembly of claim 4, further comprising:

a magnetic disc disposed in the connector receptacle to resist separation of the connector from the drive shaft.

25

8. The penetrator assembly of claim 1, where the first end of the hub includes a Luer fitting configured to be releasably engaged by the second end of the connector.

9. The penetrator assembly of claim 8, where the second end of the connector includes a Luer fitting configured to releasably engage the Luer fitting of the hub.

5

10. The penetrator assembly of claim 9, where the Luer fitting includes male threads.

11. The penetrator assembly of claim 10, where the second end of the connector includes female threads.

10

12. A penetrator assembly for penetrating a bone marrow comprising:

a hub having a first end, a second end, a passage extending from the first end to the second end, and a flange extending radially outward from the second end;

15

an outer penetrator extending from the second end of and in fixed relation to the hub, the outer penetrator defining a longitudinal channel in communication with the passage of the hub;

20

a connector having a first end and a second end that is configured to be coupled to the first end of the hub, the first end configured to be releasably coupled to a drive shaft of a driver such that the driver can rotate the connector and the hub to drill the outer penetrator into a bone and associated bone marrow, the first end of the connector comprises a connector receptacle configured to receive a portion of the drive shaft; and

25

a magnetic disc disposed in the connector receptacle to resist separation of the connector from the drive shaft.

30

13. The penetrator assembly of claim 12, where the flange is configured to stabilize the hub against tissue overlying the bone when the outer penetrator is disposed in the bone.

5 14. The penetrator assembly of claim 12, further comprising:

an inner penetrator extending from the second end of the connector and configured to extend through the longitudinal channel of the outer penetrator when the
10 connector is coupled to the hub.

15 15. The penetrator assembly of claim 14, where the inner penetrator extends from the second end of the connector by a distance that is longer than a length of the outer penetrator.

20 16. The penetrator assembly of claim 12, where the connector receptacle has a cross-sectional perimeter defined by a plurality of adjacent lines of substantially equal length.

25 17. The penetrator assembly of claim 16, where the connector receptacle has a cross-sectional perimeter that is pentagonal.

18. The penetrator assembly of claim 12, where the first end of the hub includes a Luer fitting configured to be releasably engaged by the second end of the connector.

19. The penetrator assembly of claim 18, where the second end of the connector includes a Luer fitting configured to releasably engage the Luer fitting of the hub.

5

20. The penetrator assembly of claim 19, where the Luer fitting includes male threads.

21. The penetrator assembly of claim 20, where the
10 second end of the connector includes female threads.

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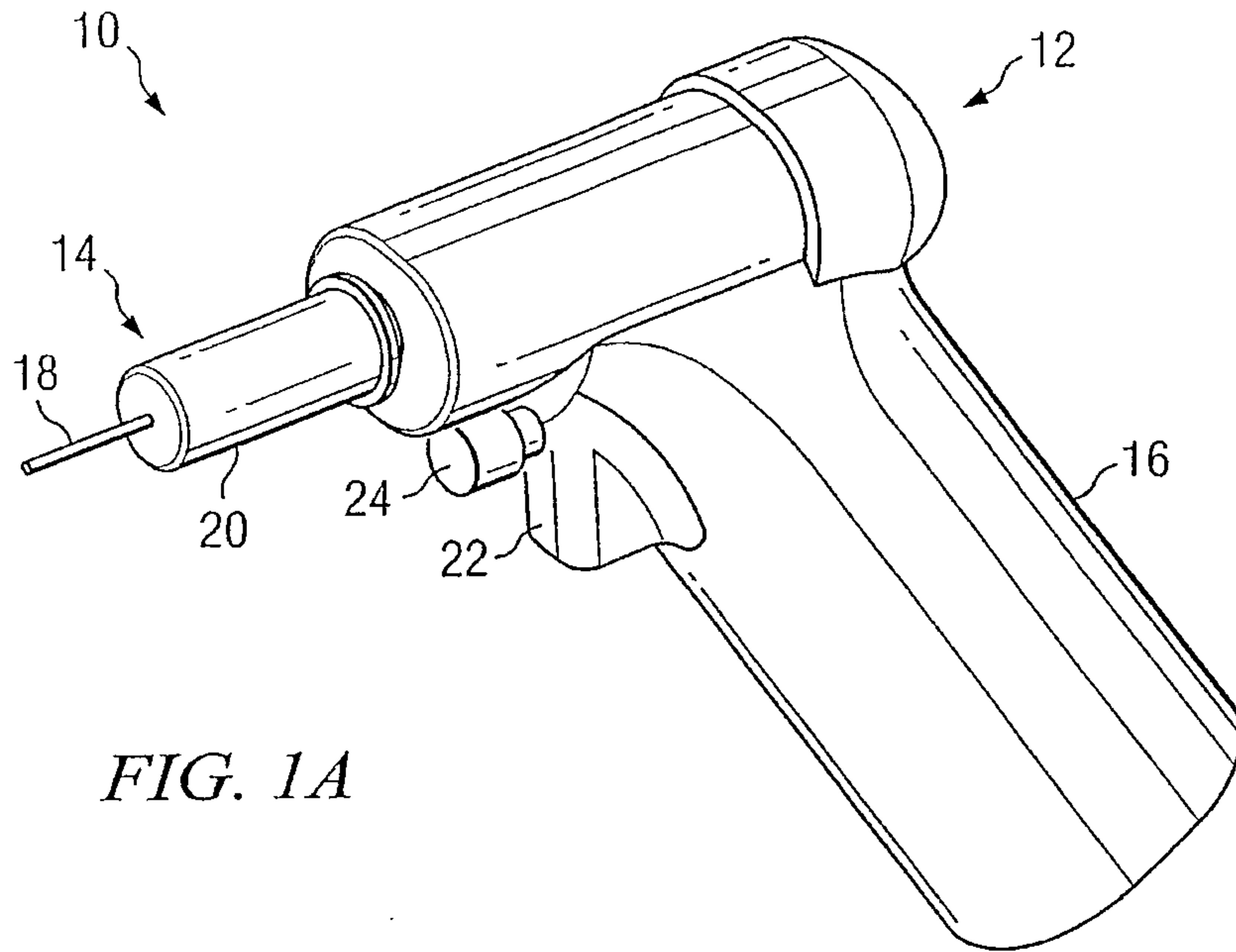


