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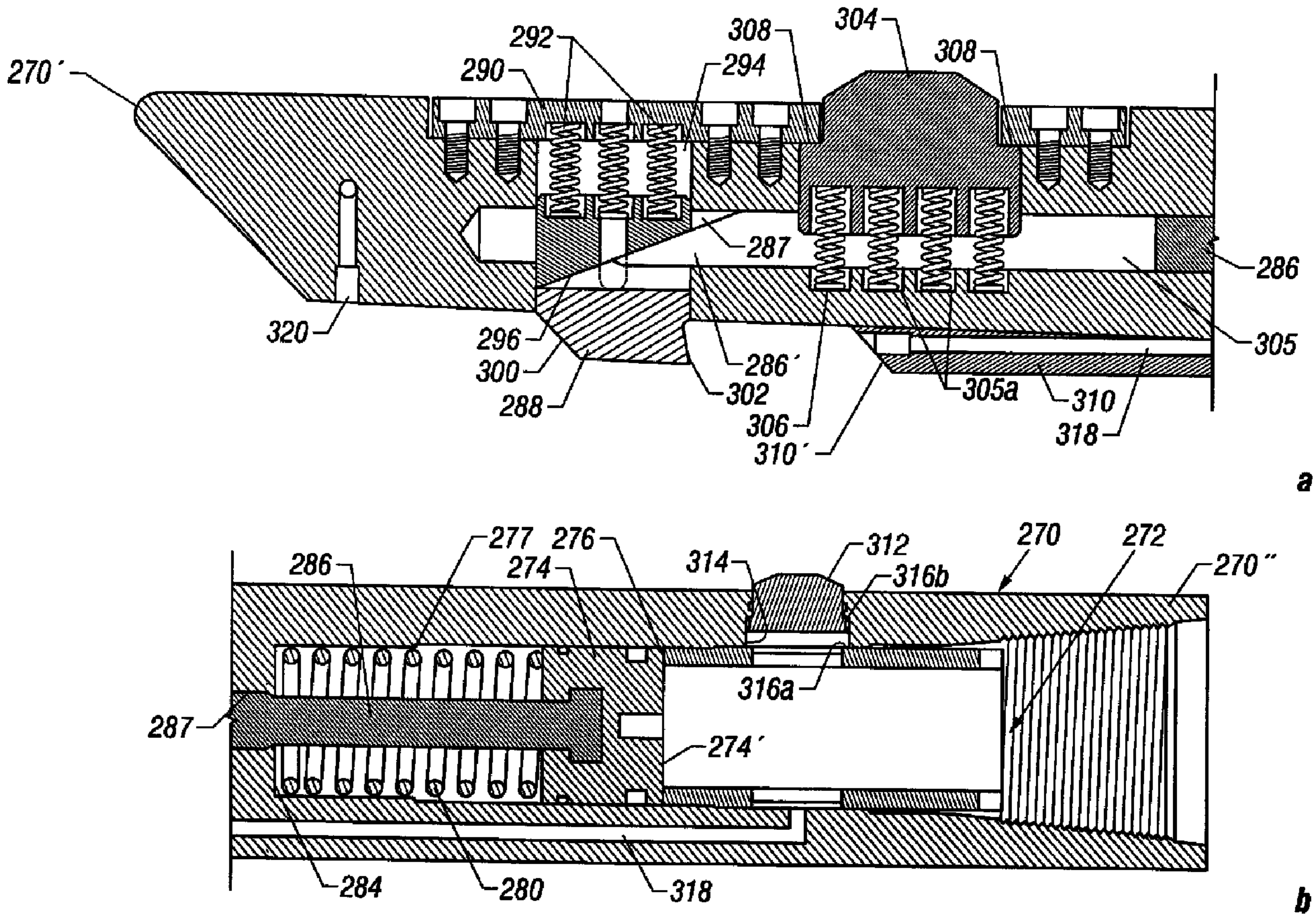

(57) Abrégé/Abstract:
A running/retrieval tool includes a housing including a retractable latch biased radially outwardly from the tool, formed to fit within a slot on a downhole tool.

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ABSTRACT OF THE INVENTION

A running/retrieval tool includes a housing including a retractable latch biased radially outwardly from the tool, formed to fit within a slot on a downhole tool.

RUNNING/RETRIEVAL TOOL

FIELD OF THE INVENTION

The present invention is directed to a borehole drilling assembly and in particular to an assembly for drilling and completing deviated boreholes.

BACKGROUND OF THE INVENTION

Deviated boreholes are drilled using whipstock assemblies. A whipstock is a device which can be secured in the casing of a well and which has a tapered, sloping upper surface that acts to guide well bore tools along the tapered surface and in a selected direction away from the straight course of the well bore.

To facilitate the use of a whipstock, a section of casing is used which has premilled window openings through which deviated well bores can be drilled. The whipstock can be positioned relative to the window using a landing system which comprises a plurality of stacked spacers mounted on a fixed mounting device at the bottom of the casing and defining at the top thereof a whipstock retaining receptacle, or by use of a latch between the whipstock and the casing. A stacked landing system can cause difficulty in aligning the whipstock with the window opening as the distance between the mounting device and the window increases. The whipstock may also turn during the drilling or setting processes resulting in the deviated well bore being directed incorrectly and/or the well bore tools being stuck in the wellbore. Sometimes a latch system is used to overcome some of these disadvantages. However, the latch can sometimes disengage between the whipstock and the casing, allowing the whipstock to turn or move down in the casing.

After the deviated wellbore is drilled, it can be left uncompleted or completed in any suitable way. To seal the deviated wellbore hydraulically from the main casing, a liner can be installed and cement can be pumped behind the liner. This is expensive and often creates obstructions in the main casing which complicates removal and run of the tools.

When the tools are used in horizontal primary bores, new problems arise. Running and retrieval tools which are useful for vertical tool manipulation are not always useful in horizontal applications.

SUMMARY OF THE INVENTION

An assembly for drilling and/or completing a deviated wellbore has been invented. In one aspect the assembly includes a toolguide which can be positioned relative to a window opening in a casing section and releasably locked in position. The toolguide or portions thereof can have applied thereto a coating which prevents damage to the metal components of the toolguide and facilitates removal of the toolguide from the wellbore after use.

In accordance with a broad aspect of the present invention, there is provided a tool guide for creating deviated borehole branches from a wellbore comprising an upper section including a sloping face portion and a lower orienting section, including at least one latch biased radially outwardly from the orienting section and positioned in a known orientation relative to the sloping face portion and a latch locking means to releasably lock the latch in an extended position, the latch locking means being actuated to lock the latch by torsion of the upper section relative to the lower orienting section.

Each latch of the orienting section is selected to fit within and lock into its own latch receiving slot formed in the casing. When the latch of the orienting section is locked into the latch receiving slot the toolguide will be maintained in position in the casing. Preferably, the casing includes at least one premilled window opening positioned in known relation relative to the latch receiving slot. Preferably, a removable liner can be positioned in the casing to close the window opening temporarily and to cover the latch receiving slot.

The orienting section can be releasably connected to the upper section. Such connection is preferably by connectors such as, for example, shear pins to the upper section so that these parts can be installed together into the casing. Preferably, the connectors are selected such that the sections can be separated by an application of force sufficient to overcome the strength of the connectors. This permits the upper section and the lower section to be separated and removed separately should one part become stuck in the casing.

The sections are movable relative to one another and means are provided to translate such movement to actuate such means as a seal.

Preferably, the lower orienting section includes a mandrel engaged slidably and rotatably within an outer housing. The mandrel is releasably connected to the upper section and moveable with the upper section. Preferably, the latch locking means is an extension of the mandrel. The extension can be formed to fit behind the latch to lock it in the outwardly biased position.

According to a further aspect of the present invention, there is provided a toolguide for creating borehole branches from a wellbore, the toolguide having a longitudinal axis and comprising an upper section including a sloping face portion, a lower orienting section, the upper section and the lower orienting section being connected and moveable relative to each other along the longitudinal axis of the toolguide, and an annular sealing means mounted below the upper section, the annular sealing means being actuatable to expand and retract upon movement of the upper section and the lower orienting section relative to one another.

In one embodiment, the upper section is attached to a central mandrel of the lower orienting section. The central mandrel is engaged slidably and rotatably within an outer housing of the lower orienting section. The outer housing carries the annular sealing means which is actuatable to expand or retract by movement of the mandrel within the outer housing. Preferably, the outer housing includes a first section and a second section and disposed therebetween the annular sealing means. The first section is moveable toward the second section to compress the annular sealing means therebetween and cause it to expand outwardly. In this embodiment, preferably the mandrel has a shoulder positioned thereon to abut against the first section and limit the movement of the mandrel into the outer housing. Abutment of the shoulder against the first section causes the first section of the housing to be driven it towards the second section and the annular sealing means to be compressed and expanded outwardly.

According to another broad aspect of the present invention, there is provided an upper section for a toolguide for use in creating wellbore branches from a well bore, the upper section being formed of a first material and having a surface and comprising a coating material disposed at least over a portion of its surface, the coating material being softer than the first material and being resistant to oil and gas.

Preferably, the coating material comprises polymers such as epoxy and/or polyurethane. The polymer is preferably coated onto the tool by use of a mold, so that the shape of the tool after coating is controllable. If damage occurs to the coating, it can be replaced.

In accordance with yet another broad aspect of the present invention, there is provided a casing section for a deviated wellbore junction comprising a cylindrical casing tube having a central axis and a window opening formed therein and a sleeve having an opening therein, the sleeve being mounted relative to the casing tube to move between a first position in which the opening of the sleeve is aligned with the window opening of the casing tube and a second position in which the opening of the sleeve is not aligned with the window opening of the casing tube.

According to another broad aspect, there is provided a casing section for a deviated wellbore junction comprising a casing tube having a central axis and a window opening formed therein and a sleeve having a first opening and a second opening therein, the sleeve being mounted relative to the casing tube to move between a first position in which the first opening of the sleeve is aligned with the window opening of the casing tube and a second position in which the second opening of the sleeve is aligned with the window opening of the casing tube.

Preferably, sealing means are disposed between the casing tube and the sleeve. These sealing means are preferably selected to effect a hydraulic seal between the parts. In one embodiment, the sealing means is formed of deformable material such as rubber or plastic and is disposed around the opening of the sleeve and along the top and bottom thereof.

In one embodiment, the sleeve is disposed within the casing tube in a counterbore formed therein such that the inner diameter of the sleeve is greater than or substantially equal to the inner diameter of the casing away from the position of the sleeve.

Preferably, the window of the casing is formed to accept a flange of a junction fitting such as, for example, a tieback hanger of a branched wellbore. In a preferred embodiment, the sleeve is selected to seal against the flange of the fitting.

In a preferred embodiment, the sleeve has formed therethrough two openings. The first opening is sized to allow access to the window opening of the casing section by deviated borehole tools and the second opening is smaller than the first opening.

In accordance with a further broad aspect of the present invention, there is provided a running tool comprising: a housing including a retractable latch biased radially outwardly from the tool formed to fit within a first slot on a downhole tool; and a rail formed to be insertable into a guide slot on the downhole tool and the rail positioned to guide the latch into engagement in the first slot.

In accordance with another broad aspect of the present invention, there is provided a running tool comprising: a housing including a retractable latch biased radially outwardly from the tool formed to fit within the first slot on a downhole tool; and a guide slot formed to accept a rail on the downhole tool.

BRIEF DESCRIPTION OF THE DRAWINGS

A further, detailed, description of the invention, briefly described above, will follow by reference to the following drawings of specific embodiments of the invention. These drawings depict only typical embodiments of the invention and are therefore not to be considered limiting of its scope. In the drawings:

Figure 1 is a schematic representation of an embodiment of an assembly according to the present invention, the assembly being positioned in a wellbore;

Figure 2 is a view showing the orientation of Figures 2a and 2b.

Figures 2a and 2b are longitudinal sections along a casing section for a deviated wellbore junction useful in the present invention;

Figure 3A is a view showing the orientation of Figures 3A-a and 3A-b;

Figures 3A-a and 3A-b are a front elevation view, partly cutaway, of a whipstock of a toolguide according to the present invention;

Figure 3B is a view showing the orientation of Figures 3B-a and 3B-b;

Figures 3B-a and 3B-b are a section along line 3B-3B of Figure 3A;

Figure 4A is a view showing the orientation of Figures 4A-a and 4A-b;

Figures 4A-a and 4A-b are a front elevation view, partly cutaway, of a whipstock of another toolguide;

Figure 4B is a view showing the orientation of Figures 4B-a and 4B-b;

Figures 4B-a and 4B-b are a section along line 4B-4B of Figure 4A;

Figures 4C and 4D are sectional views along line 4C-4C and 4D-4D, respectively, of Figure 4B;

Figure 4E is a bottom end view of Figure 4A;

Figure 4F is a top end view of Figure 4A;

Figure 5A is a front elevation view of a lower section of a toolguide according to the present invention, partly in section and in un-compressed configuration;

Figure 5B is a front elevation view of the toolguide of Figure 5A in compressed configuration;

Figure 5C is a section along line 5C-5C of Figure 5A;

Figure 6A is a view showing the orientation of Figures 6Aa and 6Ab;

Figures 6Aa and 6Ab are longitudinal sections along another lower section of a toolguide in a set configuration;

Figure 6B is a view showing the orientation of Figures 6Ba and 6Bb;

Figures 6Ba and 6Bb are longitudinal sections along another lower section of a toolguide;

Figure 7 is a view showing the orientation of Figures 7A to 7C;

Figures 7A to 7C are longitudinal sections along a casing section for a deviated wellbore junction;

Figure 8 is a view showing the orientation of Figures 8a and 8b;

Figures 8a and 8b are longitudinal sectional views along a running/retrieving tool;

Figure 9 is a longitudinal section along another casing section for a deviated wellbore junction according to the present invention;

Figure 10 is a rear plan view of a sleeve according to the present invention in flattened configuration;

Figure 11A is a sectional view through a deviated wellbore junction using a casing section according to the present invention;

Figure 11B is a front elevation view of a tieback hanger;

Figure 11C is a front elevation view of a tieback hanger;

Figure 12 is a front elevation view of another sleeve according to the present invention in flattened configuration;

Figure 13 is a view showing the orientation of Figures 13a and 13b;

Figures 13a and 13b are elevation views of a casing section including a window opening;

Figure 14 is a longitudinal sectional view along a liner positioning tool;

Figure 15 is schematic representation of a system for imparting rotational force on a drill pipe;

Figure 16A is a longitudinal sectional view along a sleeve shifting tool according to the present invention;

Figure 16B is front elevation view of a portion of the sleeve shifting tool of Figure 16A showing the sleeve engaging slips;

Figure 17 is an elevation view of a casing section including a window opening according to the present invention;

Figure 17A is a sectional view along line A-A of Figure 17;

Figure 17B is a sectional view along line B-B of Figure 17;

Figure 17C is an enlarged view of an edge of the window opening, as noted in Figure 17A;

Figure 18 is a front elevation view of a tieback hanger in accordance with another aspect of the present invention;

Figure 18A is a sectional view along line A-A of Figure 18 showing the lower setting tab;

Figure 18B is a sectional view along line B-B of Figure 18 showing the mid setting flanges;

Figure 18C is a sectional view along line C-C of Figure 18 showing the upper setting tab;

Figure 19A is a sectional view through a casing section according to Figure 17 having a tieback hanger according to Figure 18 therein with the upper setting tab in unengaged position; and

Figure 19B is a sectional view as in Figure 19A with the upper setting tab in engaged position in the window of the casing section.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

For the purposes of clarity, in the Figures only reference numerals of the main components are indicated and like reference numerals relate to like components.