FIG. 1A

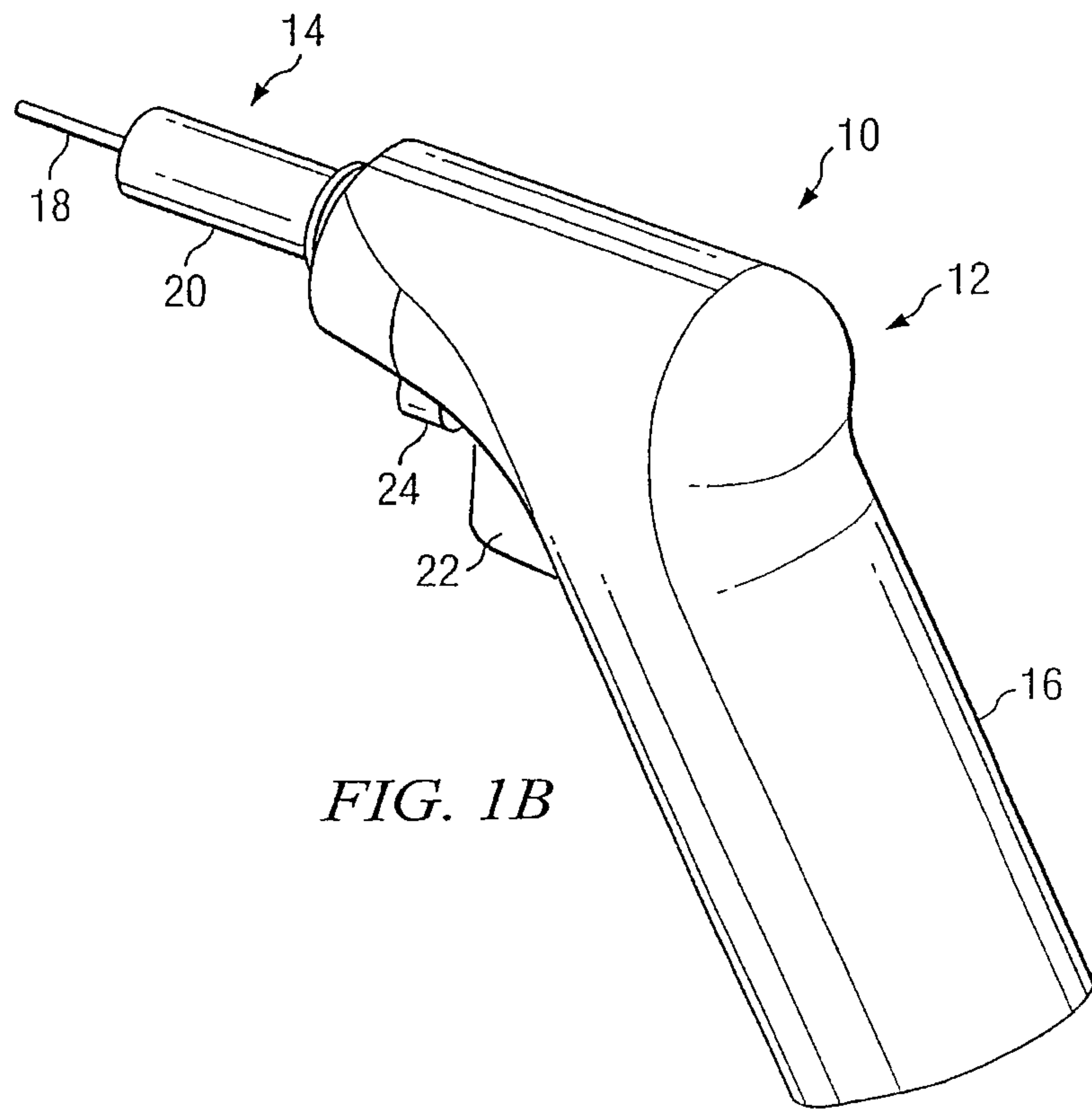
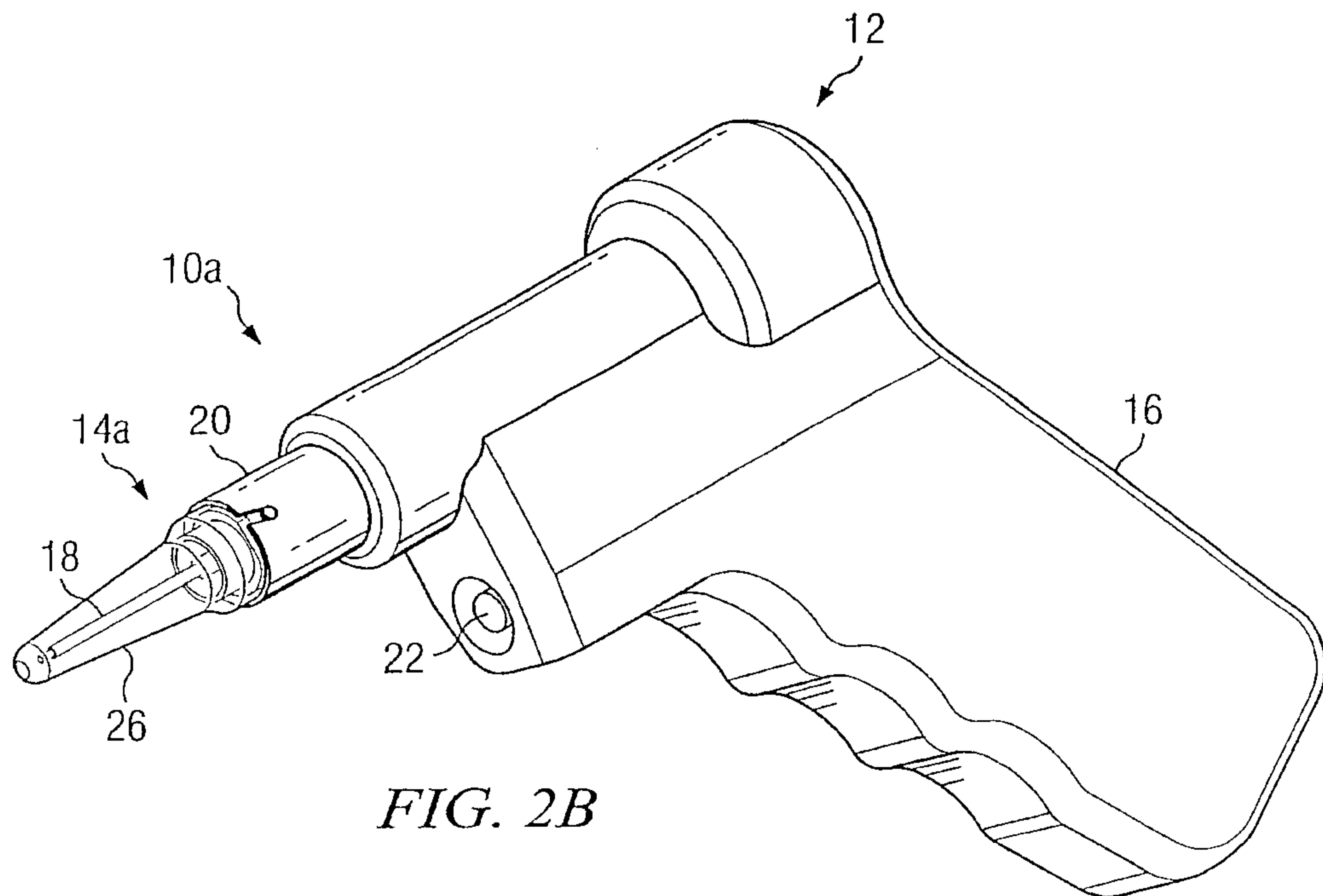
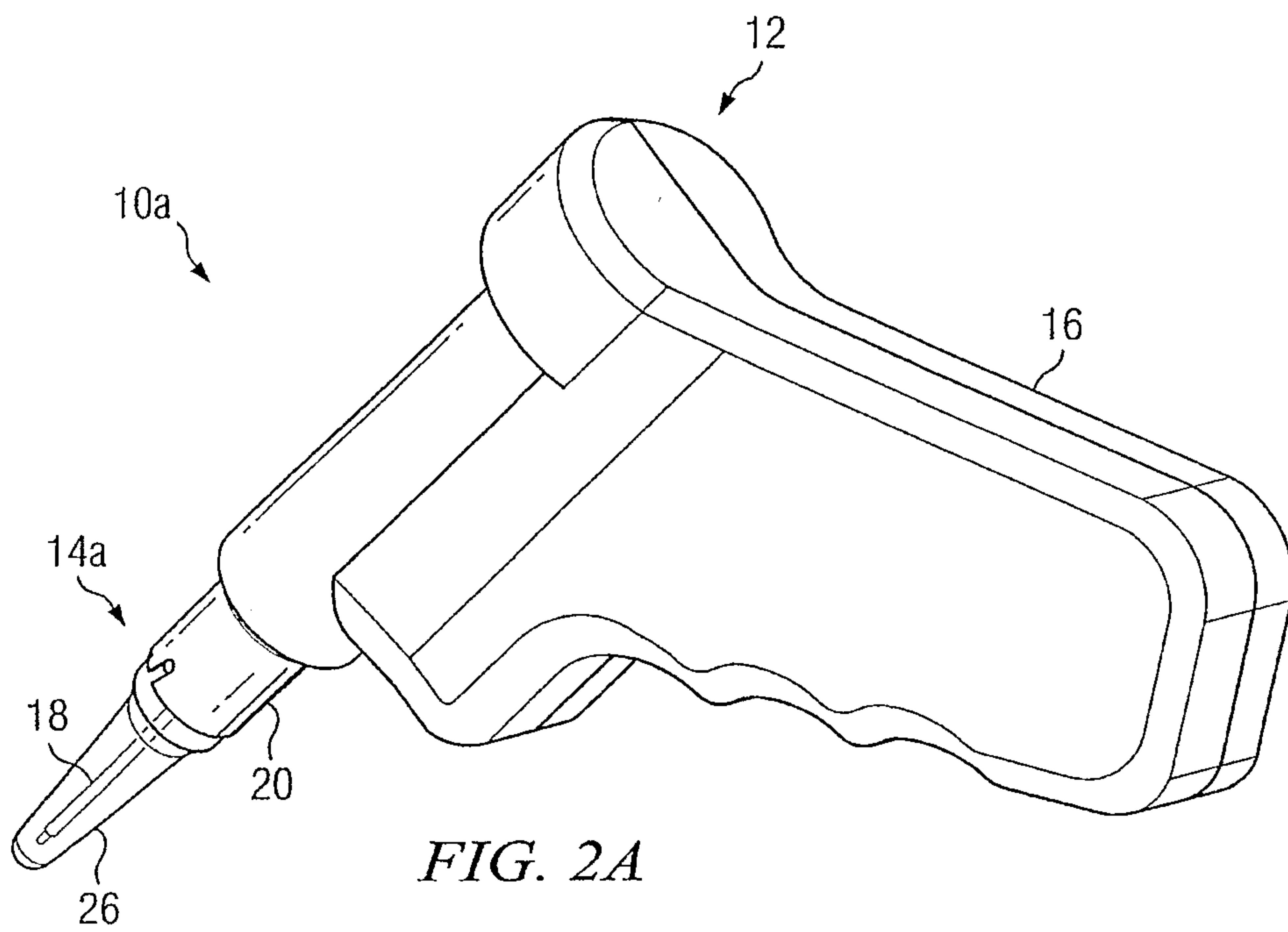
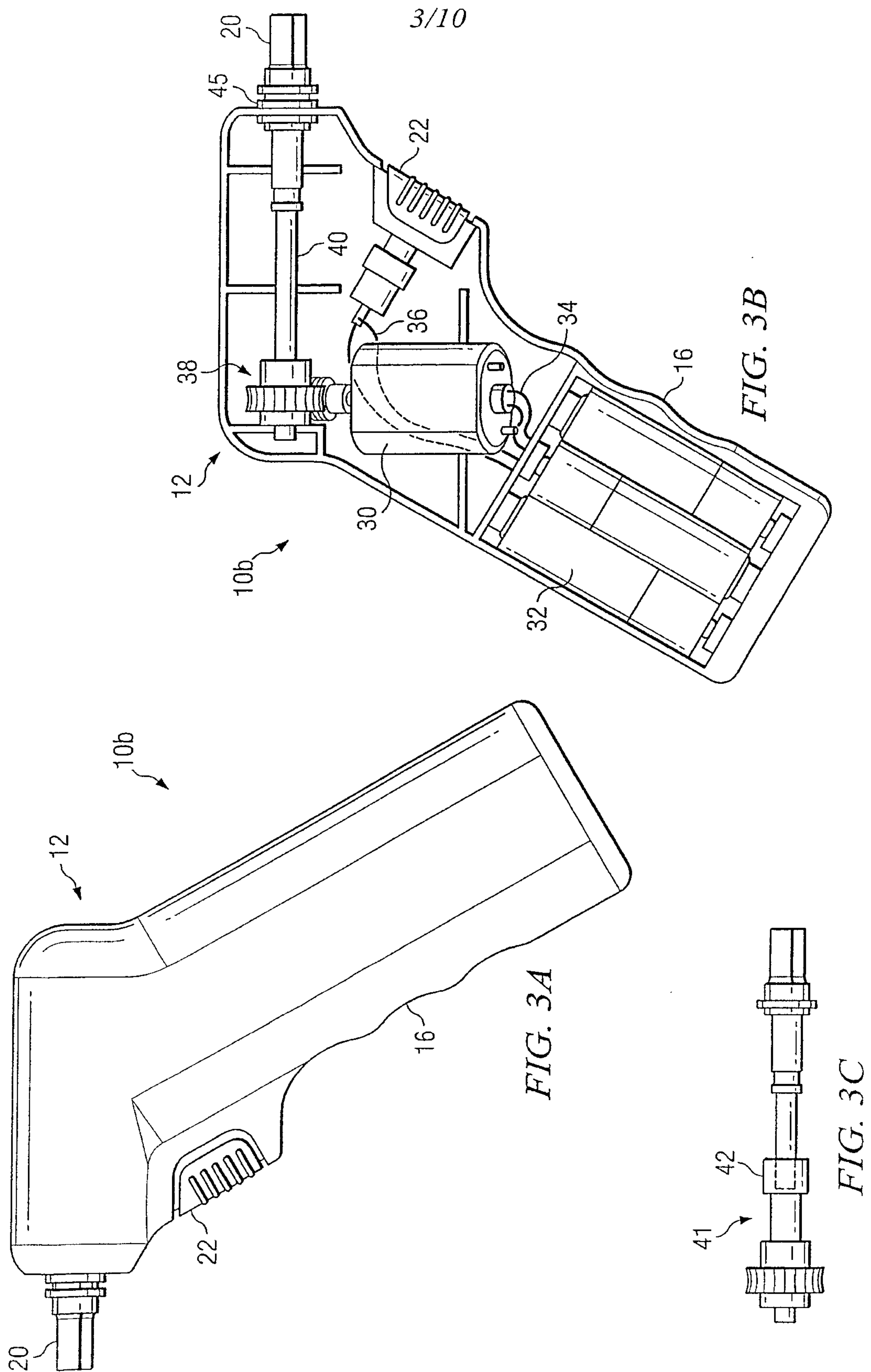


FIG. 1B

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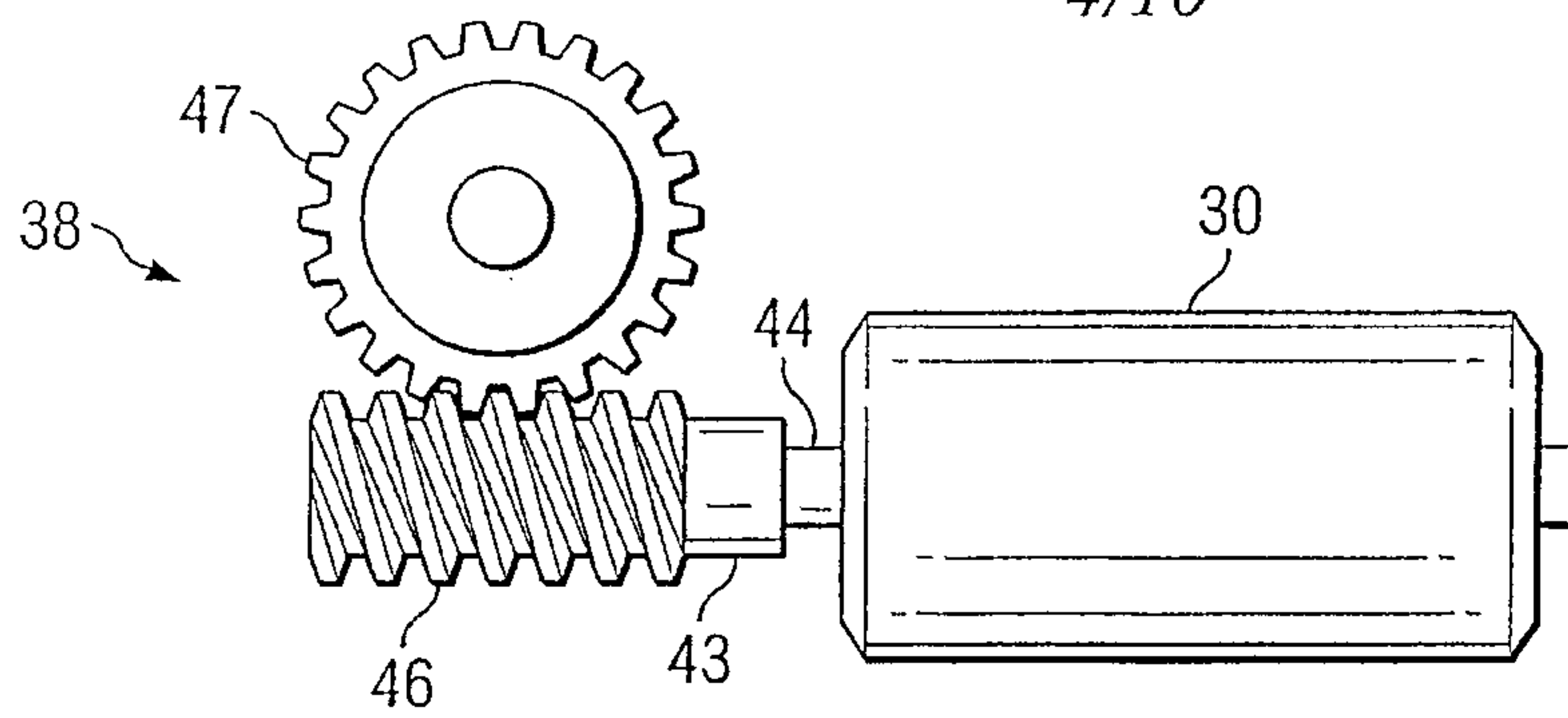


FIG. 4A

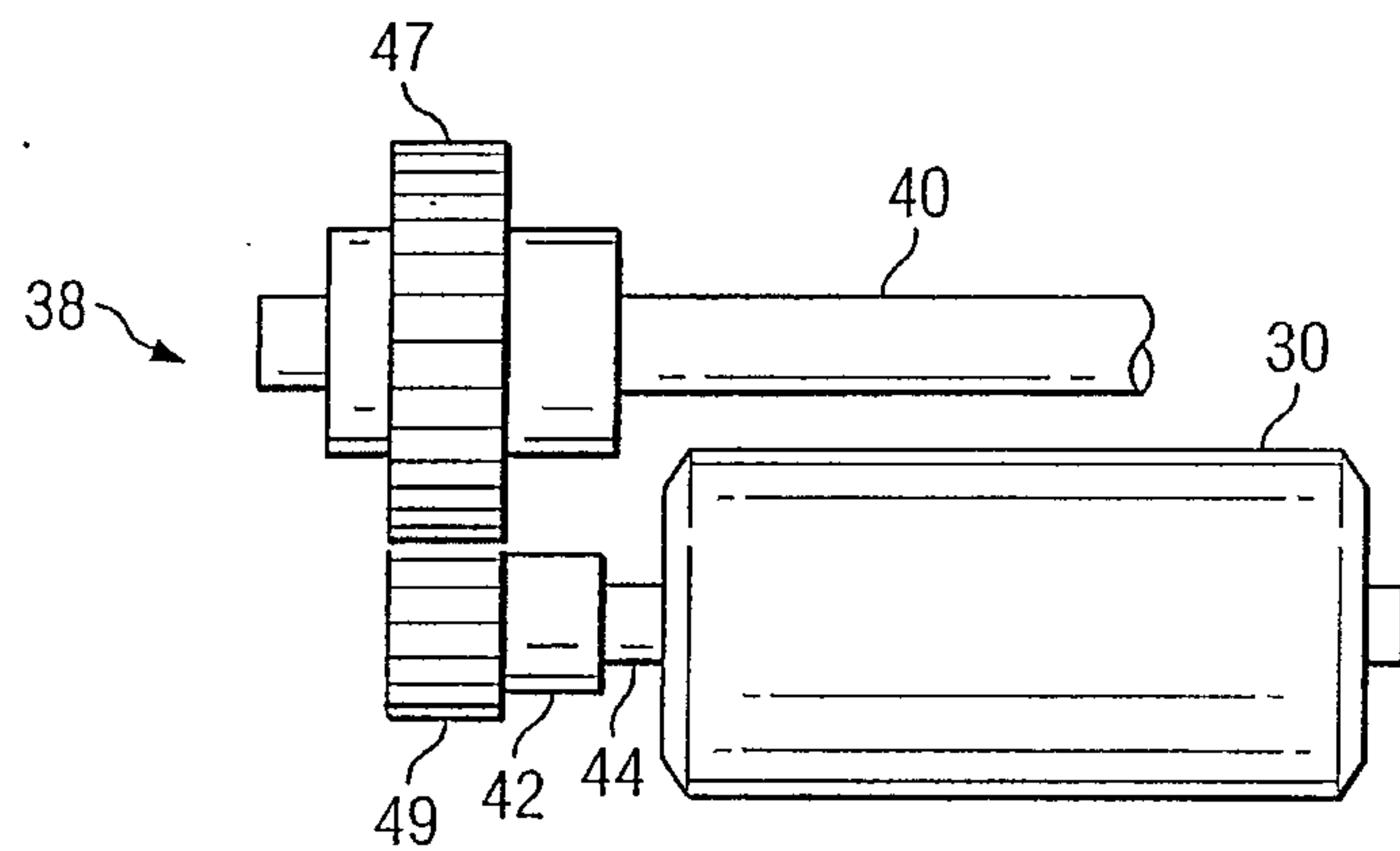


FIG. 4B

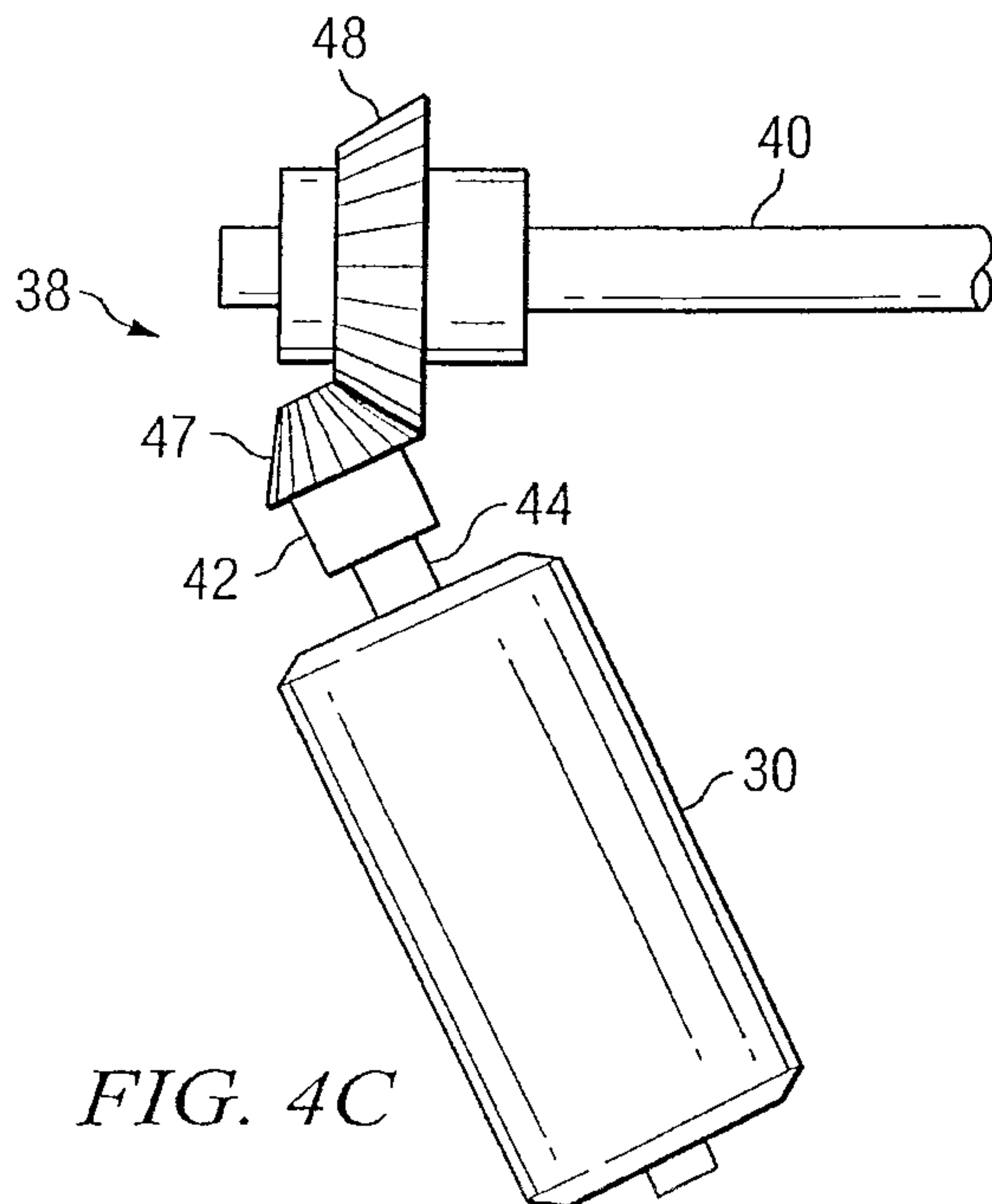
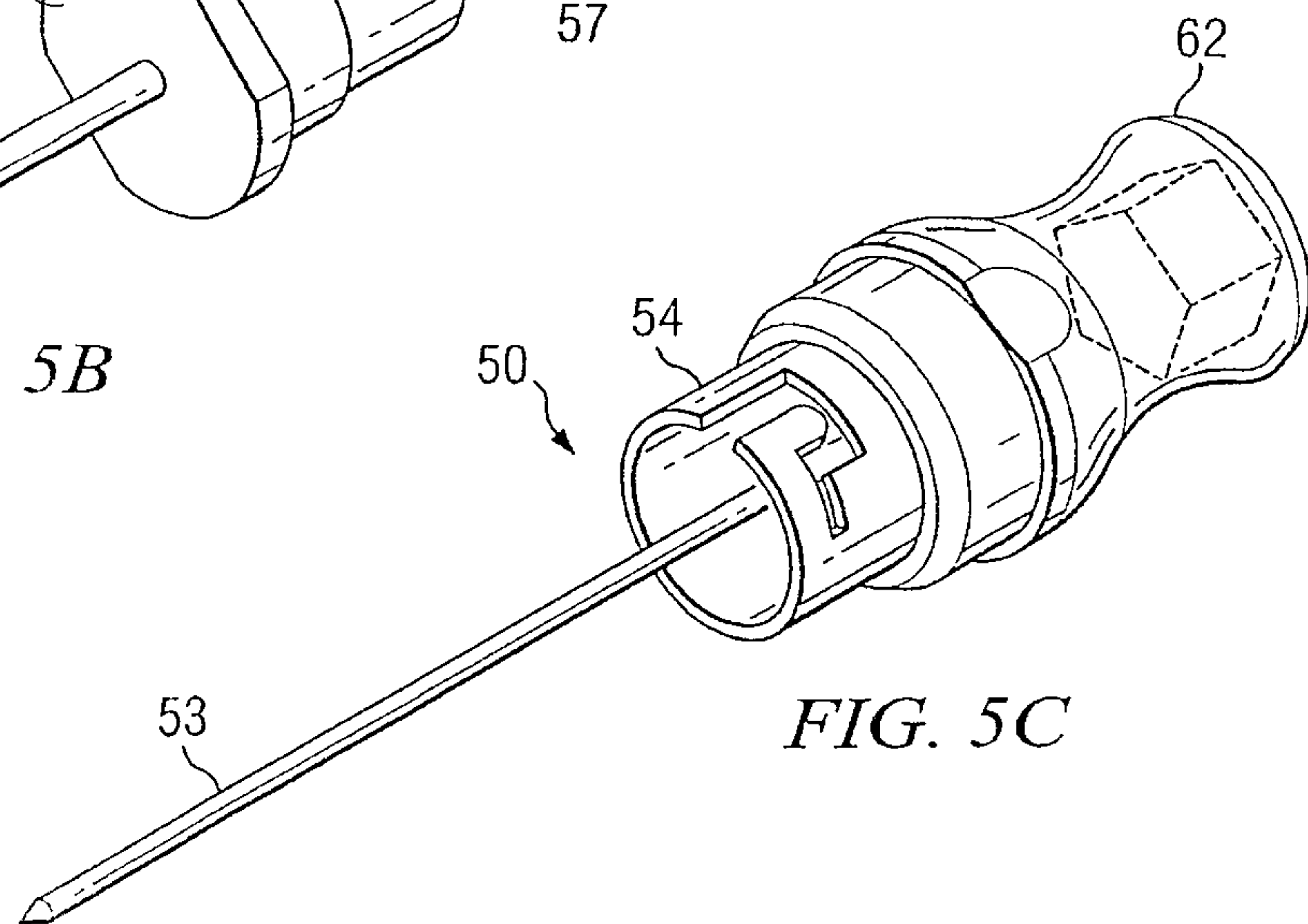