Referring to Figure 1, there is a shown a tubular wellbore casing 2 for installation in a primary wellbore 4 drilled through a formation. Primary wellbore 4 can be a main wellbore directly opening to surface or a lateral wellbore drilled from a main wellbore. Primary wellbore can range between a vertical and a horizontal orientation. Casing 2 includes upper and lower sections of production casing 6 and secured therebetween a casing section 8 for use in deviated wellbore junctions. The deviated wellbores branch from wellbore 4.

Casing sections 6 and 8 are connected by standard connectors 9 or any other suitable means. A float collar 10 is provided at the lower end of casing 2 which allows fluids to flow out of the casing but prevents flow of fluid and debris back into wellbore casing 2. Any similar one way valve can be used in the place of float collar 10. By a completion procedure, cement 11 is disposed in the casing annulus.

Casing section 8 includes a window in the form of an elongated opening 12 extending in the longitudinal direction of casing 8. In use, opening 12 is oriented toward the desired direction of a deviated wellbore to be drilled, shown in phantom at 14. The window is sized and shaped with reference to the desired diameter and azimuth of the deviated wellbore to be drilled and the diameter of the casing, as is known in the art.

Casing section 8 further has formed therein a latch receiving slot 16a at a selected orientation relative to window opening 12. The latch receiving slot can be oriented at any point around the interior circumference of the casing section, so long as its position is known with respect to the window opening. Preferably, latch receiving slot 16a is aligned with the longitudinal axis of window 12, as shown, or is directly opposite window opening 12.

A toolguide 18 is installed in casing 2 with its latch 20 extending into slot 16a. Toolguide 18 includes a lower orienting section 22, also called a monopositioning tool, from which latch 20 is biased radially outwardly, and an upper section 24, commonly called a whipstock, having a sloping face portion 26. Sections 22 and 24 are connected so that they are not free to rotate relative to each other, whereby face portion 26 is maintained in a fixed and known orientation relative to latch 20. In a preferred embodiment, as shown, latch 20 is aligned at the bottom of sloping face portion 26, so that the surface of the sloping face portion will be aligned opposite window opening 12, when latch 20 is in slot 16a.

An annular expandable seal 28 is disposed on toolguide 18 below sloping face portion 26. The seal 28 when expanded, acts to prevent debris and fluids from passing down the wellbore. Seal 28 is therefore selected to have an outer diameter, when expanded, which is greater than the inner diameter of the casing 2 in which it is to be used.

Toolguide 18 is placed in casing 2 by use of a running tool 30 which releasably locks onto upper section 24 and is shown in this drawing still attached to the upper section. Running tool 30 is connected to a drill pipe 32.

To remove the toolguide from the wellbore, a retrieving tool can be used. In one embodiment shown in Figure 13, one tool is provided which is useful for both running and retrieving operations.

To prepare for the drilling of a deviated borehole, such as that shown at 14, the wellbore casing 2 is installed and completed. Figure 2 shows apparatus useful for permitting completion of the well while preserving features used in the invention. Casing section 8 is milled to include a window opening 12 and a latch receiving slot 16a. Preferably, a slot 17 (Figure 2) for alignment of retrieval tools is also milled out in casing section 8. Preferably, window opening 12 and latch receiving slot 16a are aligned along the casing.

A liner 34 is positioned in casing 8 and seals 36a and 36b are provided between liner 34 and casing 8. A float collar 38 and an orienting subassembly 39 are attached above liner 34. Float collar 38 and orienting subassembly 39 can be positioned, as shown, or can be positioned further up the casing provided orienting subassemby is in a known configuration relative to window opining 12. Preferably, a removable filler 41, such as foam, is inserted between casing 8 and liner 34 between seals 36b to fill window opening 12 and the casing section 8 is wrapped in a rigid material 40, such as fibre glass or composite tape, to cover at least opening 12.

Preferably, slots 16a and 17 are filled with filling materials such as grease and/or foam to prevent materials from entering into the slots and the remainder of spaces 43, defined between casing 8, liner 34 and seals 36a, 36b, are filled with cement. To further prevent entry of materials into slots 16a, 17, caps 44 are welded onto the outer surface of casing 8 over the slots.

Casing 8, including the parts as noted hereinbefore, is connected to casing sections 6 to form casing string 2 and float collar 10 is attached. Casing string 2 is lowered into wellbore 4. The casing string is rotated until window opening 12 is oriented in the direction in which it is desired that the deviated wellbore 14 should extend. Suitable methods are well known in the oil industry for orienting downhole tools, for example, using a surface reading gyro, a mule shoe or other suitable means.

The cased wellbore is completed by forcing cement through the casing string and into the annulus between the casing and the wellbore. During completion, the cement is forced through float collar 38 and liner 34 but is prevented from entry behind liner 34 by seals 36a and the cement and fillers in spaces 43. (It is to be understood that only one float collar is needed and float collar 10 need not be used when float collar 38 is used.) As the cement fills the casing annulus, it is prevented from entering slot 16a by cap 44 and is prevented from entering window opening 12 by the filler 41 and rigid materials 40. The cement is allowed time to set.

After completion, a drill (not shown) of a diameter selected to be approximately equal to the inner diameter of the casing is run into the well to remove cement from the casing bore. The drill will also drill out liner 34, seals 36a, 36b, float collar 38 and cement in spaces 43. Thus, liner 34 is formed of a material such as, for example, aluminum, fibre glass, or carbon fibre-containing composite, which can be removed by drilling. Where aluminum is used in the wellbore, preferably any aluminum surfaces exposed for contact by cement, which will be used in the completion operation, are coated with a suitable material, such as rubber cement, to prevent degradation of the aluminum by contact with cement.

The casing is then ready for production or for drilling deviated wellbores. Where deviated wellbores are to be drilled a toolguide 18 will be run in and oriented in the casing as shown in Figure 1.

In Figures 3A and 3B and Figures 4A to 4F, two embodiments of an upper section according to the present invention are shown. Referring to Figures 3A and 3B, an upper section 24 tapers toward its upper end to form a sloping face portion 26 which is formed to direct any tool pushed along it laterally outwardly at a selected angle. The face portion is machined to have a selected slope x or range of slopes with respect to long axis 52 of the section depending on the build radius desired for the deviated wellbore. As an example, when x is 4°, the build radius will be approximately 15°/30 meters drilled. Preferably, sloping face portion 26 is formed to be concave along its width.

An entry guide 49 is welded at the top of face portion 26. Entry guide 49 assists in centralization and tool retrieval and need only be used, as desired. A bore 50 extends a selected distance through the upper section parallel to its central axis 52. Bore 50 is formed to engage a fishing spear device and provides one means of retrieving the toolguide from the wellbore. Extending back from face portion are slots 53 formed to accept and retain a retrieval tool having corresponding sized and spaced hooks thereon. Also formed on face portion 26 are apertures 54 formed to accept shear pins (not shown) for attachment to running tool 30 (Figure 1).

Centralizers 56 are spaced about the upper section. While only one centralizer is illustrated in the drawing, there are preferably at least three centralizers on the upper portion to center the upper section in the hole.

A socket 58 extends from the bottom of upper section 24 parallel with central axis 52. Socket 58 is shaped to accept a male portion 68 on the lower orienting section 22, as will be discussed hereinafter with reference to Figures 5A and 5B. Preferably, socket 58 is faceted at 60 and male portion is similarly faceted so that the parts lock together and male portion 68 cannot rotate within socket 58. Shear pins 61 are inserted through apertures 62 to secure male portion 68 in socket 58 and thereby, the upper section to the lower section.

The upper section is formed of hardened steel. The outer diameter of the upper section is selected to be smaller than the inner diameter of the casing in which it is to be used.

Upper section 24 has applied thereto a polymeric coating 64 (shown only in Figure 3B). Polymeric coating 64 is preferably formed of cured polyurethane. Coating 64 acts to prevent damage of the metal components of the upper section and can be reapplied if it is removed during use. Coating 64 further facilitates wash over operations, should they become necessary to remove the toolguide or upper section from the casing. The coating is thick enough so that it will accommodate normal damage from, for example, abrasion and will prevent damage to the metal surfaces of the upper section and is preferably also thick enough so that substantially only the coating will be removed by any washover operation. In a preferred embodiment, the coating is about ½ inch thick and is applied using a mold.

Because coating 64 is easily abradable and deformable, the coating can interfere with tool centralization. Thus, to permit correct centralization of the upper section within the casing, preferably centralizers 56 extend out from the metal portion of the upper section a distance at least equal with the thickness of coating 64. In this way, centralizers 56 are either flush with the surface of the coating or extend out therefrom.

Referring to Figures 4A to 4F, another upper section 24' is shown. Upper section 24' includes a sloping face portion 26'. Generally, upper sections are useful for producing only one of a long, medium or short radius deviated wellbore. However, the profile of sloping face portion 26' of section 24' is formed to allow flexibility to produce both medium and short radius laterals.

Upper section 24' is selected to be useful with a running/retrieval tool as is described in more detail in Figure 13. In particular, upper section 24' has formed at its upper end a dove-tail slot 51 and a second slot 55. These slots will be described in more detail with respect to Figure 13.

Centralizers 56' are formed integral with the metal portion of the upper section. While six centralizers are shown, it is to be understood that only three centralizers are required for proper functioning.

Upper section includes a socket 58' which is generally similar to socket 58 described with reference to Figure 3B. Socket 58' includes a faceted portion 68. Apertures 62 extend through centralizers 56' and open into socket 58' for accepting shear pins (61' in figure 6) for securing the upper section to the lower section.

A coating 64' of polymeric material is applied over selected portions of the upper section. As noted with respect to Figure 3B, preferably coating 64' is applied to be flush with the outer, contact surface of centralizers 56'. It has been found that in upper sections having a coating applied for washover purposes, the smaller diameter can reduce the width of the sloping face profile and can compromise drill guidance along the face and stability of the upper section. To provide greater lateral stability across the width of sloping face portion 26' and to provide centralization and stability to the upper tapered end of the upper section, a lip 65 extends out from face portion 26'. Coating 64' is built up against lip 65. The lip is preferably 1/2" to 1" thick.

In Figures 5A and 5B, one embodiment of a lower orienting section 22 is shown. Figure 6 shows another embodiment of a lower orienting section 22'. Any upper section can be used with these lower sections, provided that the upper sections have a socket for connection to the lower sections. In particular, either of sections 24 or 24' can be mounted on either of the lower sections described with reference to Figure 5A or Figure 6.

Section 22 is shown uncompressed in Figure 5A. In Figure 5B, section 22 is shown in a compressed, set condition as would be the condition of the section when used in a toolguide which is locked in position in a wellbore ready for use. Lower orienting section 22 includes a male portion 68 shaped to fit into the sockets 58 or 58' on the upper sections. Bores 70 (only one is shown) accept ends of shear pins 61.

Male portion 68 is connected to a central mandrel 72. Central mandrel 72 is mounted in a bore 73 in a housing 74. Mandrel 72 is both moveable through and rotatable within bore 73 as limited by movement of pin 76 on housing 74 in jay slot 78 formed in mandrel 72. Mandrel 72 can be releasably locked in position in housing by locking collet 77 frictionally engaging into knurled area 77a.

Housing 74 includes a top portion 80 and a lower portion 82. Each portion has a flange 84 which together retain an annular packing seal 28. Top portion 80 is moveable towards lower portion 82 as shown in Figure 5B to compress packing seal 28 and cause it to expand outwardly.

Referring also to Figure 5C, housing 74 at its lower end accommodates latch assembly 83. Latch assembly 83 includes latch 20, a latch retaining plate 85 and springs 86. Springs 86 act between latch 20 and latch retaining plate 85 to bias latch 20 radially outwardly from housing 74. Latch 20 is retained in a channel 88 through housing 74 which opens into bore 73. Latch 20 is prevented from being forced by the action of springs 86 out of the channel, by abutting flanges 90 which act against shoulders 92 on the latch. Latch 20 can be pushed into channel 88 by application of force on the latch toward plate 85.

Latch 20 is formed to fit into latch retaining slot 16a on casing 8 and has a ramped surface 94 on its upper edge, to ease removal from the slot, and an acute angle portion 96 which acts as a catch on its lower edge to resist against the latch moving out of the slot by any downward force.

Mandrel 72 is bifurcated at its lower end to form two arms 98a, 98b. Arms 98a, 98b are formed to be extendable through bore 73 on either side of latch 20. Arms 98a, 98b are generally wedge-shaped to permit rotation of mandrel 72 in bore 73. As mandrel rotates, arms 98a, 98b are driven from a position in which they do not restrict movement of the latch in the channel to a position in which arm 98a abuts against shoulder 99 of latch 20 and prevents it from moving back into channel 88. In this way 98a can be moved to act as a lock against retraction of latch 20 into channel 88. Arm 98b serves to stabilize the end of the mandrel, but, can be omitted from the mandrel, as desired.

In use, a toolguide is constructed by attaching an upper section (ie. Figure 3A or Figure 4A) to lower secton 22 by insertion of shear pins 61 through apertures 62 and 70. The toolguide is run into the well until the latch 20 is about 1 meter below the slot 16a in casing section 8. The toolguide is hoisted and rotated slowly, until latch 20 is located in slot 16a. When the latch is located in the slot, the torque load will suddenly increase. As the string torques up, jay pin 76 will release, allowing mandrel 72 to rotate in a direction indicated by arrow a. When the force on the toolguide is released, the mandrel will be free to move down in housing 74 (Figure 5B). During rotation of the mandrel, arms 98a, 98b will be rotated so that arm 98a abuts against shoulder 99 of latch 20 and locks latch in the outwardly biased position. Mandrel arms can take other forms provided they are formed to lock behind the latch in response to rotation of the mandrel and/or movement of the mandrel through the housing.

A downward movement of the string allows the toolguide to travel down until portion 96 of the latch lands against the bottom of slot 16a. Latch 20 and housing 74 will support the weight of the tool and upper portion of the housing will be driven down by the weight of the upper section to compress seal 28 allowing it to set. The set force is locked in by collet 77. The upper section 24 is now aligned with window opening 12 and the directional drilling operations can begin.

After the directional drilling operations are completed, a retrieving tool is run in to retrieve the toolguide. Preferably, in the simplest retrieval procedure, a straight upward force, for example of about 20,000 psi on the toolguide will unlock locking collet 77 and permit mandrel 72 to be pulled up. This pulls arm 98a out of abutting engagement with the latch and releases seal 28. The toolguide can then be removed from the well.

If the toolguide gets stuck in the well, a force is applied which is sufficient to shear pins 61 so that the upper section can be removed separately from the lower section.