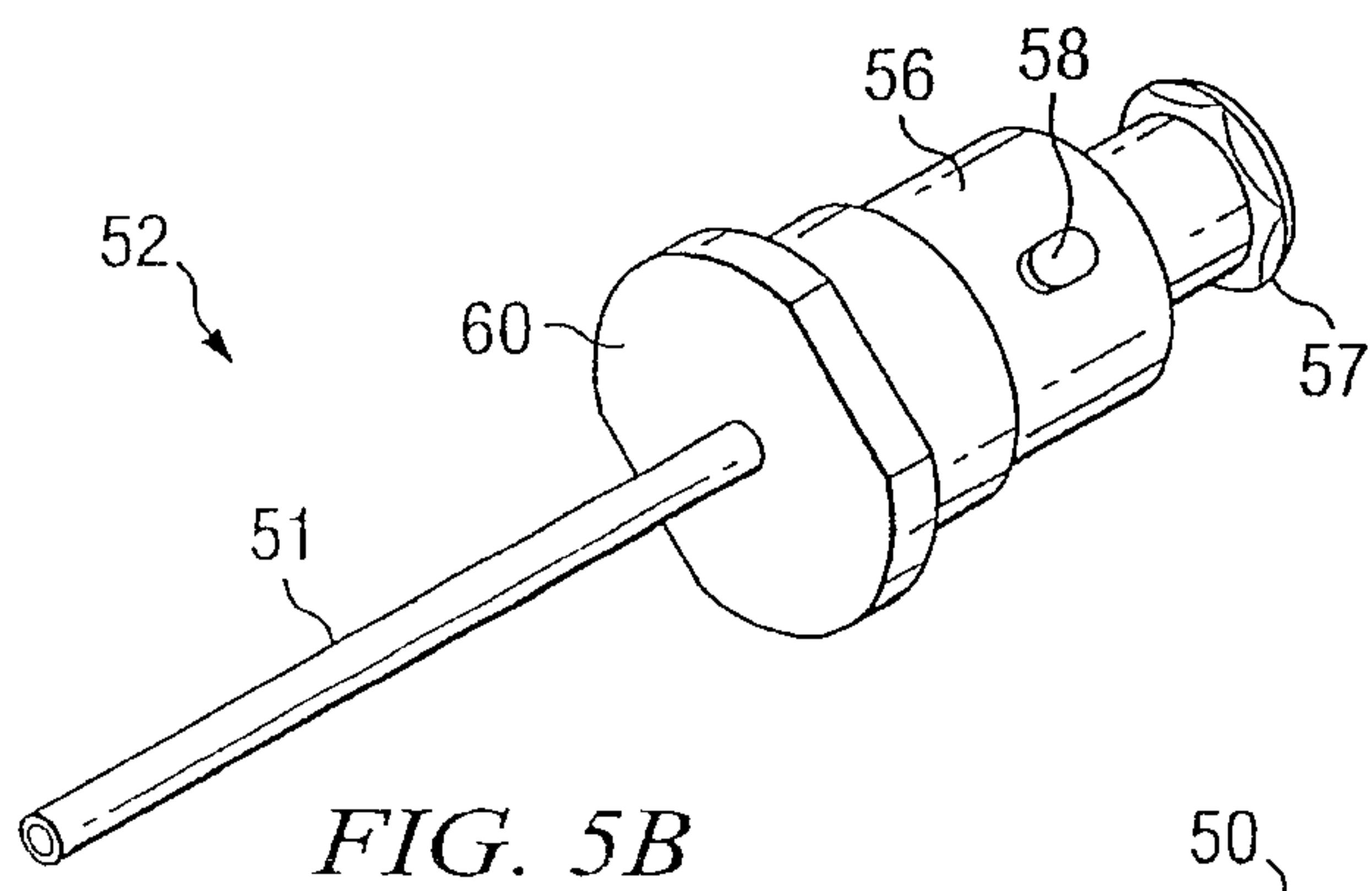
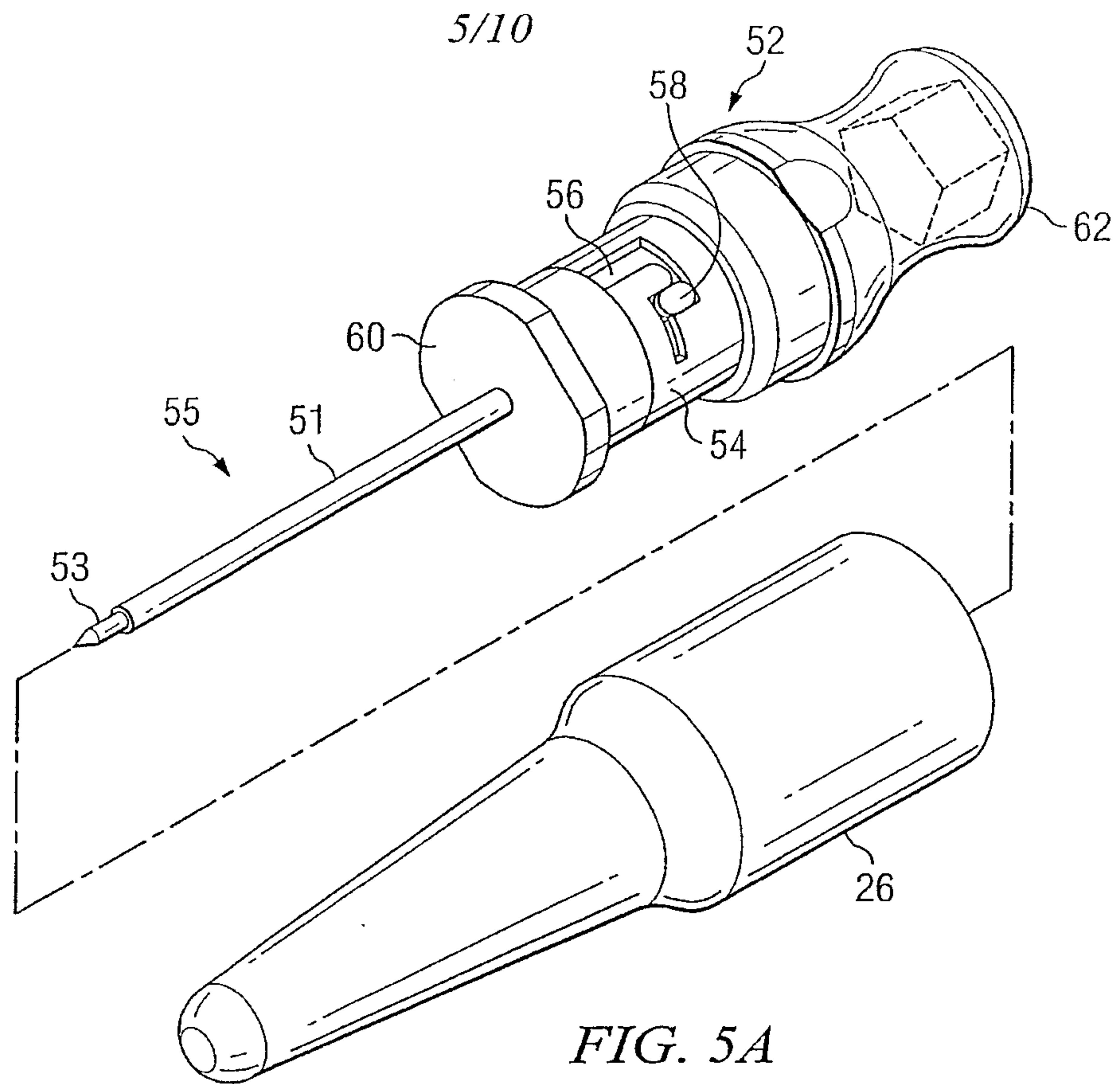
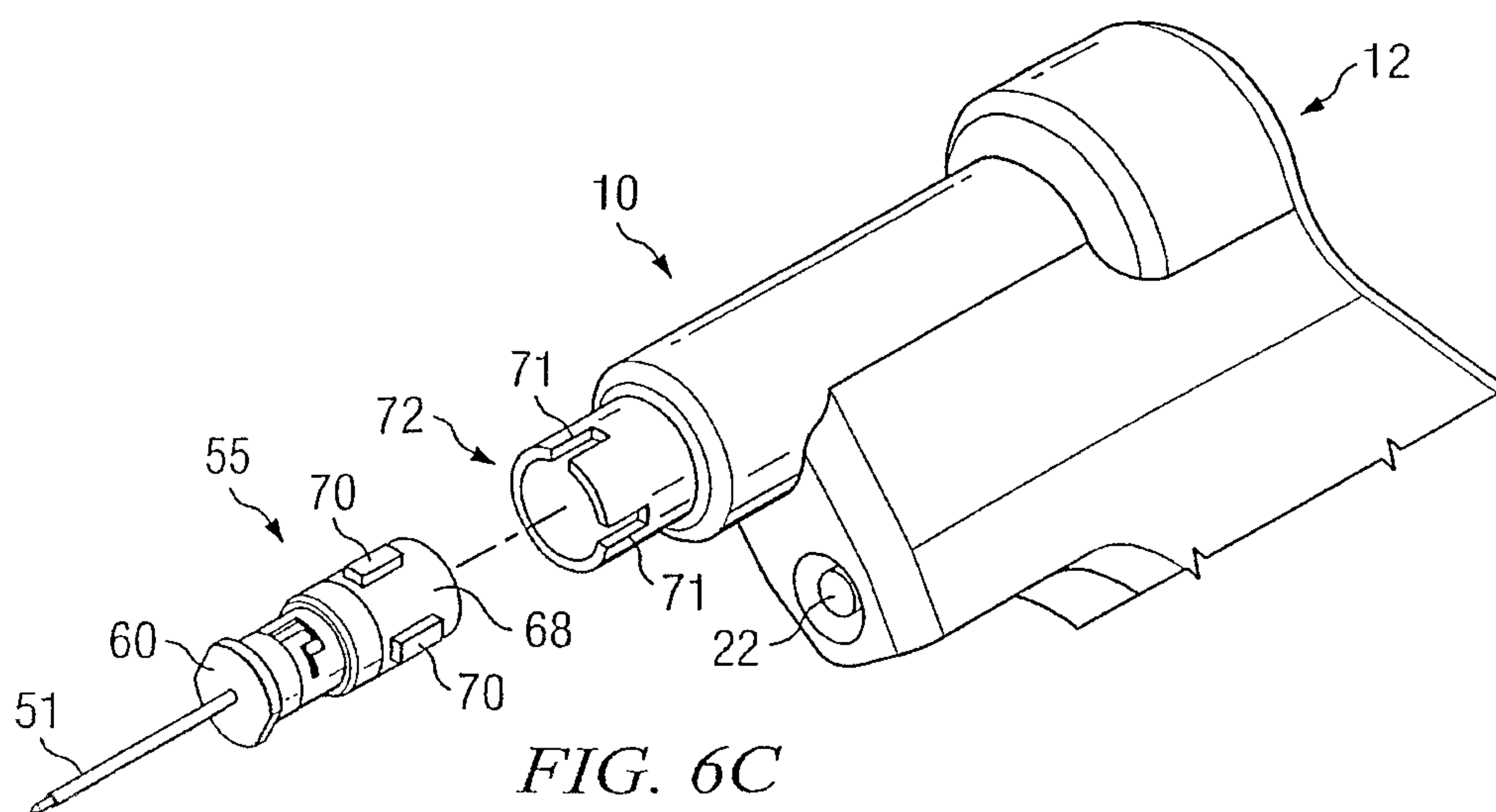
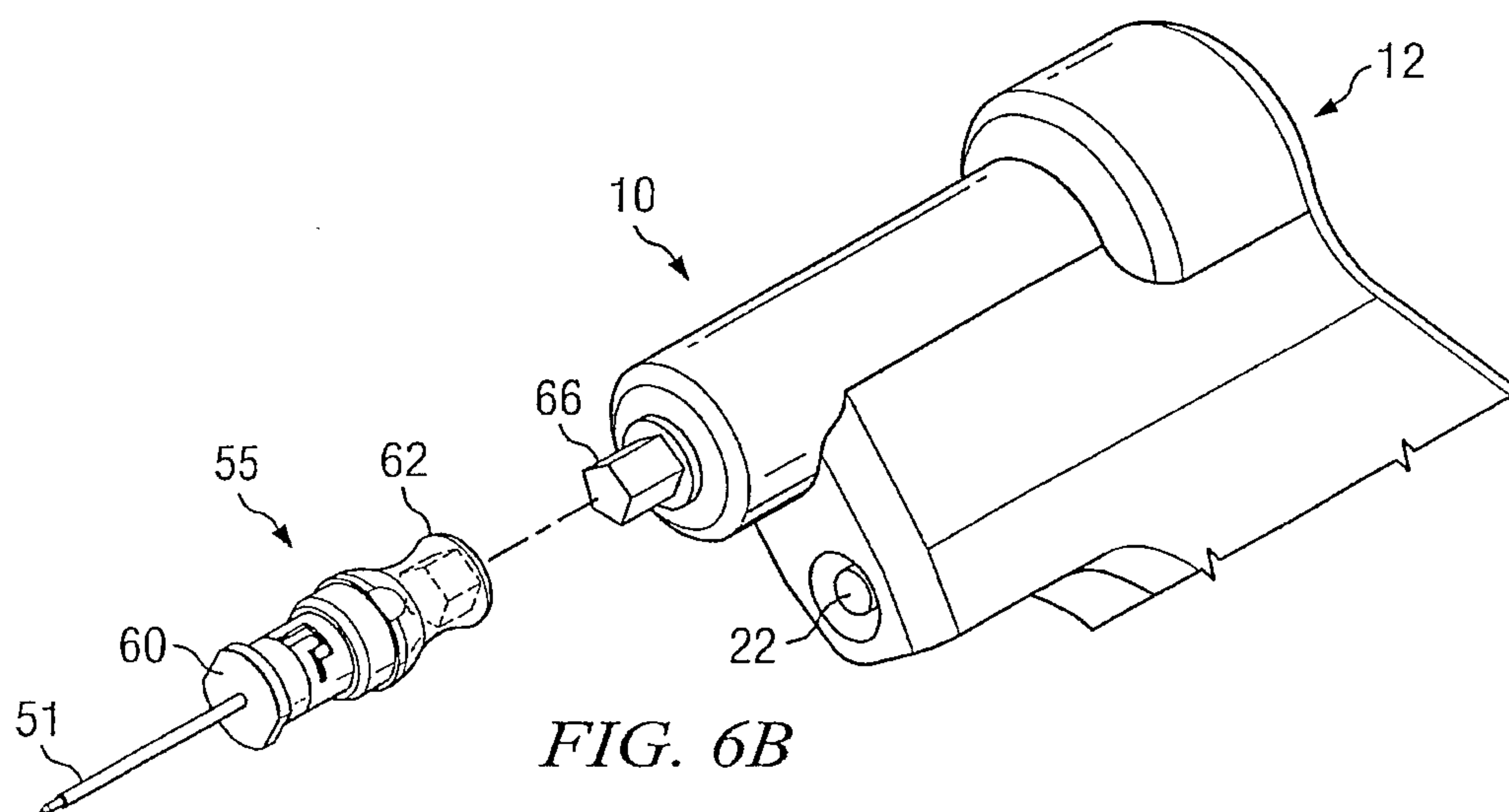
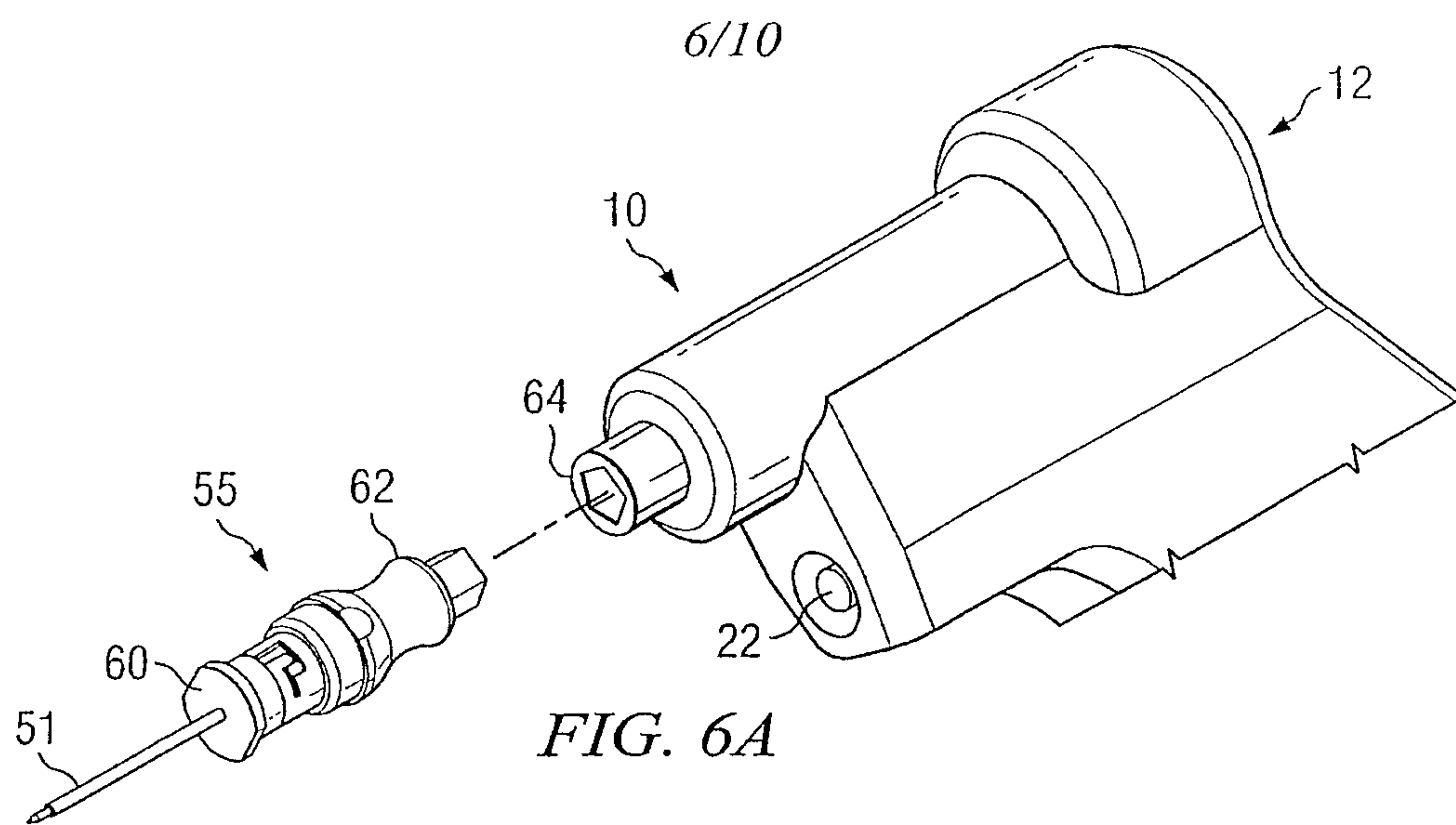
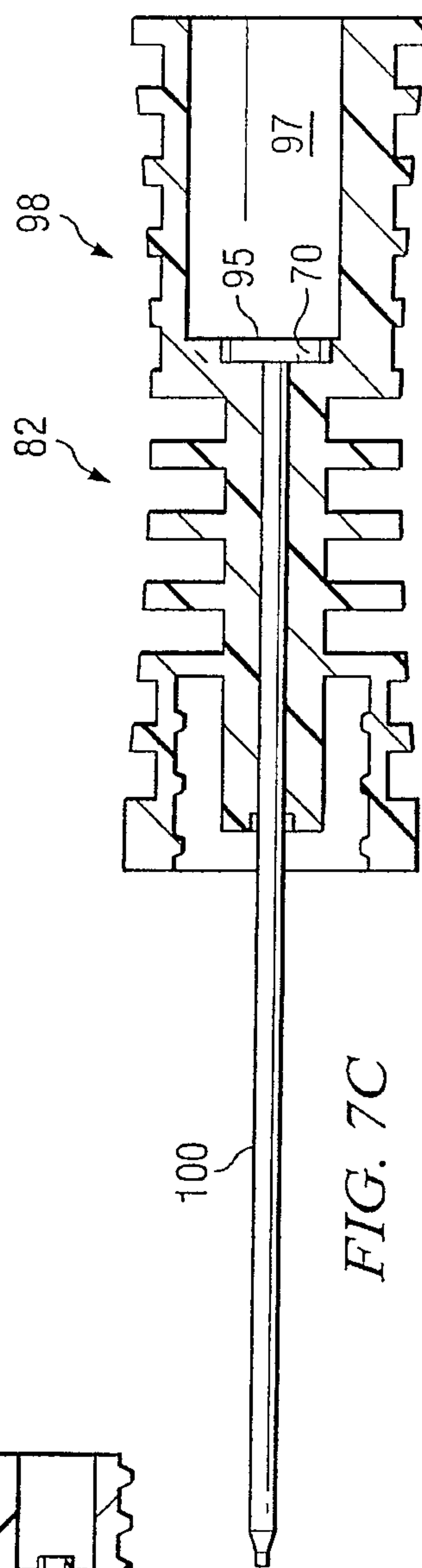
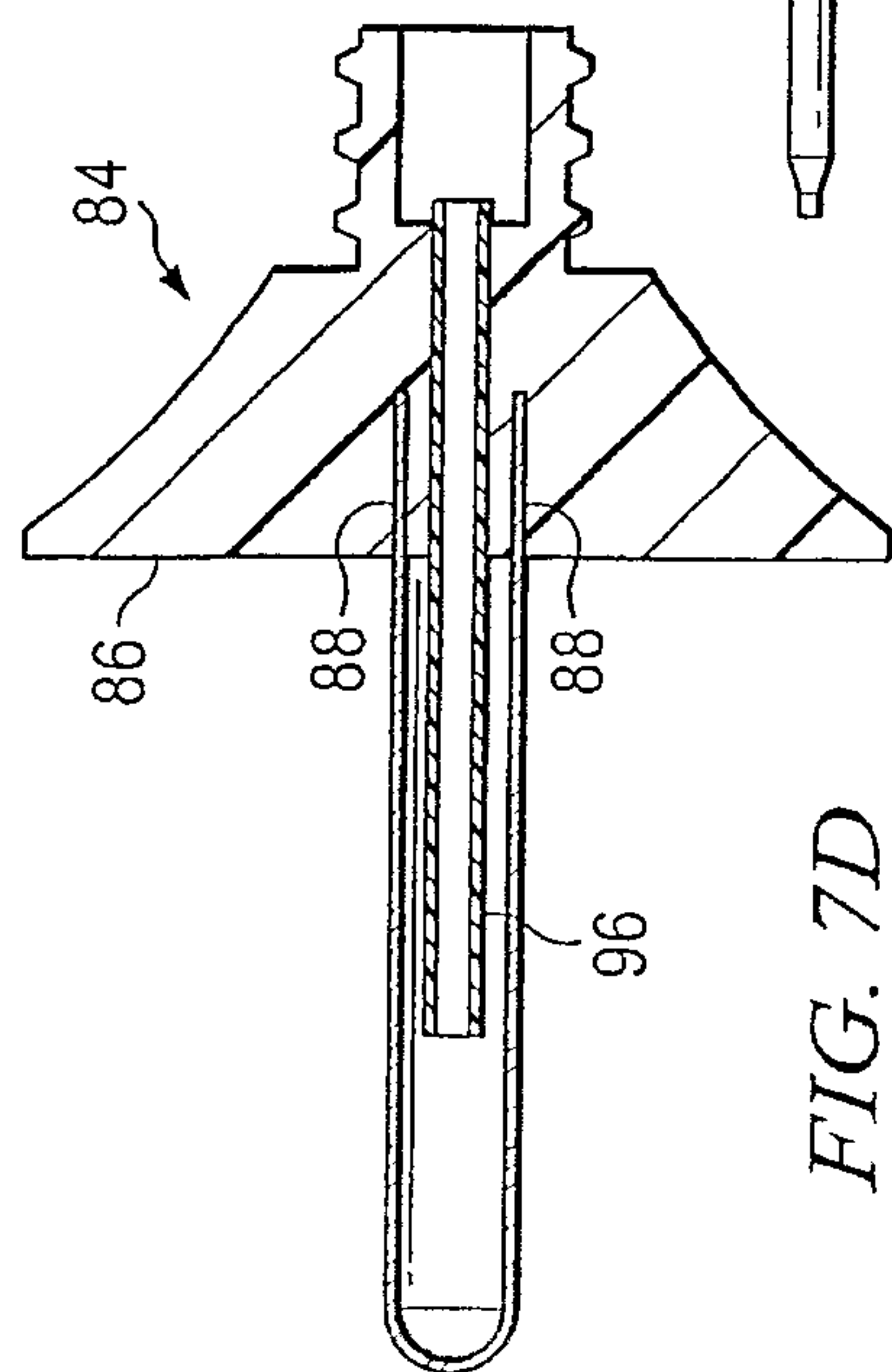
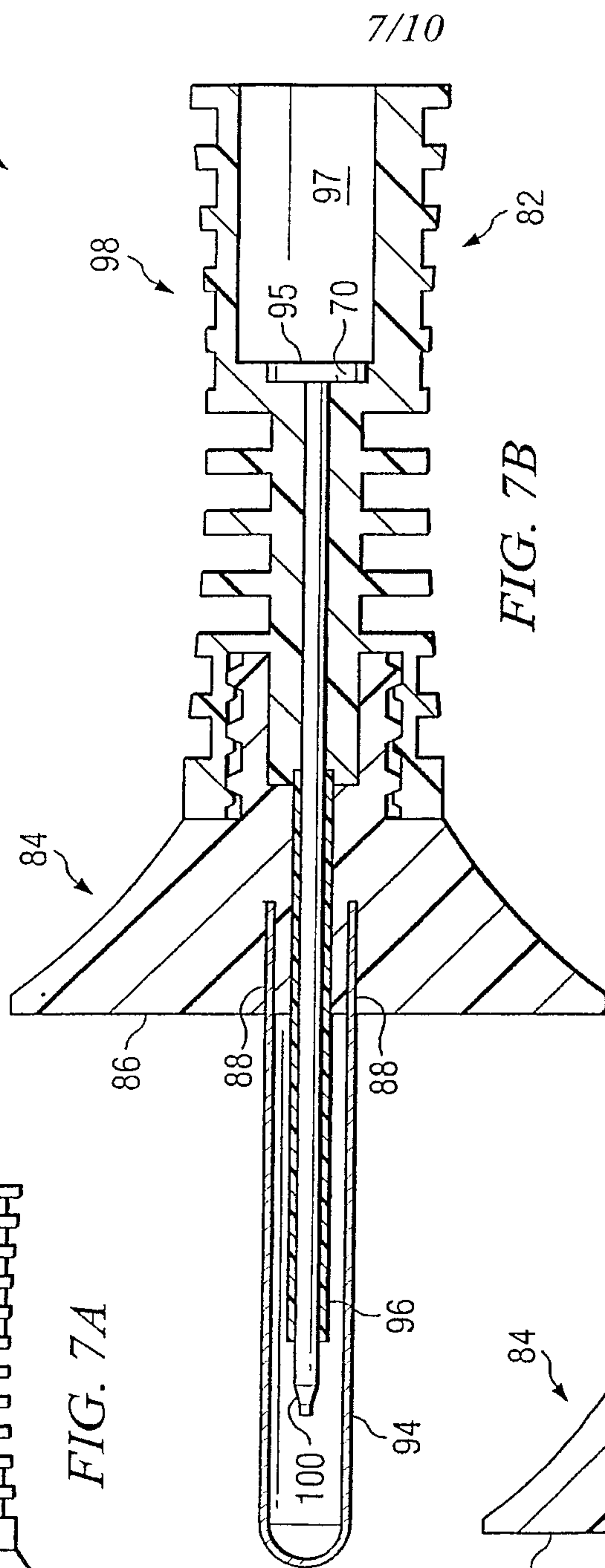