Referring to Figure 6A, another lower section 22′ is shown connected to an upper section 24′. Lower section 22′ includes a male portion 68′ shaped to fit into socket 58′ of section 24′. Bores 70′ accept ends of shear pins 61′.

Male portion 68′ is an extension of a mandrel 172 which is positioned in a bore 173 in housing 174. Mandrel 172 is slidably moveable through bore 173 along long axis 178 of the lower section, but can be releasably locked against longitudinal sliding movement by frictional engagement of locking collet 177 against knurled portion 177a of the mandrel. Mandrel 172 and bore 173 are correspondingly faceted along corresponding portions of their length to substantially prevent rotational movement of mandrel 172 within bore 173.

An annular packing seal 28 is retained on housing 174 and a tube 179 is positioned to ride over an upper surface of housing 174. Tube 179 is releasably secured through shear pins 179a to upper section 24' to move therewith. Pressure of tube 179 against annular packing seal 28, for example when the weight of the upper section is released onto the lower section, compresses the seal and causes it to expand outwardly.

Lower section 22' carries a latch assembly 183 including a latch 20', a latch retaining plate 184 and latch biasing springs 186. Springs 186 act between latch 20' and plate 184 to bias latch 20' to extend radially outwardly from housing 174. Latch 20' is formed to fit into a latch retaining slot, such as 16a in Figure 1, as noted with reference to latch 20 of Figure 5B.

Latch 20' is retained in a channel 188 which opens into bore 173. Latch 20' is prevented from being forced by the action of springs 186 out of channel 188 by abutting flanges 190 which act against shoulders 191 on the latch. Latch 20' has formed into its surface an upper cavity 192 and a lower cavity 193.

Mandrel 172 has an extension 198 on its lower end which is capable of fitting into cavity 192 when mandrel is advanced toward the latch. When extension 198 of mandrel 172 fits into the cavity, latch 20' is prevented from moving back into channel 188 and, thereby is locked in an outwardly extending position. To strengthen the locking of latch 20' in the outward position, the latch preferably has formed thereon a cavity on each side thereof for accepting a pair of spaced extensions on the mandrel.

A rod 199 extends below latch 20. Rod 199 extends in bore 200 and is slidably moveable therein. Rod 199 and bore 200 are correspondingly faceted along at least a portion of their lengths so that rod 199 is substantially prevented from rotating within the bore. Rod 199 has an end 199' which is capable of fitting into cavity 193 on latch 20'. Cavity 193 and end 199' are formed, as by shaping, such that cavity 193 will only accept end 199' therein when end 199' is directly aligned with the cavity. When end 199' is inserted into cavity 193, the latch is maintained in a recessed position in the channel and is prevented from being biased to extend fully outwardly. Thus, rod 199 acts as a lock for latch 20'. Apertures 201 are formed through housing 174 for alignment with holes 202 on rod 199. Shear pins (not shown) can be inserted through apertures 201 into holes 202 to releasably lock rod 199 against slidable movement in bore 200. Other releasably lockable means can be used in place of shear pins such as spring biased pins or a locking collet. A releasable locking means which can be repeated locked and unlocked is preferred where the tool is to be repeatedly used downhole without being brought back to surface.

Rod 199 extends out of housing 174 and end 199" opposite end 199' is retained in a bore 204 formed in a lower housing 206. A portion of end 199" is enlarged so that rod is retained in the bore. End 199" and bore 204 are similarly faceted to prevent rotation of rod 199 in the bore. However, bore 204 is selected to have a greater inner diameter, ID_b, than the width, w, of end 199" so that rod 199 can move laterally within bore 204. This forms a wobble shaft arrangment and provides that housing section 206 can move out of axial alignment with axis 178 of housing 174.

Housing 206 houses an orienting assembly including a plurality of orienting dogs 208. Preferably there are four orienting dogs spaced apart 90 degrees aligned around a circumference of the housing. Dogs 208 are retained in housing in any suitable way such as by abutting flanges, not shown. Dogs 208 are biased outwardly by springs 210, such as Belleville washers, which are actuated to apply various, selectable degrees of force to the dogs. Springs 210 are actuated to vary their biasing force by a hydrostatic piston assembly 212. In particular, piston 212 includes a piston 214 having a face 214' in communication with a chamber 216 opening though aperture 218 to the exterior of the tool. Opposite face 214" of the piston is open to chamber 219 selected to be at a pressure generally corresponding to ground surface atmospheric pressure. Piston 214 is drivingly connected to rod 220 and rod cup 222. Upper end 222' of rod cup 222 is drivingly connected to springs 210.

As the pressure in chamber 216 increases relative to the pressure in chamber 219, piston 214 will be driven to drive rod 220 and rod cup 222 to compress springs 210. It will be readily understood that movement of the rod cup varies the pressure applied to the springs and thereby the pressure at which dogs 208 are biased outwardly from housing 204. Preferably, at maximum compression springs 210 are selected to bias dogs 208 outwardly at a pressure of 20,000 to 30,000 psi and preferably 25,000 psi. The springs can be replaced with other biasing means such as a hydraulic means which is acted upon by the hydrostatic piston. In addition, the assembly can be selected to act on dogs from both the bottom side and the top side or just from one side, as shown.

Where greater load is required to be applied to the dogs, additional hydrostatic pistons can be added in series.

The lower sections of Figures 6A-6B is useful with a casing section 224 as shown in Figure 7A to 7C. To fully understand the operation of lower section 22' to orient and lock a toolguide into position, we must first review the structure of the casing section. Because of the length of casing section 224, it has been separated into three views. Figure 7A shows the lower portion of the casing section, Figure 7B shows the middle portion of the casing section and Figure 7C shows the upper portion of the casing section. For ease of production and handling, the casing section can be produced in separate sections, as shown, for connection together. Alternately, the casing section can be formed as one piece. Casing section 224 is used with other sections, such as those indicated as sections 6 in Figure 1 to form a casing string. Casing sections 6 can be connected below the section by threaded engagement to pin end 224' in Figure 7A and casing sections can be connected above casing section 224 by threaded connection to box end 224" in Figure 7C.

Casing section 224 includes a window opening 112 which is sized and shaped to permit directional drilling therethrough. Casing section retains therein a sleeve 123 as will be described hereinafter.

A radial profile 230 is formed at a selected distance below window 112. Radial profile 230 is selected to have a length Lp greater than the axial length Ld of dogs 208 (Figure 6) so that dogs 208 can be accommodated in profile 230. Casing section also includes a latch receiving slot 16a formed a selected distance below and a selected radial orientation from window 112. Preferably, latch receiving slot 16a is positioned directly below the window for ease of manufacture. Latch receiving slot 16a is selected to be of a size to accommodate the face of latch 20'.

In use a toolguide including lower section 22' and upper section 24' is run into a casing string including section 224. The lower section is selected such that both the diameter across dogs 208, when they are fully extended, and the diameter of the tool across seals 28, will be greater than the diameter of the casing. Since dogs 208 are biased outwardly, dogs will engage against the surface of the casing.

A running tool is connected to upper section and the weight of the tool guide is supported on running tool. At surface, the tool is in the relaxed, unset position (not shown). In particular, the shear pins are inserted through apertures 201 into holes 202 which locks housing 174 down in close position to housing 206 and maintains end 199' in cavity 193 to retain latch 20' in a recessed position. To maintain this configuration during handling, the shear pins at this connection are selected support the weight of the housing 206 and its components. No weight of the upper section is applied at locking collet 177 and therefore substantially no engagement is made between the locking collet and portion 177a. Finally, the pressure in chamber 216 is generally equal to the pressure in chamber 219. Thus, piston is equalized and substantially no pressure is applied at springs 210 of dogs 208. Dogs 208 are therefore biased outwardly a minimum selected pressure, for example, 0 to 500 psi and are capable of being driven inwardly to move into and along the casing string.

As tool is being run into the casing string, the hydrostatic pressure of the fluids in the well will increase as the depth of the tool increases. As the pressure increases of the well fluids increase, the pressure in chamber 216 increases causing piston 214 to be driven into chamber 219, which is at a lower pressure. Movement of piston is translated to rod 220 which, though rod cup 222, compresses springs 210. Compression of springs 210 drives dogs 208 outwardly at increased pressures until maximum pressure is reached. When maximum pressure is reached the weight of the running string is sufficient to drive the tool through the casing string. However, the pressure in dogs is selected such that it will affect the load required to move the tool though the casing. In one embodiment, the maximum biasing pressure on dogs is selected to be about 20,000 to 30,000 psi. Preferably, the leading, lower edges 208' of the dogs is sloped to facilitate movement of the dogs over raised or recessed portions of the casing string.

It will be appreciated that, because of the alignment of the dogs about a circumference of the lower section and the pressure acting on the dogs, it will be determinable when the dogs have passed from the standard casing diameter over or into a radial form in the casing. Preferably, the trailing, upper edge 208" is selected to be square or only slightly sloped to engage more firmly against raised shoulders in the casing. Thus, to ensure that the dogs are located in profile 230, the toolguide can be pulled up while monitoring the force on the running string to confirm that the dogs have engaged against the upper shoulder of the profile. Preferably, no other radially recessed areas in the casing are of a size to permit dogs 208 to drop therein. Thus, tool orientation along the length of the casing string can be determined by monitoring the force applied to the running string to determine when the dogs are located in profile 230. During use of the toolguide in a horizontal section of well, the housing 206 can move laterally, at connection of rod 199 in bore 204, out of alignment with the remainder of the tool. This prevents the dogs from being acted upon by the entire weight of the string.

During confirmation of dog orientation, sufficient pressure will be applied to the string in a upward (toward upper section) direction, that shear pins in apertures 201 will shear (i.e. at 5,000 psi) and housing 174 will be pulled along rod 199 away from housing 206.

This will cause end 199' to be pulled out of cavity 193. The pressure of springs 186 behind latch 20' drives latch 20' outwardly. Since cavity 193 will then be out of alignment with rod end 199', engagement cannot be made again between latch 20' and rod 199, even where force is again applied toward the lower section.

The distance between latch 20' and dogs 208 is selected to be generally equal to the distance between profile 230 and latch receiving slot 16a so that when latch is biased outwardly it will be at the same position along the casing as the slot 16a. Thus, by rotation of the tool, latch 20' can drop into slot 16a. In this configuration sloping face 26' of upper section 24' will be oriented to direct tools moved along it, laterally outwardly toward window 112.

When the running tool is removed from the upper section, the weight of the upper section will be pushed down or set down on the lower section causing tube 179 to force seal 28 to expand outwardly and to cause extensions 198 of mandrel to move into cavity 192 to lock latch 20' in outwardly extended position. Also when the weight of the upper section is set down on the lower section, locking collet 177 will be driven by its spring to engage against the knurled portion 177a of mandrel.

Referring to Figure 9, another casing section 108 according to the present invention is shown. Casing section 108 is useful in the drilling and completion of deviated well bores. It is used attached to other casing sections such as those indicated as sections 6 in Figure 1 to form a casing string.

Casing section 108 includes a window opening 112 and a sleeve 123. Casing section 108 has a known internal diameter, indicated at IDc. A cylindrical section is removed from the inner surface of the casing to form a groove 119 which has a larger inner diameter than the casing. A key 121 is secured, as by welding, in the groove adjacent its bottom edge.

Sleeve 123 is disposed in groove 119. An embodiment of the sleeve for use in the embodiment of Figure 9 is shown in flattened configuration in Figure 10. To ready the sleeve shown in Figure 10 for use, sides 123a, 123b of the sleeve are brought together and preferably attached, as by welding.

Sleeve 123 has a key slot 125 at its lower edge to engage key 121. Key slot 125 has two locking slots 125a and $125a^1$ and a ramped portion 125b therebetween to facilitate movement of key 121 between slots 125a, $125a^1$. Sleeve 123 is rotatable and longitudinally moveable in groove 119 and key slot 125 is formed to limit the movement of sleeve 123 over key 121 between a first position at locking slot 125a and a second position at locking slot $125a^1$. Sleeve 123 is selected to have an inner diameter IDs which is greater than or equal to the inner diameter IDc of casing 108.

Sleeve 123 has a first opening 127 which is larger than window opening 112 but is positioned on the sleeve such that it can be aligned over window opening 112. Sleeve 123 preferably also has a second opening 129 which is substantially equal to or smaller than window opening 112. Second opening 129 is shown spaced about 180 degrees from opening 127 in Figures 7A to 7C, while in Figure 9 opening 129 is rotated only about 80 degrees from first opening 127. Second opening 129 is also positioned on sleeve 123 such that it can be aligned over window opening 112. Key slot 125 is shaped relative to key 121 to permit movement of the sleeve to align one of the first and second openings 127, 129 over window opening 112 and locking slots 125a, $125a^1$ are positioned to lock the sleeve by its weight at these aligned positions.

Seals 131 are provided at the upper and lower limits of the sleeve between the sleeve and groove 119. In the embodiment of Figure 10, seals 133, 135 are also provided about openings 127 and 129, respectively. Seals 131, 133, 135 are each formed of materials which are hydraulically sealing such as o-rings positioned in retaining grooves or lines of vulcanized polymers such as urethane. Preferably, the seating areas for the seals are treated, for example by machining to provide a smooth surface, to enhance the sealing properties of the seals. The seals act against the passage of fluids between the sleeve and the structure to which they are seated, for example the casing or the flange of a tieback hanger. In an alternate embodiment, the seals are secured to the casing and the sleeve rides over them.

In the embodiment of Figure 10, an aperture 137 is provided on the sleeve which is sized to accept, and engage releasably latches on a shifting tool (not shown). The latches of the shifting tool hook into apertures 137 on sleeve 123 and shift tool is raised to pull the sleeve upwardly to release key 121 from locking slot 125a or $125a^1$ into which the key is locked. The shifting tool then rotates sleeve 123 within groove 119.

The sleeve can be shifted by other means such as a sleeve shifting tool, as will be described in more detail hereinafter, having pads with teeth formed thereon for being forced against the sleeve material so that the sleeve can be rotated in the groove.

Window opening 112 has a profiled edge 113. Edge 113 is formed to accommodate and retain a flange 115 (Figure 11A) formed on a deviated wellbore liner or tieback hanger 117.

In use, casing section 108 having sleeve 123 disposed therein is prepared for placement downhole by aligning opening 127 over window 112. To prevent inadvertent rotation of sleeve 123 in its groove, shear pins 138 are inserted to act between the sleeve and the casing section. A liner is then inserted through the internal diameter and opening 112 is filled and wrapped, as discussed with respect to Figure 2. A casing string is formed by attaching casing section 108 to other casing sections selected from those which have window openings or those which are standard casing sections. The casing string is then inserted into the wellbore and is aligned, as desired. The wellbore is then completed.

After completion, the hardened cement and the liner are removed from the casing string. This exposes sleeve 123 within casing section 108. A toolguide, for example, according to Figure 1 or any other toolguide, is positioned in the well such that the face of its upper section is opposite opening 112 and a deviated wellbore is drilled.

Once the deviated wellbore is drilled, at least a junction fitting such as a tieback hanger 117 is run into the well and positioned such that its flange 115 is engaged on edge 113. Sleeve 123 is then lifted and rotated by engaging the setting tool in apertures 137 such that opening 129 is aligned over opening 112 and thereby the central opening of the tieback hanger. This causes seals 135 to seal against flange 115 and prevents fluids from outside the deviated casing from entering into casing section 108 at the junction. Using the sleeve of the present invention, the deviated wellbore does not need to be completed using cement to seal against passage of fluids outside the casing. However, where desired, the deviated wellbore can be completed using cement to increase the pressure rating of the seal.

The sleeves according to the present invention can be rotated using any suitable tool. A tool which engages in apertures 137 can be used or alternately a sleeve shifting tool 450 can be used as shown in Figures 16A and 16B which does not require the alignment of dogs into apertures but rather frictionally engages the sleeve. In particular, tool 450 is sized to be insertable into the inner bore of the casing and sleeve and includes an elongate body 452. A plurality of sleeve engaging slips 454a, 454b are mounted in the body to be moveable radially inwardly and outwardly between a retracted position (i.e. 454a') and an extended position (i.e. 454b'). In the extended position, the slips 454a, 454b are selected to frictionally engage against the sleeve with sufficient force to permit lifting and rotating of the sleeve.

Preferably, the sleeve engaging slips are selectively positioned along the tool so that they will engage the sleeve adjacent the upper and lower edges thereof and at a plurality of positions about the inner radius. The sleeve engaging slips can be formed in any suitable way to engage against the sleeve. In one embodiment, the sleeve engaging faces 455 of the slips are roughened or knurled or have teeth formed thereon in a suitable way to permit the slips to bite into the material of the sleeve. In the illustrated embodiment, slips are provided in two orientations. Slips 454a are selected to enhance frictional engagement to provide for longitudinal movement (ie. lifting) of the sleeve and slips 454b are selected to enhance frictional engagement to provide for rotational movement of the sleeve. In particular, slips 454a include elongate teeth 456a formed orthogonal to the long axis 452x of the body 452 and slips 454b include elongate teeth 456b formed substantially parallel to long axis 452x. Preferably the teeth 456a, 456b are formed with leading edges formed to define acute angle so that they exhibit enhanced frictional engagement in one direction.

Sleeve engaging slips 454a, 454b can be moved radially inwardly and outwardly between the retracted position and the extended position in any suitable way. In the illustrated embodiment, the slips 454a, 454b are moveable by changes in fluid pressure as controlled from surface. In particular, body 452 is formed as a tube having an inner bore 458 closed at one end 452a by a plug 458b. Body 452 is connected at opposite end 452b to a tubing string 459 extending upwardly toward surface such that bore 458 can be pressured up by feeding a fluid from surface through tubing string 459.

Slips 454a, 454b are mounted in ports 460 to be radially slidable therein relative to the long axis of the tool. The outer diameter of the slips conform closely to the inner diameter of the ports so that resistance is provided to fluids passing therebetween. O-rings 463 are provided about the slips to form a seal between ports 460 and slips 454a, 454b. Ports 460 open into bore 458 to be in communication therewith and open to the outer surface 452' of body 452. Ports 460 have a reduced diameter at portion 460' to prevent slips 454a, 454b from dropping into bore 458 and straps 464 are mounted, as by use of fasteners or weldments, across ports adjacent outer surface 452' to hold the slips in the ports. Slips 454a, 454b each include a slot 466 extending across the engaging face thereof to accept strap 464. Slot 466 permits the engaging face of the pad to extend out beyond strap. As will be appreciated, strap 464 also prevents the rotation of the slips within the ports, thereby preventing the teeth from rotating out of their selected orientation. Springs 467 are provided between the straps and the slot 466 to bias the slips inwardly. Preferably, straps 464 are not intended to hold the slips in the ports against fluid pressure behind the slips. Instead, the tool is intended only to be pressurized while within a member such as the casing which prevents the slips from extending to bear against the straps.

Although Figure 16B appears to show that a plurality of slips are positioned in close proximity about the tool, preferably there are two to four slips 454a positioned at each of the top and the bottom of the tool. In each position, these slips are equally spaced apart around the circumference. The same arrangement is selected for the slips 454b.

As noted above, the slips 454a, 454b are moveable by changes in fluid pressure in bore. In use, when the pressure of the fluid in bore 458 is increased relative to the pressure about the tool, slips 454a, 454b are driven outwardly through ports 460 against the tension in springs 467 and into extended position until the slips engage against the sleeve. If a sufficiently high pressure is provided to the bore, the slips will bite into the sleeve with a frictional engagement sufficient to move the sleeve by movement of the tool, as by movement from surface. If the pressure is maintained, the slips will remain in the extended position. If the pressure is lowered, to a pressure relatively equal to or less than the ambient pressure around the tool, the slips will be retractable and will not maintain a frictional engagement with sleeve which is sufficient to move the sleeve by movement of the tool.

To assist in the pressurization of the bore, a check valve 468 is provided adjacent end 452b, either in the bore of the tubing string 459, as shown, or in bore 458 of body 452 above the upper set of slips. Check valve 468 permits the flow of fluid behind slips 454a, 454b, but substantially prevents fluid from passing upwardly out of bore 458. Thus, pressure can be maintained behind the slips to maintain them in an extended position without maintaining the pressure in the entire tubing string to surface. When check valve 468 is used, a means for releasing the pressure from within the bore is required in order to permit the tool to be disengaged from the sleeve, once the sleeve has been shifted. As an example, valve 468 can be mechanically or electrically openable or a vent can be provided. In the illustrated embodiment, plug 458b is burstable by application of pressure greater than a selected value. Therefore, when it is desirable to release the tool from engagement with the sleeve, further fluid pressure is forced into bore 458 through check valve 468 until plug 458b bursts allowing equalization between the bore pressure and the pressure about the tool.

To permit proper positioning of the tool at the location of the sleeve in the well bore, a wobble shaft arrangement 470 and an orienting assembly 471, as discussed hereinabove with respect to Figures 6A-6B, can be used.

The sleeve according to the present invention can be modified to permit other uses. For example, a sleeve can be used which has one or two openings which can be aligned with window opening and can also be positioned to block a window opening. Referring to Figure 12, one embodiment of such a sleeve is shown. Sleeve 223 is shown in flattened configuration and when readied for insertion into a groove of a casing section sides 223a, 223b are brought together. A key slot 225 is formed at the lower edge of sleeve 223 for riding over a key formed in the groove of the casing section in which the sleeve is to be used. Key slot 225 has three locking slots 225a, 225a' and 225a" to permit sleeve 223 to be moved between three positions. The first position of which is where the key is locked, by the weight of the sleeve, into slot 225a and opening 127 is aligned with the window opening of the casing section. The second position is that in which the key is locked into slot 225a' and opening 129 is disposed over the casing window opening. The third position is the one in which the key is locked into slot 225a" and a solid portion of the sleeve indicated in phantom at 234, is disposed to block off the window opening of the casing section. The sleeve can be moved between any of these positions by a shifting tool. The groove into which the sleeve is mounted is formed to accommodate such movement.

Seals 233, 235 are provided around openings 127, 129 and seals 231 are provided around the upper and lower regions of sleeve 223 to hydraulically seal between the sleeve and the casing into which the sleeve is mounted. The seals are on the other side of the sleeve and are shown in phantom in this view.

Referring to Figure 11B, generally the tieback flanges are formed as tabs 115' and are disposed on the tieback 117 to extend out from the sides thereof. Generally, there can be two tabs 115', as shown, or four tabs 255 shown in phantom. Because of the arrangement of the tabs, it has been difficult or impossible to use a liner having an outer diameter just less than the inner diameter of the casing through which it is to be run. In particular, in such an arrangement, the casing window is so large across its width that the flange tabs have nothing to latch against.

Referring to Figure 11C, a tieback hanger 117' has been invented which is useful for use in tying back a liner having an outer diameter close to that of the casing inner diameter. Tieback hanger 117' has flanges 252 positioned at the top and bottom of its open face 254.

Tieback hanger 117' is intended to be used with a casing section, such as that shown in Figures 7A to 7C and in Figure 13 (13a, 13b), having a wall 256a extending out into window 112 adjacent the top thereof and another wall 256b extending out at the bottom of the window. Walls 256a, 256b provide surfaces against which flanges 252 can latch. Walls 256a, 256b are recessed relative to the inner surface of casing section 224, so that when flanges 252 latch against the walls, sleeve 123 can be rotated over the open face 254 of the tieback hanger to hydraulically seal off the liner. In this embodiment, preferably, the open face 254 of the tieback hanger has bonded thereto, as by vulcanization, a polymeric material 258 such as, for example, urethane to seal against the sleeve.

Walls 256a, 256b can be partial or complete. Preferably the walls are disposed at the top and bottom of the window and form a V-shaped opening. The walls can be formed integral with the casing section 224 or can be attached, as by welding, to the outside of the casing section.

The tools disclosed herein must be run into and retrieved from the well. Running and retrieval tools are known. However, previous running and retrieval tools are sometimes difficult to manipulate and operate. These previous tools are particularly difficult to operate in horizontal runs of casing.

A new tool 270 which can be used for both run in and retrieval of whipstocks is shown in Figure 8 (8a, 8b). Tool 270 is intended for use with a whipstock as shown in Figures 4A and 4B and a casing section as shown in Figures 7A to 7C. To facilitate understanding of the tool 270 reference should be made to those Figures.

Tool 270 includes a front end 270' and a threaded end 270" for connection to a drill pipe, such as that shown as 32 in

Figure 1. A bore 272 extends a portion of the length of the tool and opens at end 270". A piston 274 is disposed to move slidably along a length of bore between shoulders 276, 277 and a spring 280 is disposed between piston 274 and an end wall 284 of bore 272 to bias piston outwardly against shoulder 276. A rod 286 is connected to piston 274 and is driven thereby. Rod 286 is extends through a channel 287 extending from bore 272 and has a tapered end 286'. Preferably, rod 286 is bifurcated to form two arms, each with a tapered end.

Tool 270 houses a latch assembly including a latch 288, a latch retaining plate 290 and a plurality of springs 292 acting between the latch 288 and the plate 290 to bias the latch radially outwardly from the tool. Of course, the plate can be replaced with an end wall formed integral with the body of the tool. However, a plate is preferred for ease of manufacture. Latch 288 is retained in a channel 294 through tool 270. Latch 288 can be recessed into channel 294 by application of force sufficient to overcome the tension in springs 292 on the latch toward plate 290. Latch 288 is prevented from being forced by the action of springs 292 out of the channel, by abutting against end 286' of rod 286 which extends into channel. In particular, latch 288 has a ramped surface 296 over which tapered end 286' can ride.

Movement of rod 286 through channel 287, by movement of piston, causes latch 288 to be moved radially inward and outward in tool, by movement of tapered end 286' over ramped surface 296. Thus, by controlling the pressure acting on piston face 274', latch 288 can be selectively moved.

Latch 288 is formed to fit into a slot, such as slot 55 on upper section 24' of Figure 4A.

Latch has a ramped surface 300 on its front edge, to ease the movement of the latch over protrusions. A reverse angle portion 302 is provided on the rear edge of the latch which acts as a catch to resist against the latch moving out of the slot by any force applied toward end 270".

Tool 270 further includes a orienting key 304 retained in cavity 305. Key 304 is biased radially outwardly from the tool by means of springs 306 acting between the key and an end wall 305a of cavity 305. Key 304 is prevented from being forced out of cavity 305 by shoulders 308. Key 304 is selected to fit into an orienting slot on a casing section, such as slot 309 in casing section 224.

Tool 270 has formed thereon a dove-tailed rail 310. Rail 310 is selected to fit into a dove-tail slot on a whipstock, such as that indicated as slot 51 in Figure 4A. Rail 310 is oriented relative to latch 288 with consideration as to the orientation of slots 51 and 55 on the whipstock with which the tool is to be used. Rail 310 is spaced from latch 288 a selected distance which corresponds to the distance between slot 55 and 51 on the whipstock. Preferably, rail 310 is formed to be in longitudinal alignment with latch 288. Rail 310 is oriented on the tool relative to key 304, with consideration as to the orientation which slot 309 has relative to a slot 51, when a whipstock is mounted in the casing section. In the illustrated embodiment, slot 309 is longitudinally aligned with window. Thus, when a whipstock is mounted in the casing section, the sloping face of the whipstock will be positioned opposite the window and slot 309 and in the illustrated embodiment rail 310 is spaced 180 degrees from key 304.

Another key 312 is preferably provided on the tool and spaced 180 degrees from rail 310. Key 312 rides in a port 314 opening between the outer surface of the tool and bore 272. Key 312 can be moved along a portion of the port 314 as limited by shoulders 316a, 316b.

Tool 270 preferably includes a first fluid delivery port 318 extending between bore 272 and an end 310' of rail 310. A second fluid delivery port 320 extends between bore 272 and a position adjacent latch 288.

In use in a running operation, tool 270 is attached to whipstock 24' at surface. This is done by advancing the tool toward the whipstock so that rail 310 is inserted into slot 51. This requires that latch 288 be forced into channel 294 by any suitable means. When rail 310 is fully inserted in slot 51, latch 288 will engage in slot 55. A drill pipe is attached at end 270". Latch 288 is maintained in slot by action of springs 292.

Tool 270, with whipstock 24' attached, is then run into the well on the drill pipe. When whipstock is properly mounted in the casing, whipstock is released from the whipstock by applying pressure against the piston to drive rod 286 through channel 287 to, thereby, drive latch 288 into a recessed position in the tool. Pressure can be applied to the piston, for example, by forcing a drilling fluid, such as mud, through drill pipe into bore 272. Application of drilling mud increases the pressure in the bore and drives piston against spring 280, which in turn drives rod 286 to advance against latch 288.

When latch 288 is removed from slot 55, rail 310 can be removed from slot 51. Tool 270 is then free to be returned to surface.

To use tool 270 in a retrieval operation, the tool is run in on a drill pipe until it runs into the whipstock. The tool is then pulled out a short distance and is rotated until key 304 drops into slot 309. Because the orientation of slot 309 with respect to a whipstock mounted in the casing section is selected to correspond to the location of the key 304 with respect to rail 310, the rail will be aligned with slot 51 of the whipstock when key 304 is engaged in its slot 309.

Pressure is then applied to piston, such as by pressuring up the drill string, to retract latch 288 so that the tool can thus be advanced to insert rail 310 in slot 51. Applying fluids to bore 272 also serves to cause fluid to be passed through and out ports 318 and 320 at high pressures to clean out slots 51 and 55 which may be filled with debris. Pressure in bore 272 also acts against key 312 to cause it to be driven radially outwardly from the tool. This causes the rail to be driven toward the casing wall. Key 312 is particularly useful when the tool is used in horizontal runs of casing. In horizontal wells, the whipstock is sometimes mounted against the upper side of the casing, as determined by gravity. When the tool is used to latch onto the whipstock, the weight of the tool and drill pipe will cause key 304 to be driven into cavity 305. Thus, rail is out of position for insertion into slot and will simply ride under the sloping face of the whipstock. Key 312 can then be used to raise the tool toward the upper side of the well casing so that rail 310 can align with slot 51.