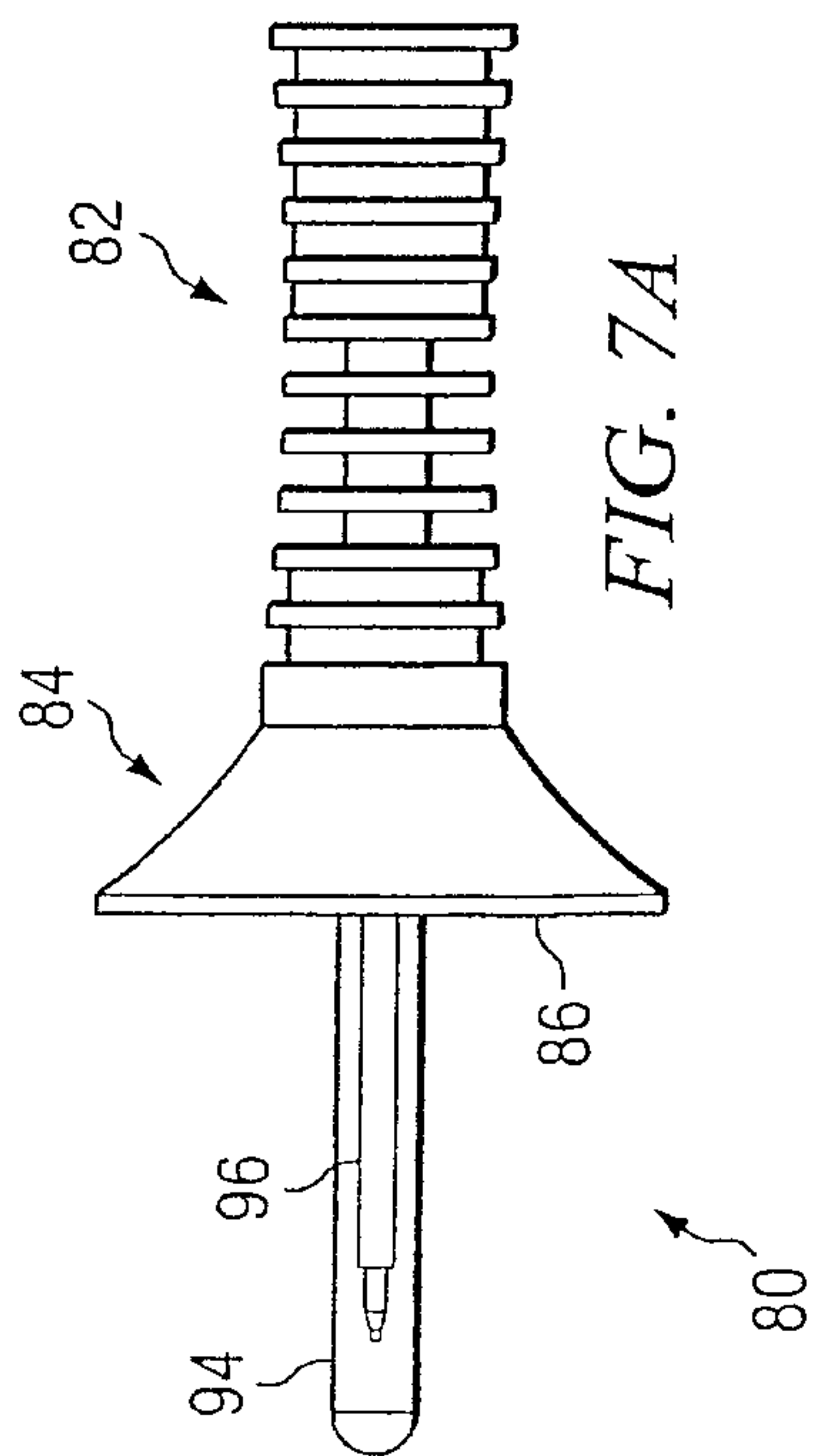
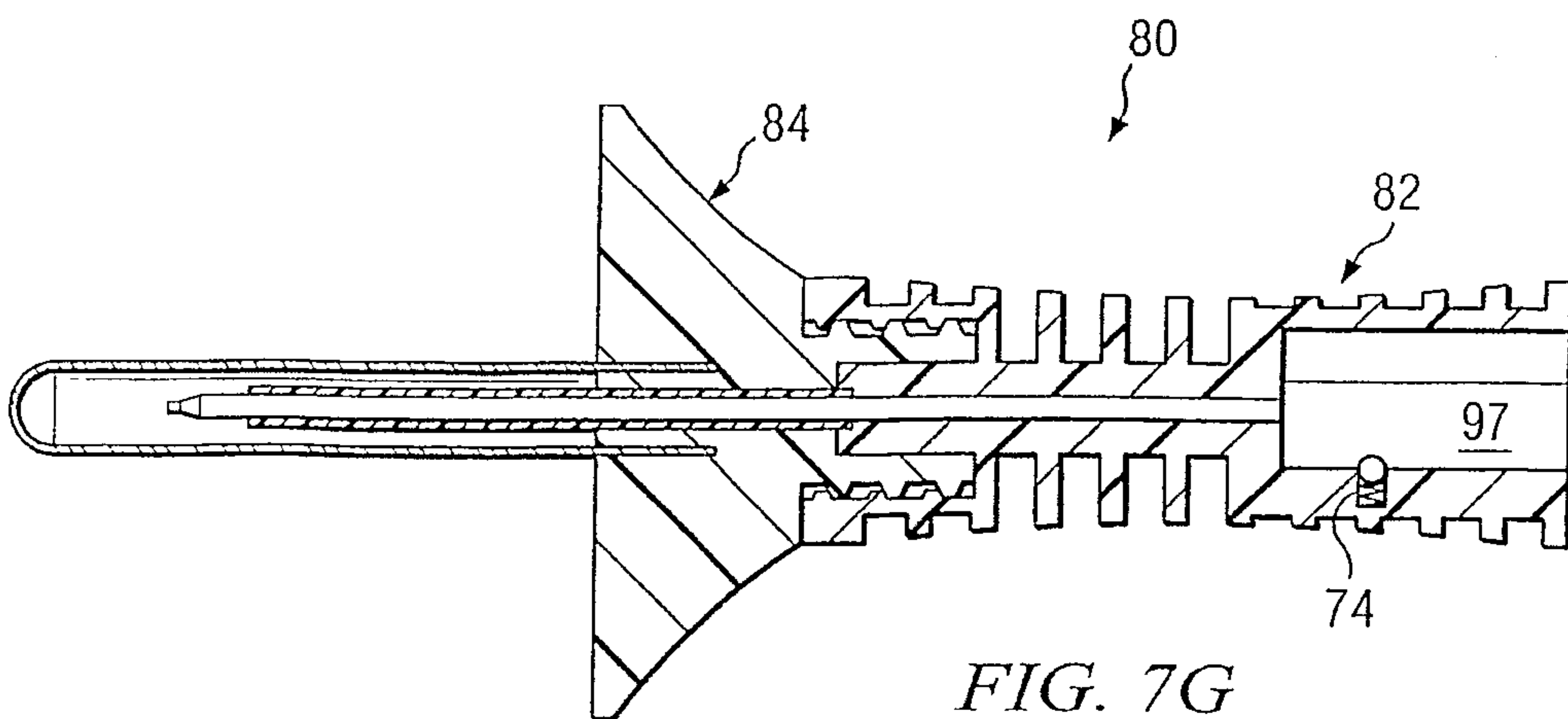
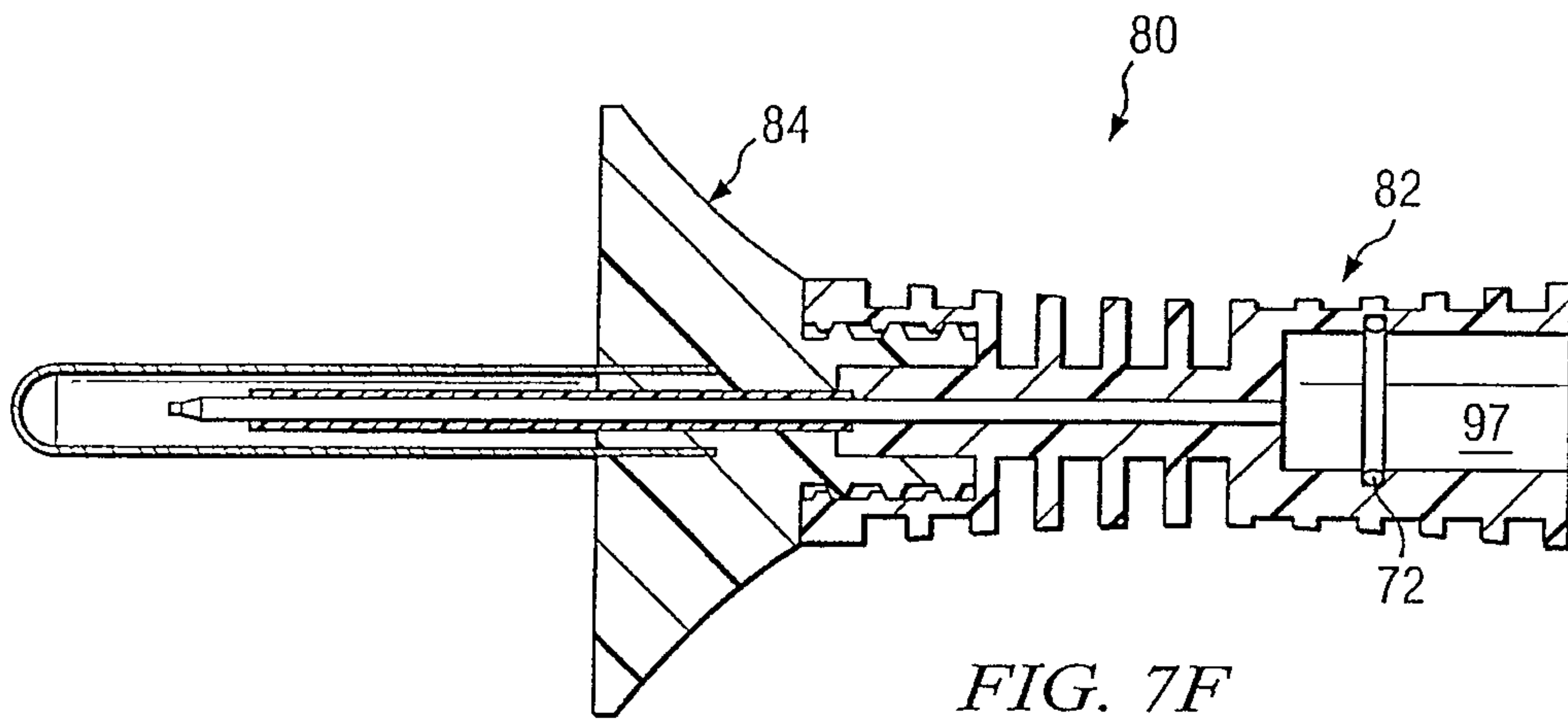
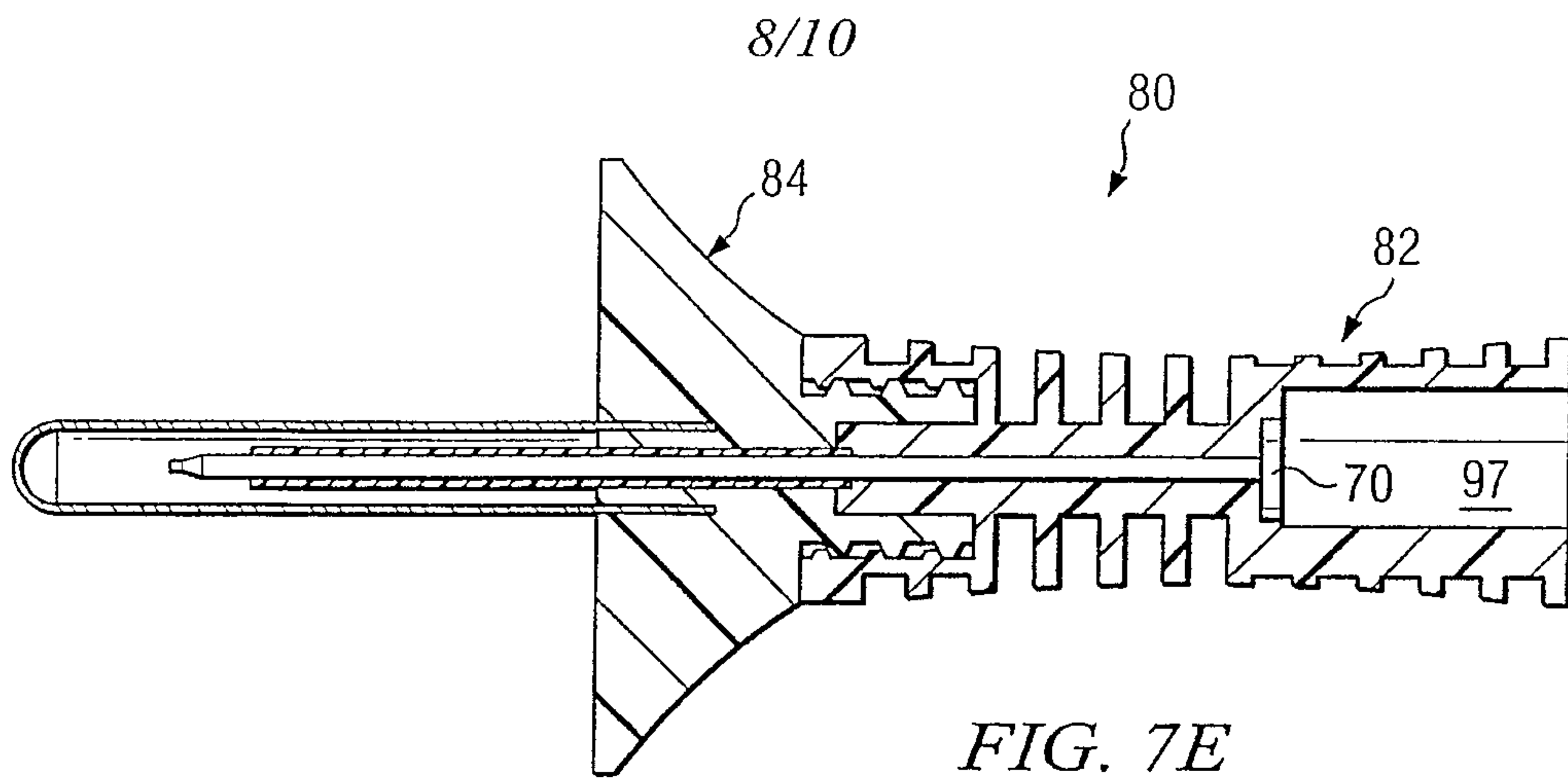