When rail 310 is inserted fully into slot 51, the drill pipe can be depressurized to permit the latch to be biased outwardly into slot 55. Tool 270, with whipstock 24', attached can then be retrieved back to surface.

When rail 310 and latch 288 are engaged in their respective slots on the whipstock, all forces, either longitudinal or torsional, which are applied to the tool are directly transmitted to the whipstock. The tool 270 permits both run in and retrieval and is useful in horizontal well sections.

To facilitate use of the tools and the casing sections described herein and others not herein described, preferably a high side tool is used. To facilitate use of the high side tool, preferably sensors such as, for example, magnetic sensors, are mounted in the tools and/or the casing section components (ie. the sleeve), for reading by the high side tool. The sensors are preferably mounted so that it can be determined both (a) where the high side, according to gravity, is and (b) the degree to which any well component has been rotated.

Another problem which occurs in downhole assembly manipulation is the orientation of the tieback hanger in proper position for insertion through the window. Previous tools actuate the tieback hanger and liner too slowly and therefore increase the chances of the liner being stuck against a negative pressure formation.

Referring to Figure 14, a tool 330 has been invented which useful for downhole placement and positioning of tieback hangers. Tool 330 includes a housing 332 with a bore 334 extending therethrough. Slidably positioned in bore 334 is a rod 336. Rod 336 and bore 334 are similarly faceted at least along a portion of their lengths so that rod 336 is substantially prevented from rotating in the bore. Rod 336 has a box end 336' for connection to a drill pipe (not shown). Box end 336' acts to limit the sliding movement of rod 336 through bore 334 by abutment against housing 332.

At its opposite end 336", the rod has formed thereon threads 338 for connection to a flex shaft which extends into a whipstock and bends along the face thereof for connection to a hydraulic liner running and setting tool, as are known (not shown). A shoulder 340 is formed to abut against the end of the flex shaft, when the flex shaft is engaged on the rod.

Housing supports a collet 341, a key 342 and a poppet 343. Collett 341 includes a plurality of (ie. four) circumferentially aligned dogs 344. Dogs 344 are biased radially outwardly by springs 345 and are selected to locate in a profile formed in a casing section (not shown) for use with the tool. Preferably, the profile is a radial groove to avoid having to properly orient the dogs to drop into the profile and to thereby ease location of dogs 344 therein.

Key 342 is biased radially outwardly from housing by springs 346 but is secured in the housing by walls 348. Rearwardly extending arms 347 extend from key 342 into bore. Cavities 348 are formed in rod 336 to accept arms 347, when they are aligned. When key 342 is recessed into cavities, rod 336 is prevented from sliding movement through bore 334. The diameter of the tool at key 342, when the key is fully extended is selected to be greater than the diameter of the casing in which the tool is to be used. This provides that when the tool is located in the casing, the key will be forced against the tension in springs 346 into the housing. Key 342 has chamfered ends 342' to facilitate riding over protrusions. The sides of key 342 (which cannot be seen) have substantially no chamfer to be square or to form a reverse angle so that they will tend to catch on protrusions in the casing. The key is formed to fit into an orienting slot on the casing section in which it is to be used. When whipstock is connected through the flex shaft to tool 330, the whipstock face is positioned in a selected orientation relative to key 342. The selected orientation will depend on the orientation of the slot for key 342 relative to the window opening in the casing.

Poppett 343 is positioned in a hole 349 opening into bore 334 and is biased into the bore by a spring 350. A cavity 351 is formed on shaft 336 for accepting head 343' of the poppett, when the head and the cavity are aligned. When poppett 343 is positioned in cavity 351, shaft 336 is prevented from sliding movement within bore 334. A seal 352 disposed about poppet 343 forms a chamber 354. The pressure in chamber 354 is selected to be a level near surface pressure. A port 356 extends from the exterior of the tool either along shaft 336, as shown, or along housing to open adjacent head 343'.

Tool is used to rapidly position a tieback hanger for proper placement in the window to affect latching of the tieback flange against the window. In use, at surface tool is connected at end 336" to a flex shaft which has attached thereto a tieback hanger and a hydraulic liner running tool. Housing 332 is moved along rod 336 until poppet 343 snaps into cavity 351. A drill pipe (not shown) is attached at end 336' and the tool with attachments is inserted into the well.

In the casing, dogs 344 ride along the inner surface of the casing and key 342 is driven inwardly so that arms 347 engage in cavities 348. As the tool run further into the well, the hydrostatic pressure in the well will be communicated to head 343' of the poppet through port 356. As the hydrostatic pressure increases, poppet will be driven back into chamber 354 and out of engagement with rod 336. This will release the full weight of the rod and attachments onto key 342. Rod will remain in fixed position relative to housing, however, because of arms 347.

The tool is run to a depth such that dogs 344 drop into their profile in the casing. When the dogs are located in their profile, the key will be positioned at the appropriate level to engage in its slot and the tool need only be rotated to locate key 342 in its slot. When key 342 locates in its slot, springs 346 drive arms 347 out of cavities 348 and rod 336 will immediately slide through bore 334 in response to the weight of the attached tieback hanger and other attachments. Because of the fixed orientation of key 342 relative to the tieback hanger face and the fixed orientation of the key's slot relative to the casing window, the tieback hanger will be advanced through the casing and the window in proper position for latching the flanges onto the window edge. The liner can then be manipulated using the hydraulic liner running tool.

It will be appreciated therefore that this tool is particularly useful in placement of a tieback hanger. The liner remains stationary only long enough for the tool to be rotated to located key 342 in its slot. This is a great reduction in liner stationary time over previous tools and prevents liner lock up against negative pressure formations.

The tools for formation and completion of deviated wells, as described hereinbefore and other not specifically described herein, require manipulation by rotation of the tool. In deep well operation and particularly in horizontal well applications, it is virtually impossible to rotate the tool by manipulation from surface.

Referring to Figure 15, according to one aspect of the present invention, a motor 400 for imparting rotational drive such as, for example, a mud motor is connected at an end of a drill pipe 32' adjacent the tool 402 or well component to be rotated. The motor is connected to the drill pipe such that when the motor is driven, rotational force will be communicated to the drill pipe to cause it to rotate within the casing.

Preferably, the motor is driven by pumping drilling fluid therethrough. The motor is preferably a high torque, low speed motor which is selected to stall when the load thereon exceeds a selected level. In particular, when, for example, a tool is to be rotated until a latch drops into a slot, the motor will have a selected power to drive the drill pipe to rotate but when the latch is positioned in the slot and the load increases, the motor will stall to cease rotation of the drill string.

In an embodiment, where hydraulic pressure is required below the motor, such as for example, where the tool 402 is like tool 270 of Figure 8, a bypass valve 404 is positioned above motor 400 to permit flow through a bypass port 406 passing without effect through motor and extending towards tool 402.

Figure 11C, showed a tieback hanger which is useful for tying back a liner having an outer diameter close to that of the casing inner diameter. Figures 17 to 19B show another tieback hanger 500 and casing 502 arrangement which is similarly useful but avoids increasing the OD or decreasing the ID of the casing at the window opening.

Tieback hanger 500 is intended to be used with a casing 502, such as that shown in Figures 17 to 17B, having an window opening 504 formed therethrough. The casing wall edges 505 defining the window opening include profiled areas 506, 508 formed from the thickness of the casing wall material which extend inwardly over the window opening. Preferably, the profiled areas are formed to extend from the outer surface of the casing and to substantially follow the circumferential curvature of the casing outer wall. Preferably, the profiled areas are formed to taper gradually toward their edges so that a beveled edge is formed. The profiled areas can be formed to extend at selected positions around the window opening or about the entirety thereof. In the illustrated embodiment, profiled areas 506 are formed adjacent the bottom of window opening 504 and profiled areas 508 are formed adjacent the upper end of the window opening.

Tieback hanger 500 includes a sleeve 510 including an outboard end 512 for connection to a lateral liner (not shown) and an anchored end 514 for connection to casing. End 514 has a lower setting tab 516 and an upper setting tab 518 formed to engage against the profiled areas 506, 508 formed about window opening 504. Setting tabs 516, 518 are formed to flare outwardly adjacent the edge of end 514 and to mate with the profiled areas 506, 508. Setting tab 516 forms a tapering dovetail configuration, as best seen in Figures 18 and 18A, which can be wedged between profiled areas 506 which form a tapering dovetail mortise, as best seen in Figures 17 and 17A. This prevents the tie back from being pushed entirely out of the window during setting. Upper setting tab 518 is also flared to form a dovetail, as best seen in Figure 19A, which can be wedged against profiled areas 508. The thickness of setting tabs 516, 518 is preferably selected such that the end 514 substantially abuts against the outer surface of the casing, while the setting tabs substantially do not extend inwardly beyond the inner surface of the casing. This selected thickness provides that a minimum amount of material is added to the OD of the liner tieback.

When setting tabs 516, 518 are engaged against corresponding profiled areas 506, 508, tieback hanger will extend through the window opening and hang off from the casing.

In some wells, the laterals extend from the main well bore in such a way that the liner tieback can drop back into the casing and obstruct the passage of tools through the main well bore and into the lateral. In one embodiment as shown, the tieback hanger can be prevented from dropping into the casing by forming the edges of the window opening to engage the end of the tieback hanger against both passing through the window opening both outwardly and inwardly into the casing bore. The edges of the window opening can be formed so that the edges of the tieback hanger can snap into the opening and be engaged therein. In particular, as best shown in Figure 17C, the window edges on which profiled areas 508 are formed include a recess 520 formed in the thickness of the casing wall. Recess 520 is formed between profiled area 508 and inner edge 522 of the window opening. Setting tab 518 is formed to wedge against profiled area 508 and engage into recess 520. Setting tab 518 includes an extension 524 which can be snapped past edge 522 and be accommodated in recess 520. The recesses and extensions can be any suitable shape, provided that each extension can fit into its corresponding recess. Preferably, trailing edges 525 of extensions 524 are chamfered to facilitate unsnapping of the tieback liner from the recess, if desired. Recesses and extensions can be elongate extending along selected lengths of the edges of the window. However, the positioning of the recesses and extensions on their respective parts must be selected so that they can be aligned and mated into each other.

In one embodiment, the distance d1 across the setting tab 518 is slightly greater than the distance d2 across the window between the profiled areas 508. This increases the engagement of the tieback hanger in the window opening and strengthens the casing about the window by transmission of forces.

Preferably, all profiled areas 506, 508 and recesses are formed in the wall thickness of the casing without changing the ID or the OD of the casing at the window.

In addition to the recess/extension engagement or as an alternative thereto, flanges 530 can be provided on the tieback hanger to abut against the edges of the window opening when the setting tab 516 are wedged between profiled areas 506. Flanges 530 acts to abut against the casing to prevent the tieback hanger from tipping back into the casing bore. It is useful to provide both the profiled area 530 and the recesses 520 to act as back up systems against each other.

Preferably all parts of the tieback hanger either sit within the window opening or extend outwardly of the window opening without extending into the bore of the casing, so that a sleeve, such as sleeve 123 of Figure 7A to 7C, can be rotated over the window opening 504.

It will be apparent that many other changes may be made to the illustrative embodiments, while falling within the scope of the invention and it is intended that all such changes be covered by the claims appended hereto.

CLAIMS:

1. A running tool comprising:

a housing including a retractable latch biased radially outwardly from the tool formed to fit within a first slot on a downhole tool; and

a rail formed to be insertable into a guide slot on the downhole tool and the rail positioned to guide the latch into engagement in the first slot.

2. A running tool as claimed in claim 1 wherein the latch is retractable by means actuated by application of pressure thereto.

3. A running tool as claimed in claim 1 wherein the latch is releasably connected to the first slot.

4. A running tool as claimed in claim 1 further comprising:

a piston assembly slottedly engaged to the latch, wherein pressure applied causes sliding movement of the piston assembly that causes radial movement at the latch.

5. A running tool comprising:

a housing including a retractable latch biased radially outwardly from the tool formed to fit within a first slot on a downhole tool; and

a guide slot formed to accept a rail on the downhole tool.

6. A running tool as claimed in claim 1 wherein the rail and the slot are correspondingly shaped.

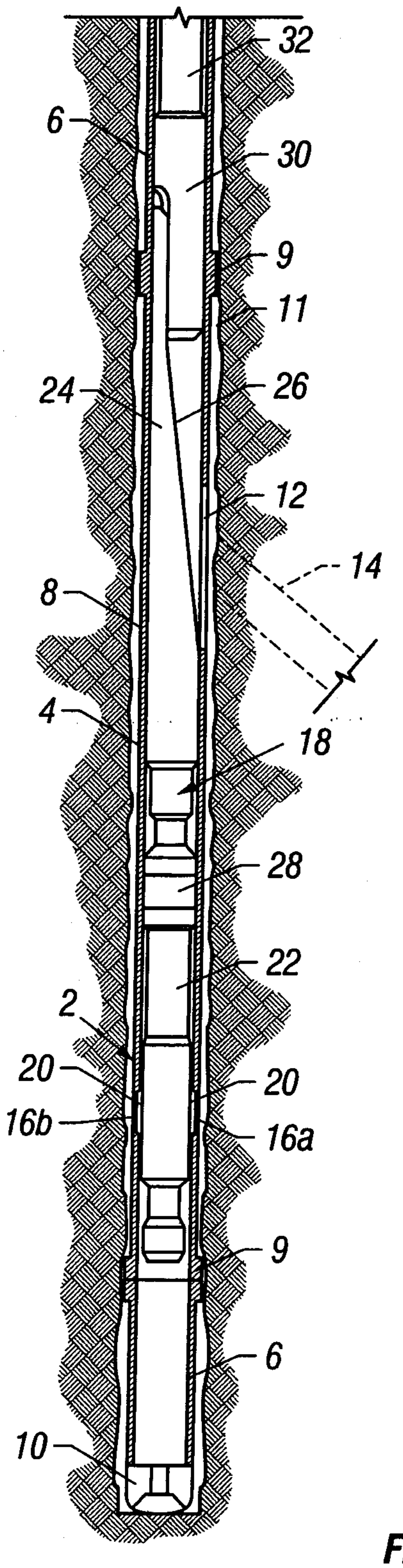


FIG. 1

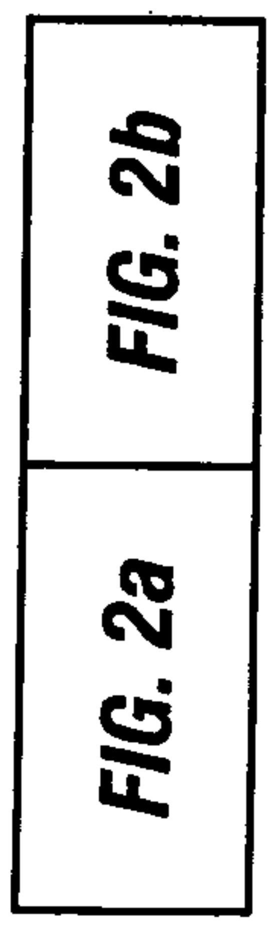


FIG. 2

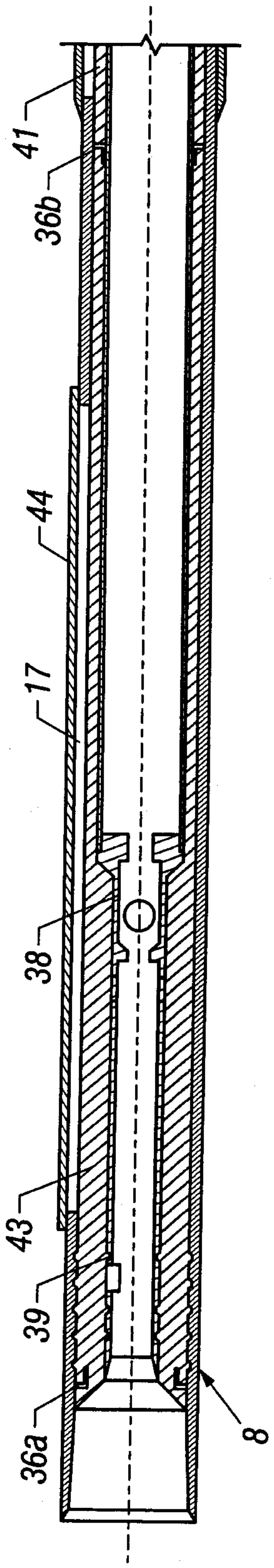


FIG. 2a

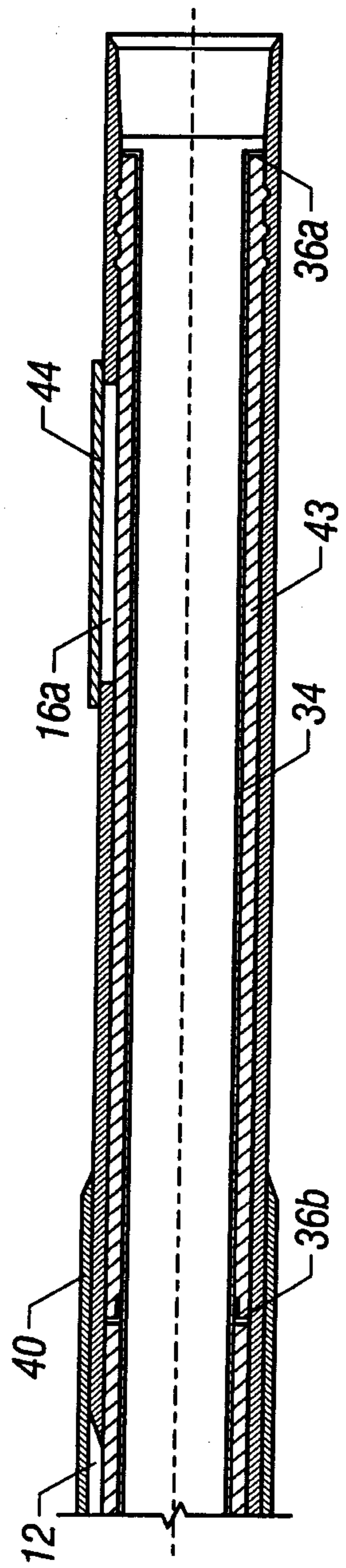


FIG. 2b

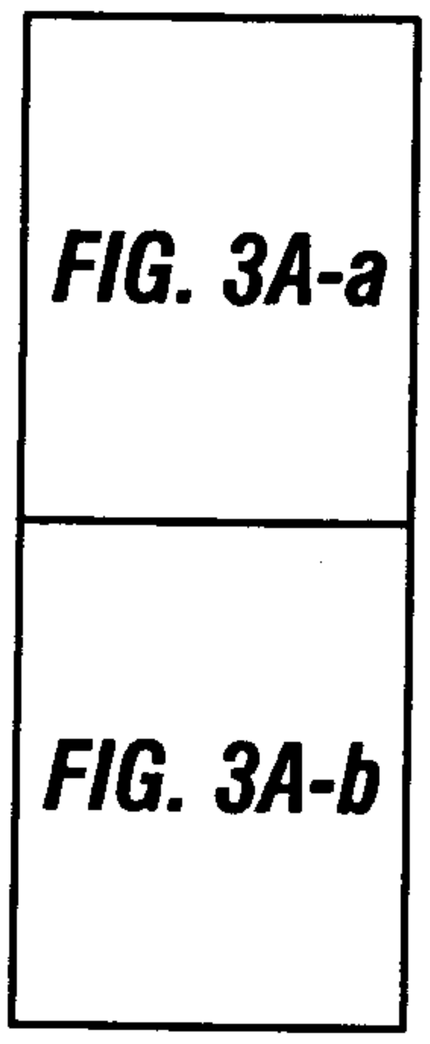


FIG. 3A

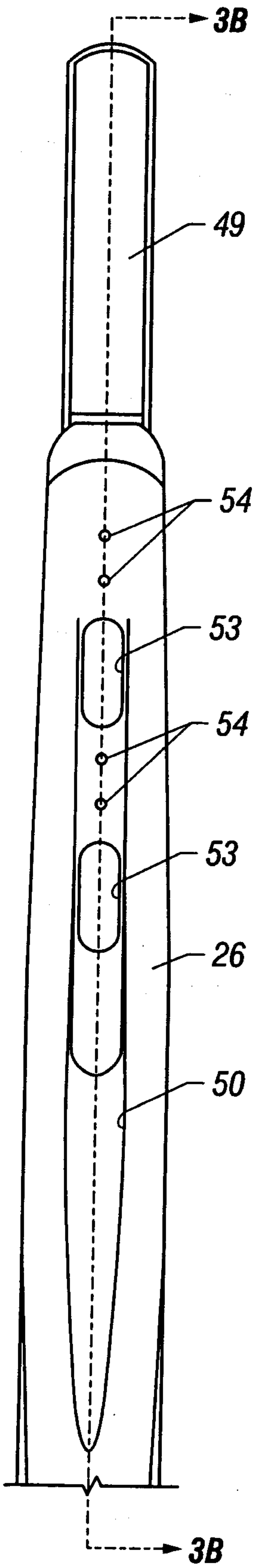


FIG. 3A-a

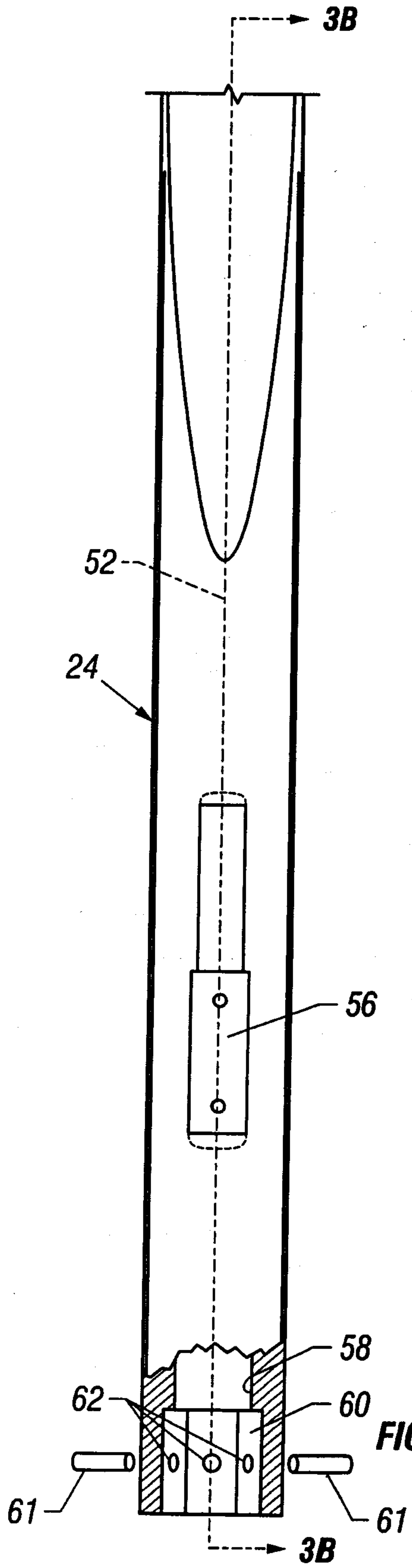


FIG. 3A-b

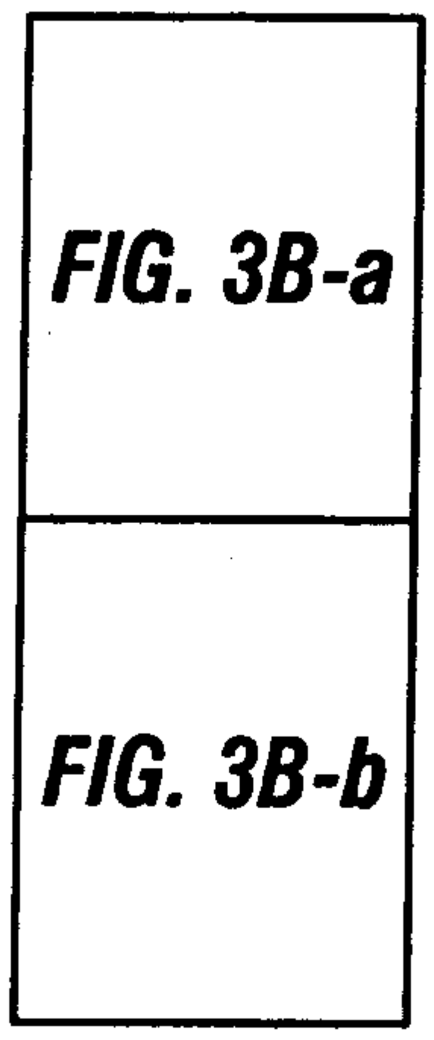