FIG. 4C









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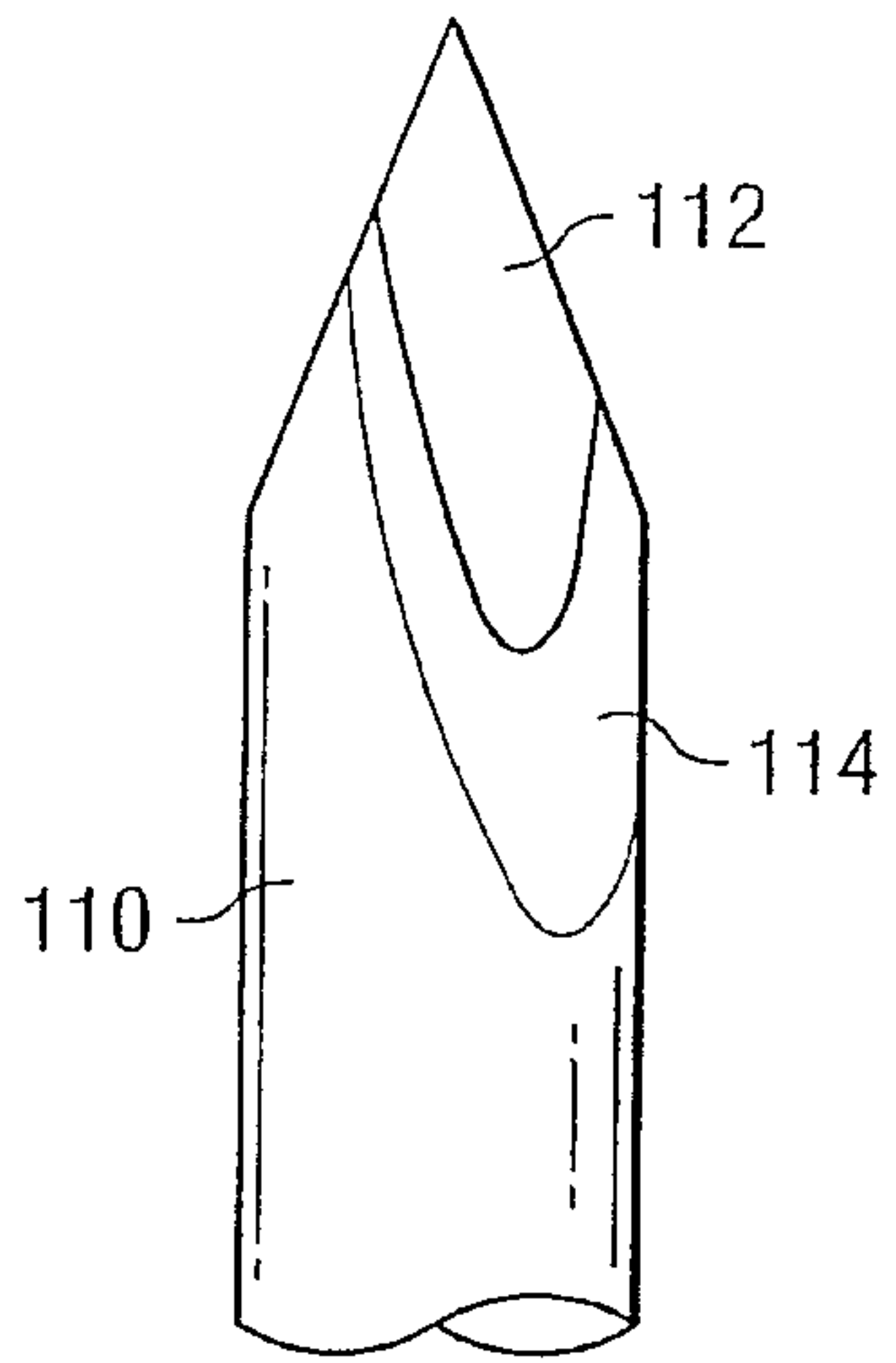