FIG. 3B

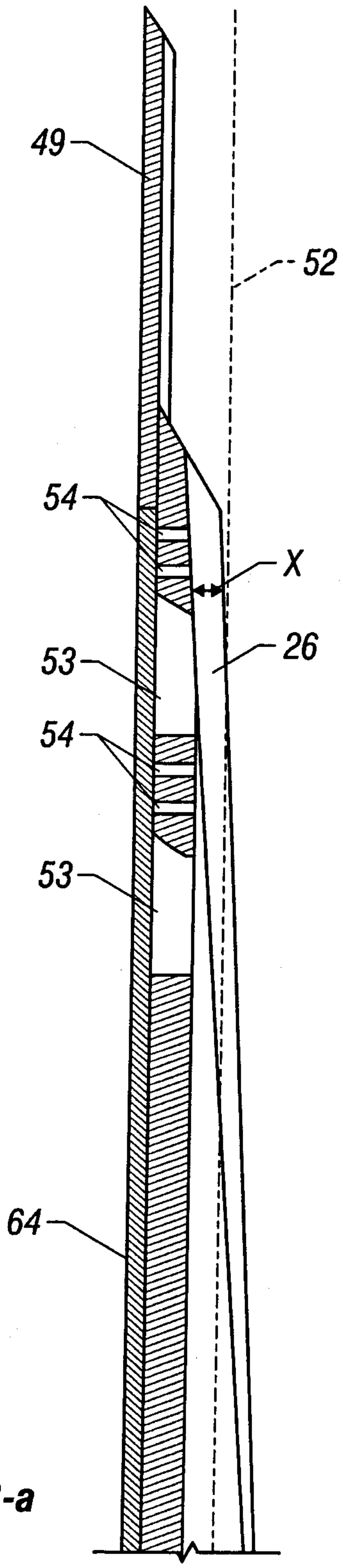


FIG. 3B-a

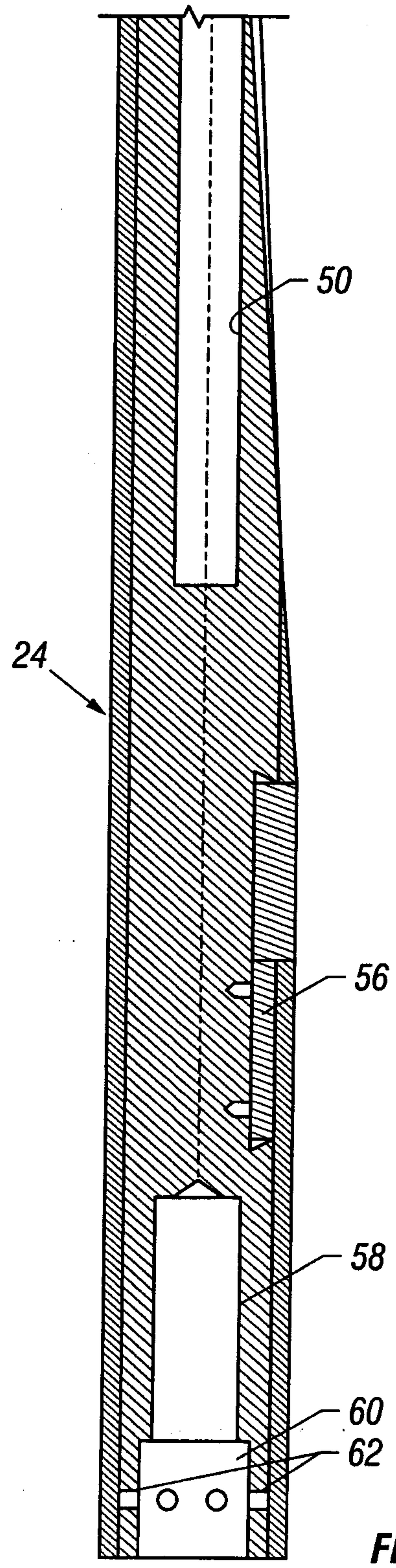


FIG. 3B-b

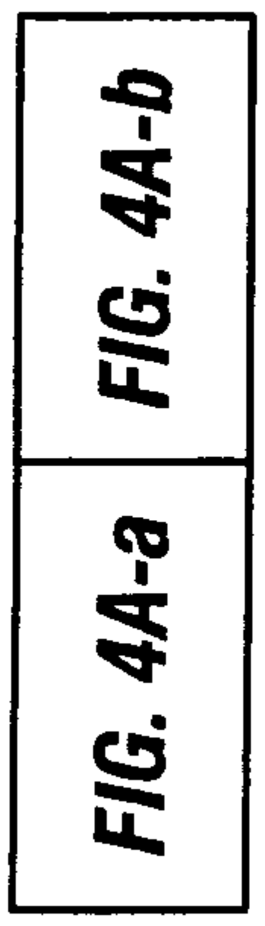


FIG. 4A

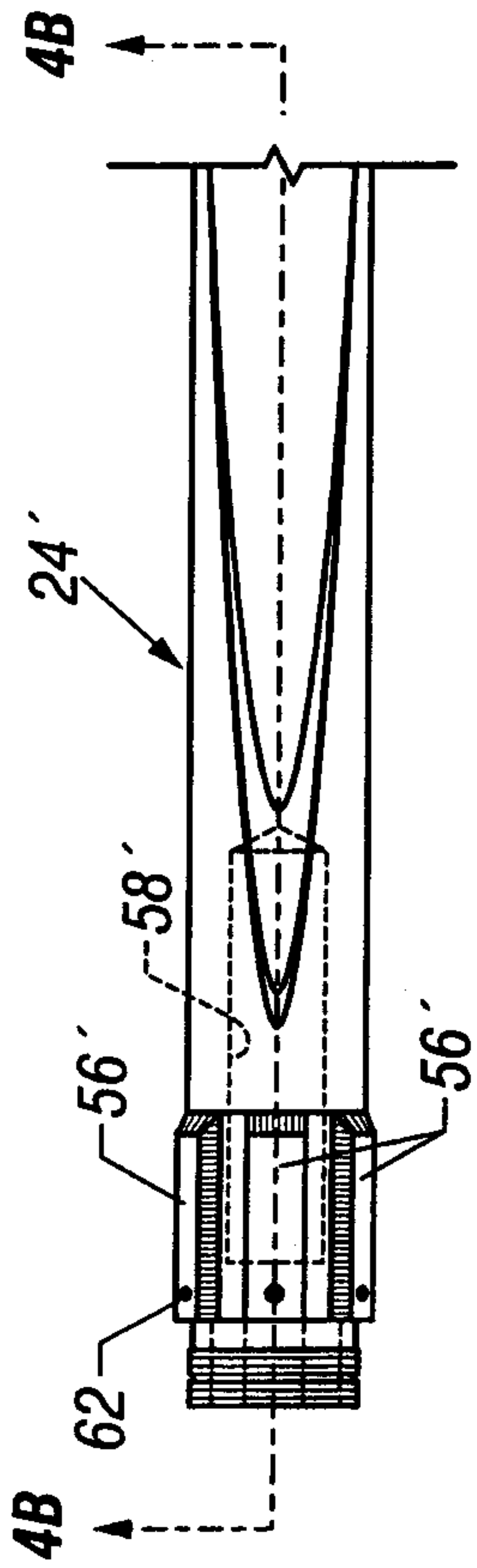


FIG. 4A-a

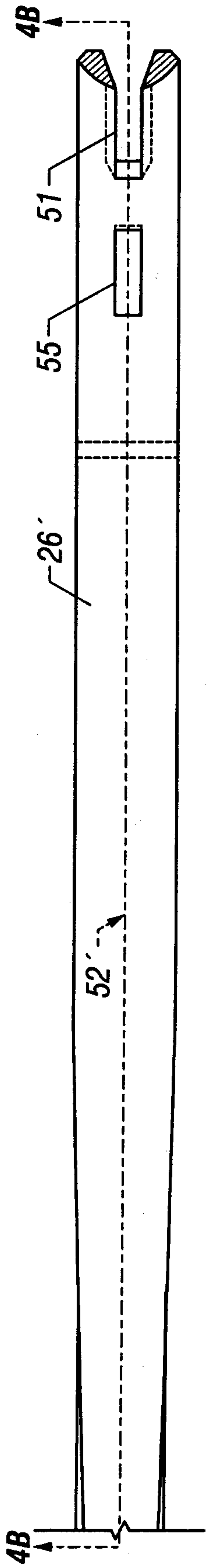


FIG. 4A-b

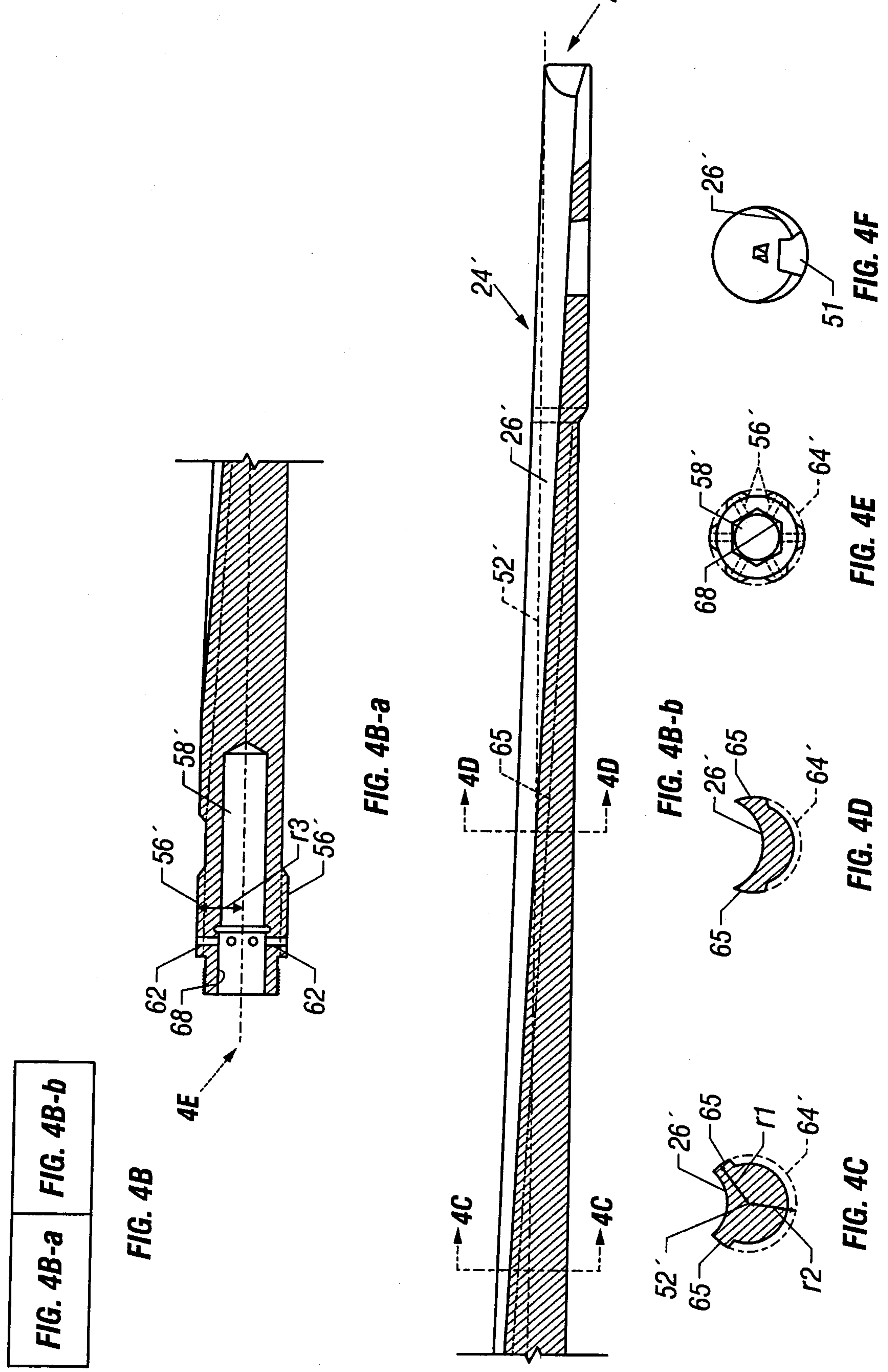


FIG. 4B-a
FIG. 4B-b
FIG. 4B
4E
62
68
62
56´
r3
56´
58´
4F
24´
26´
52´
65
4D
4D
4C
4C
26´
51
FIG. 4F
58´
56´
64´
68
FIG. 4E
26´
65
64´
65
FIG. 4D
26´
65
r1
64´
52´
65
r2
FIG. 4C