FIG. 8A

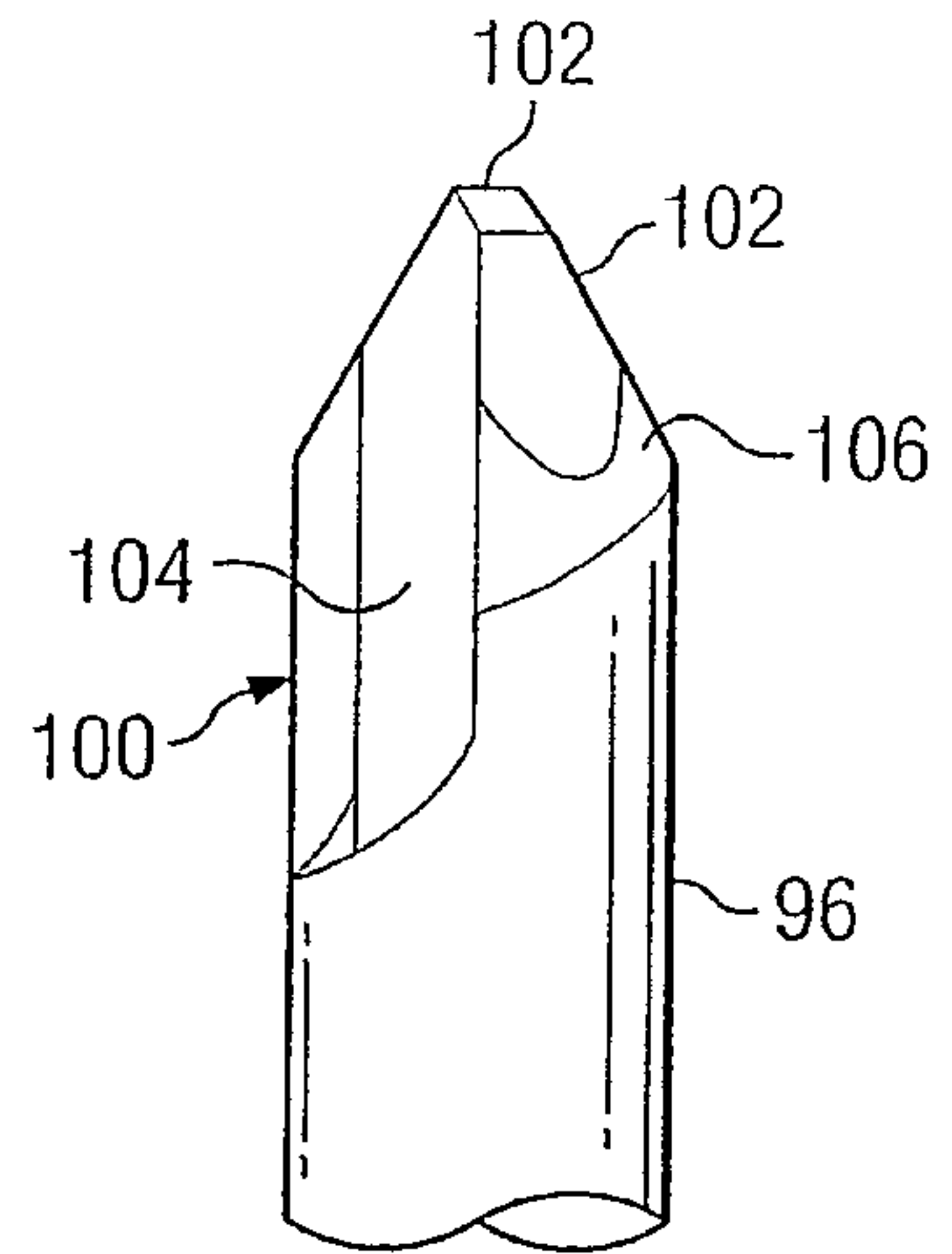


FIG. 8B

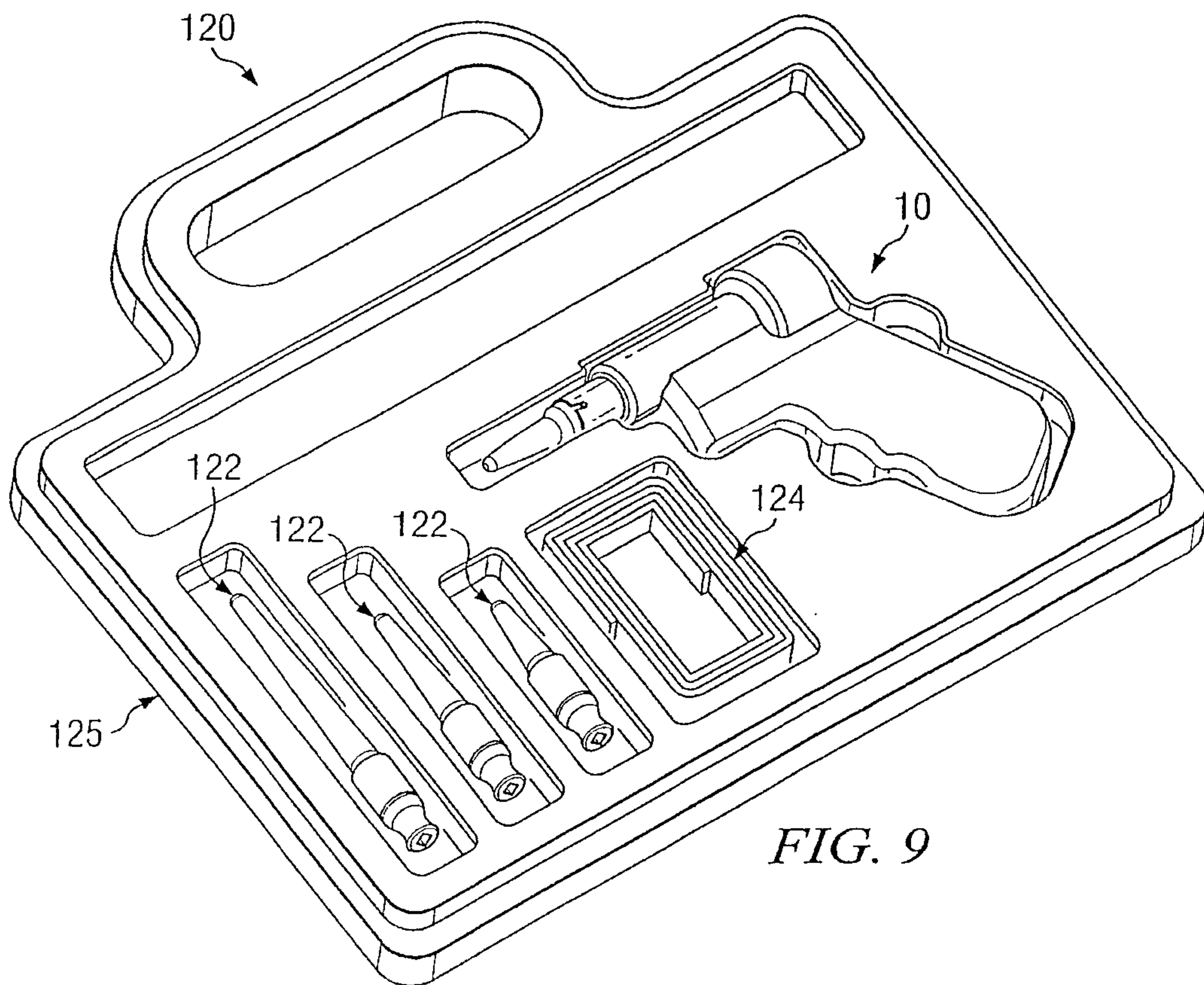


FIG. 9

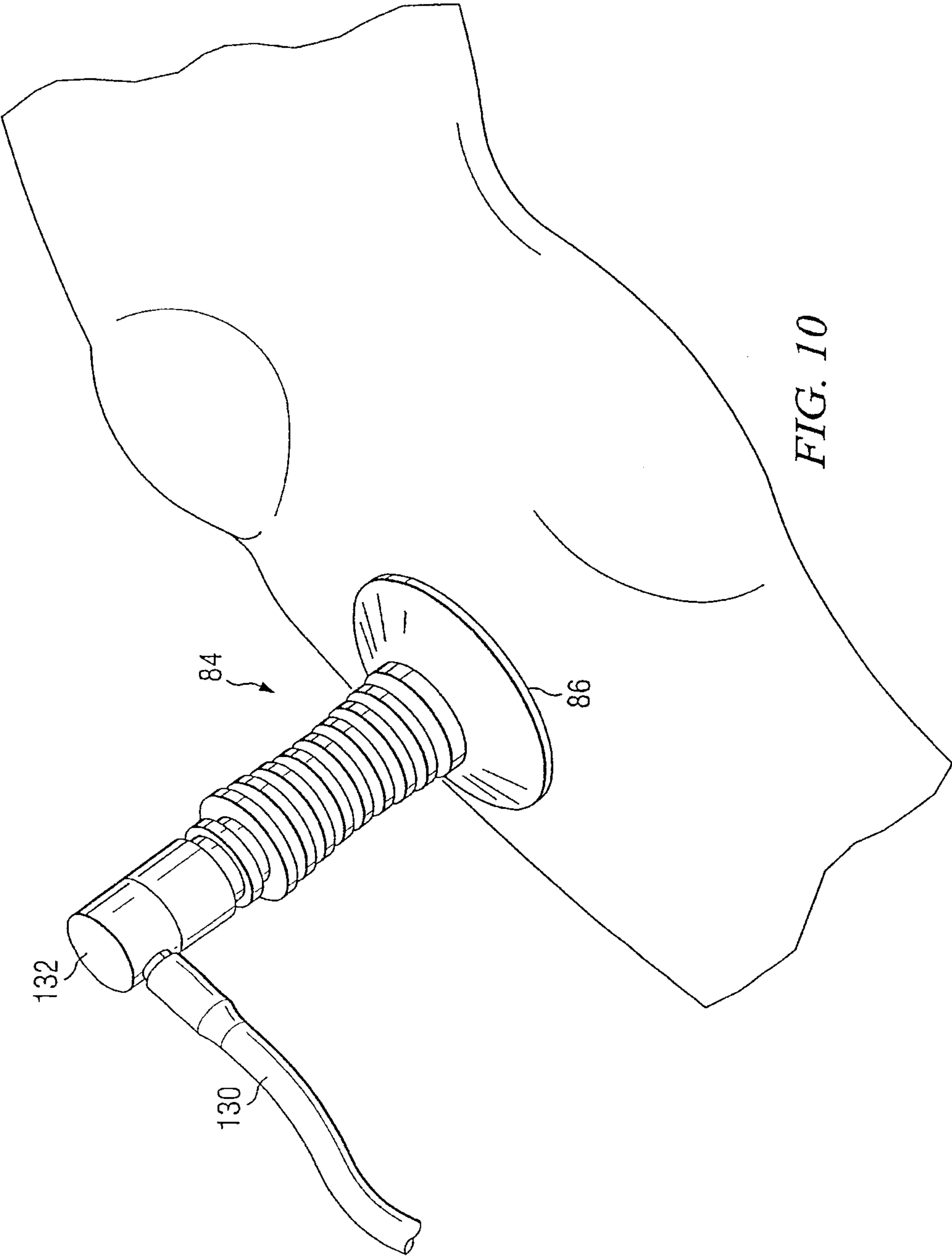


FIG. 10