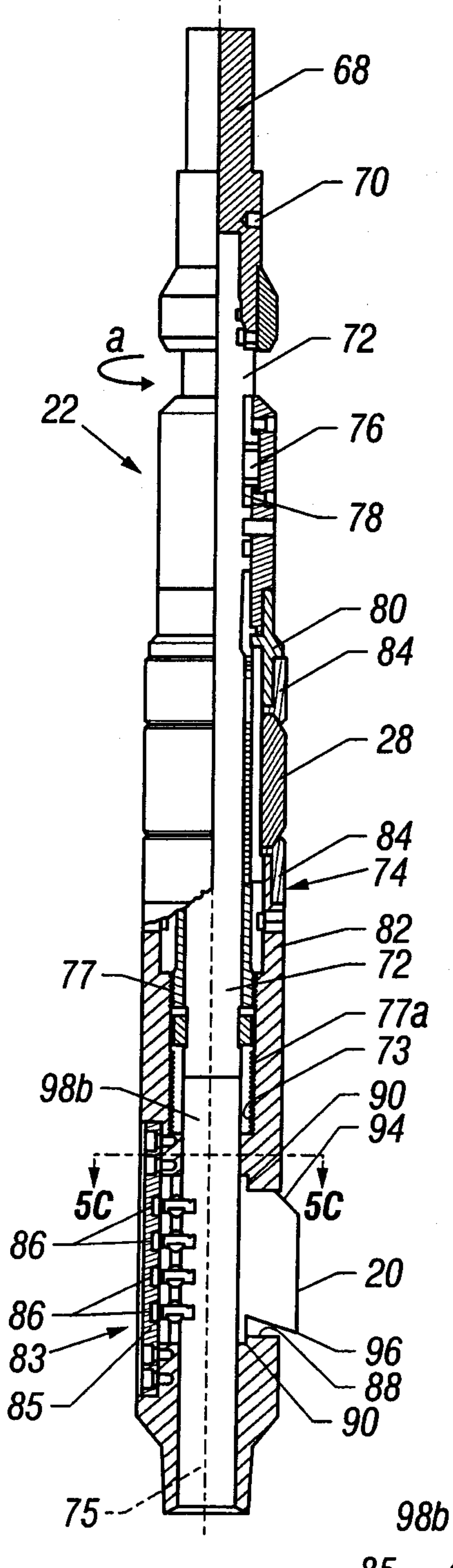


FIG. 5A

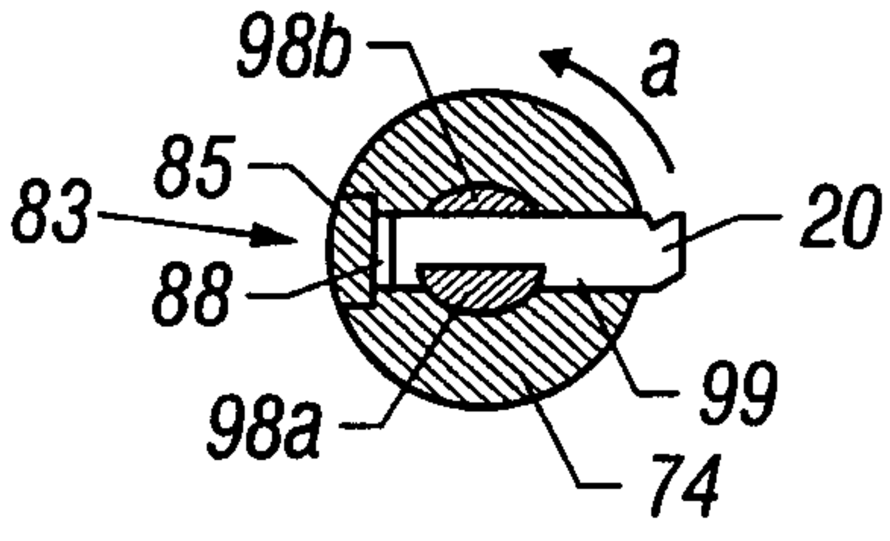


FIG. 5C

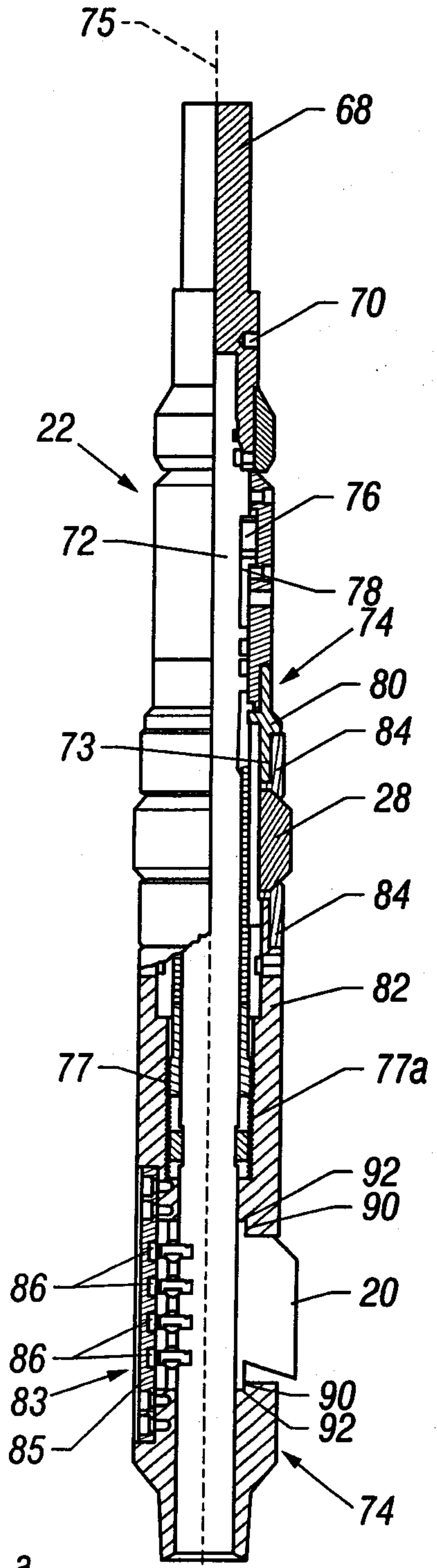


FIG. 5B

FIG. 6Aa	FIG. 6Ab

FIG. 6A

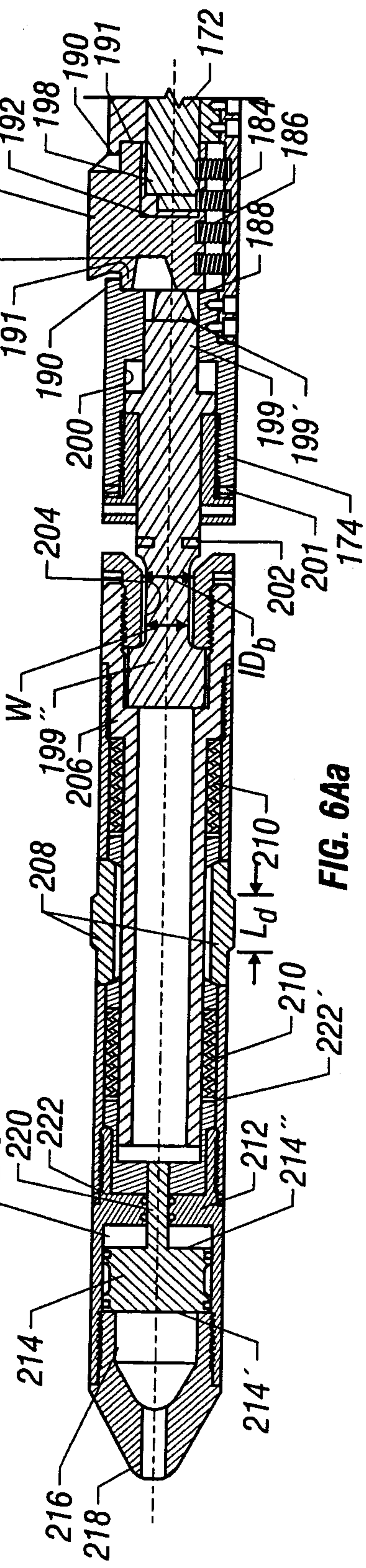


FIG. 6Aa

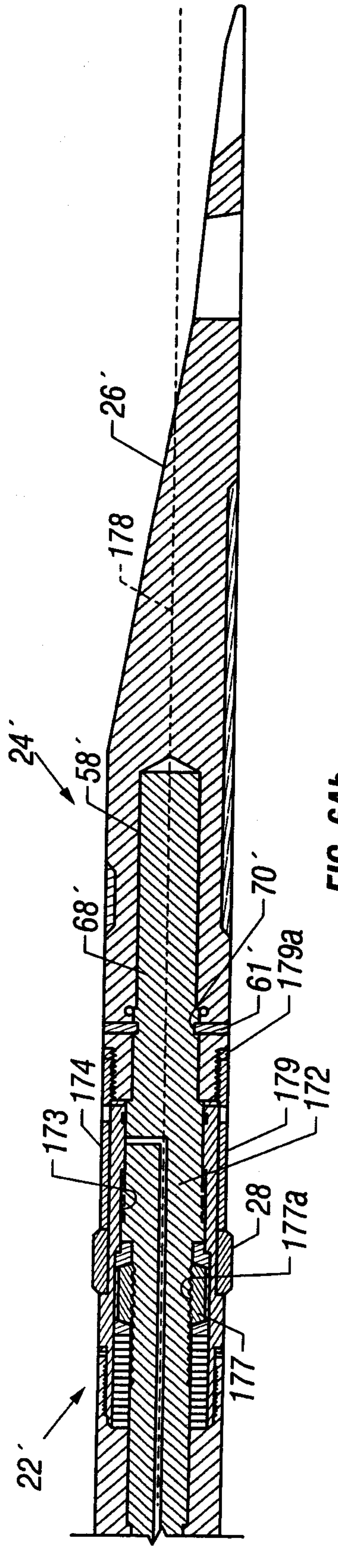


FIG. 6Ab

FIG. 6Ba | FIG. 6Bb

FIG. 6B

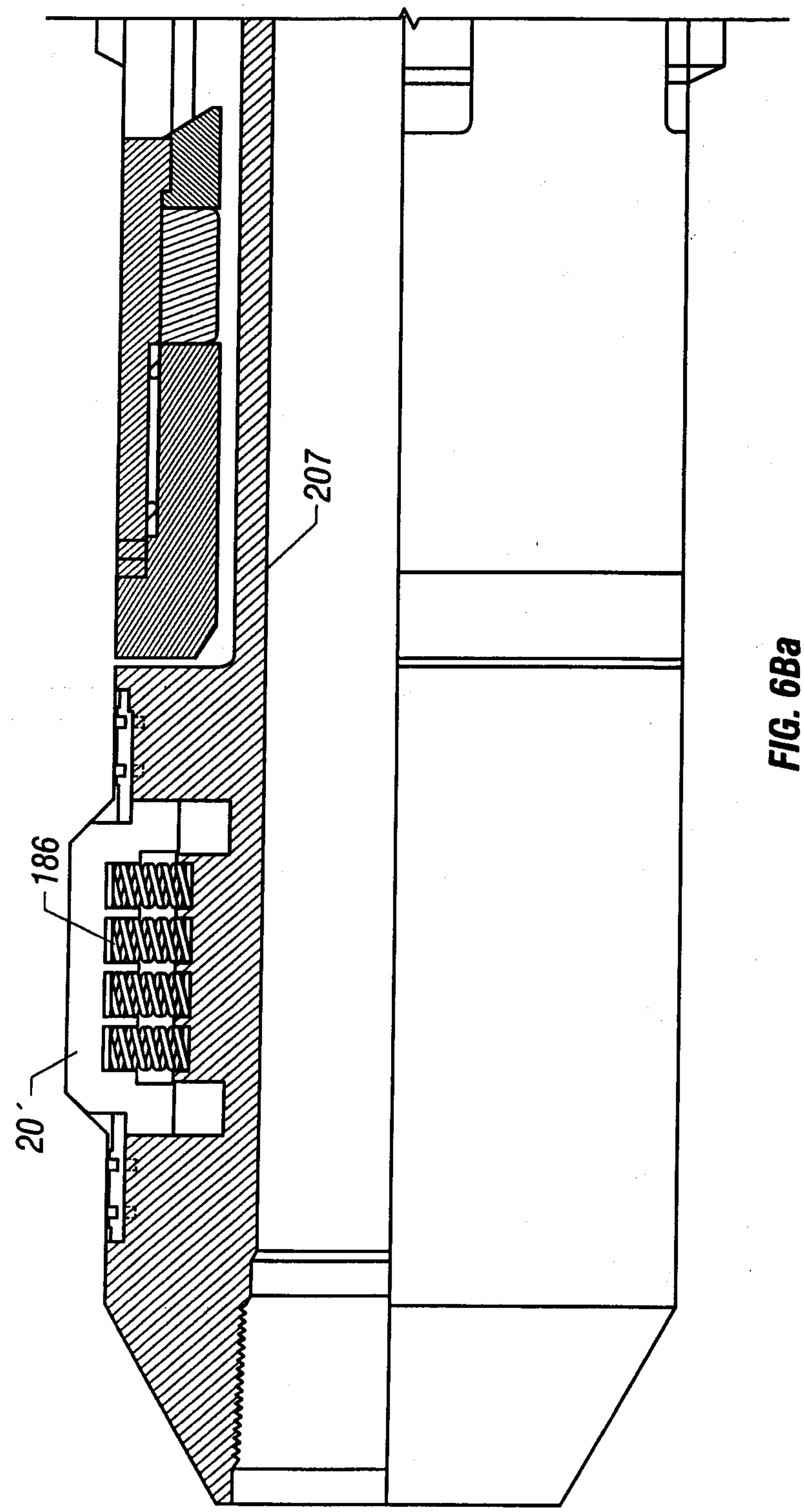


FIG. 6Ba

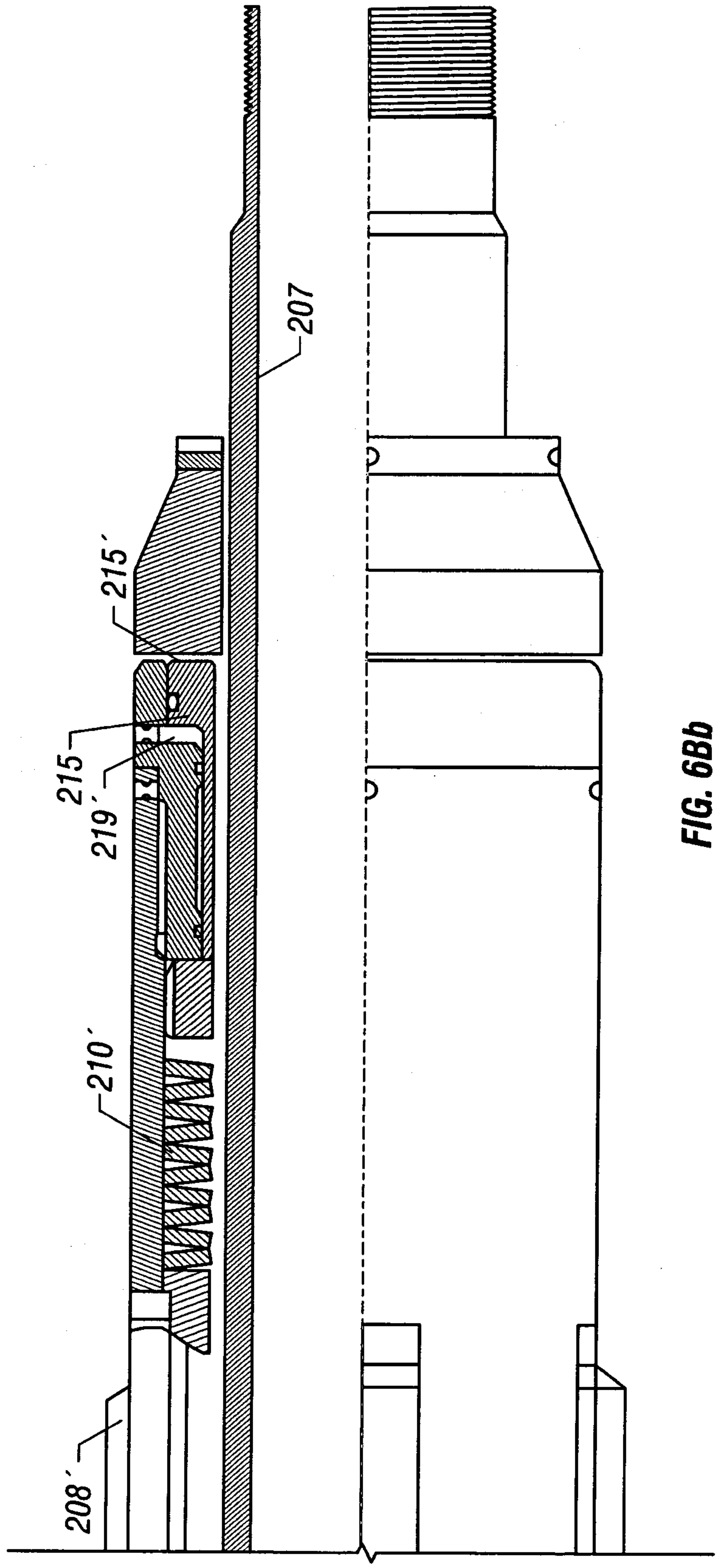
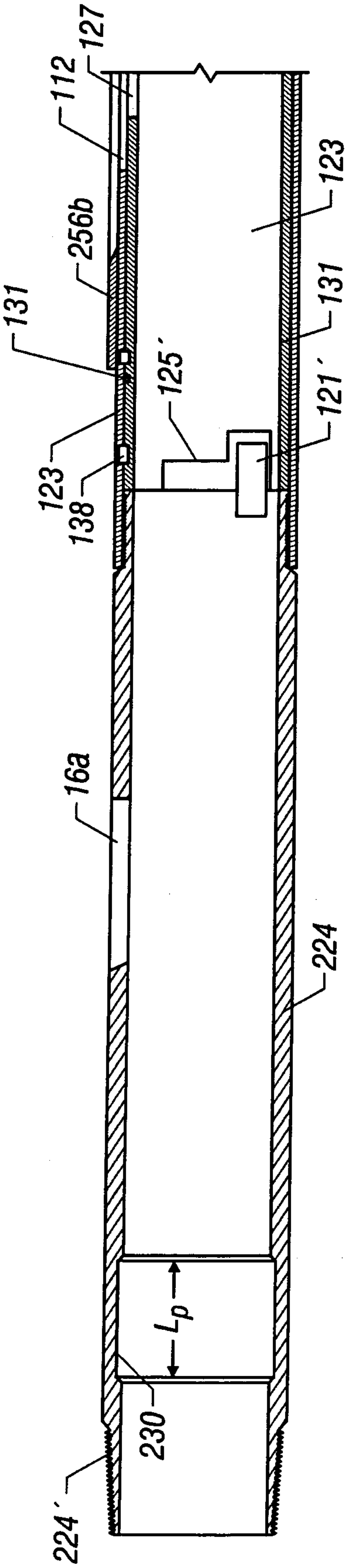


FIG. 6Bb


FIG. 7A
FIG. 7B
FIG. 7C

FIG. 7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112
256b
123
131
131
125´
121´
123
138
16a
224
L_p
230
224´

FIG. 7A

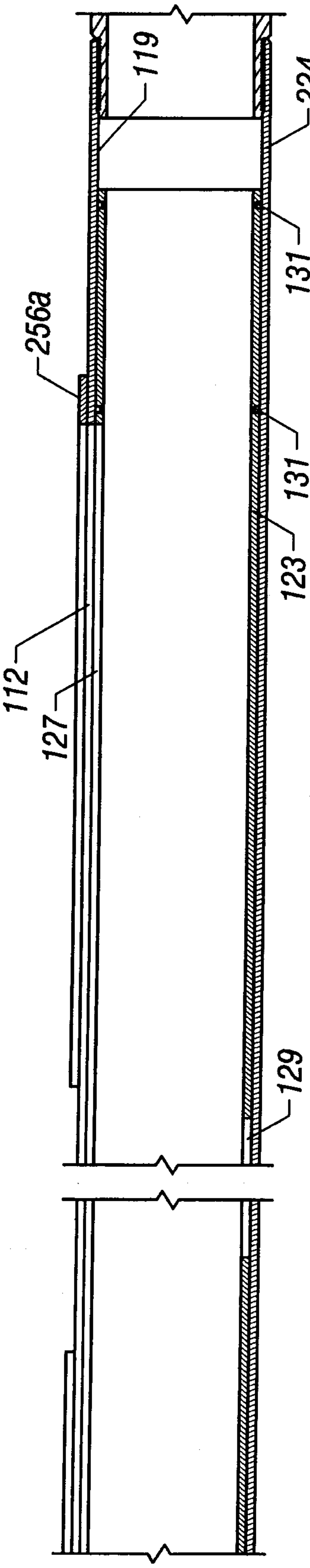


FIG. 7B

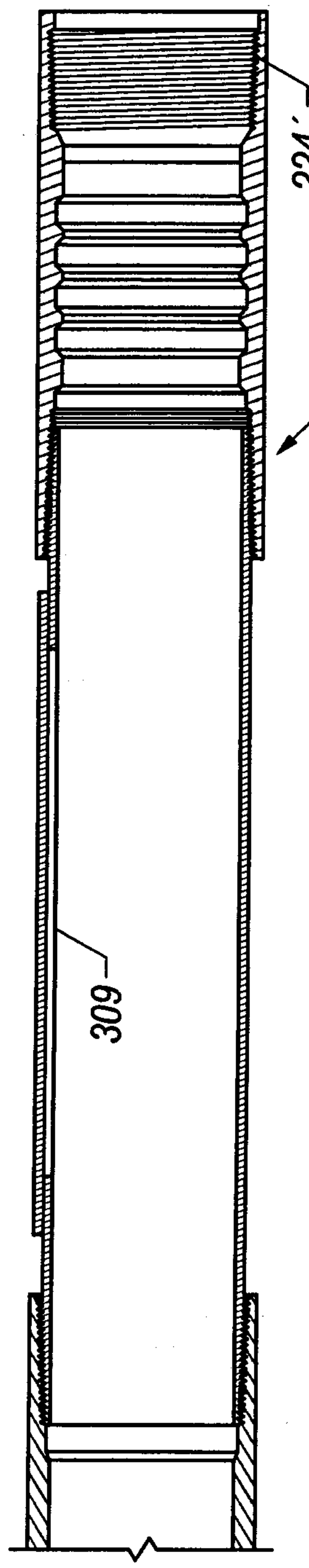


FIG. 7C

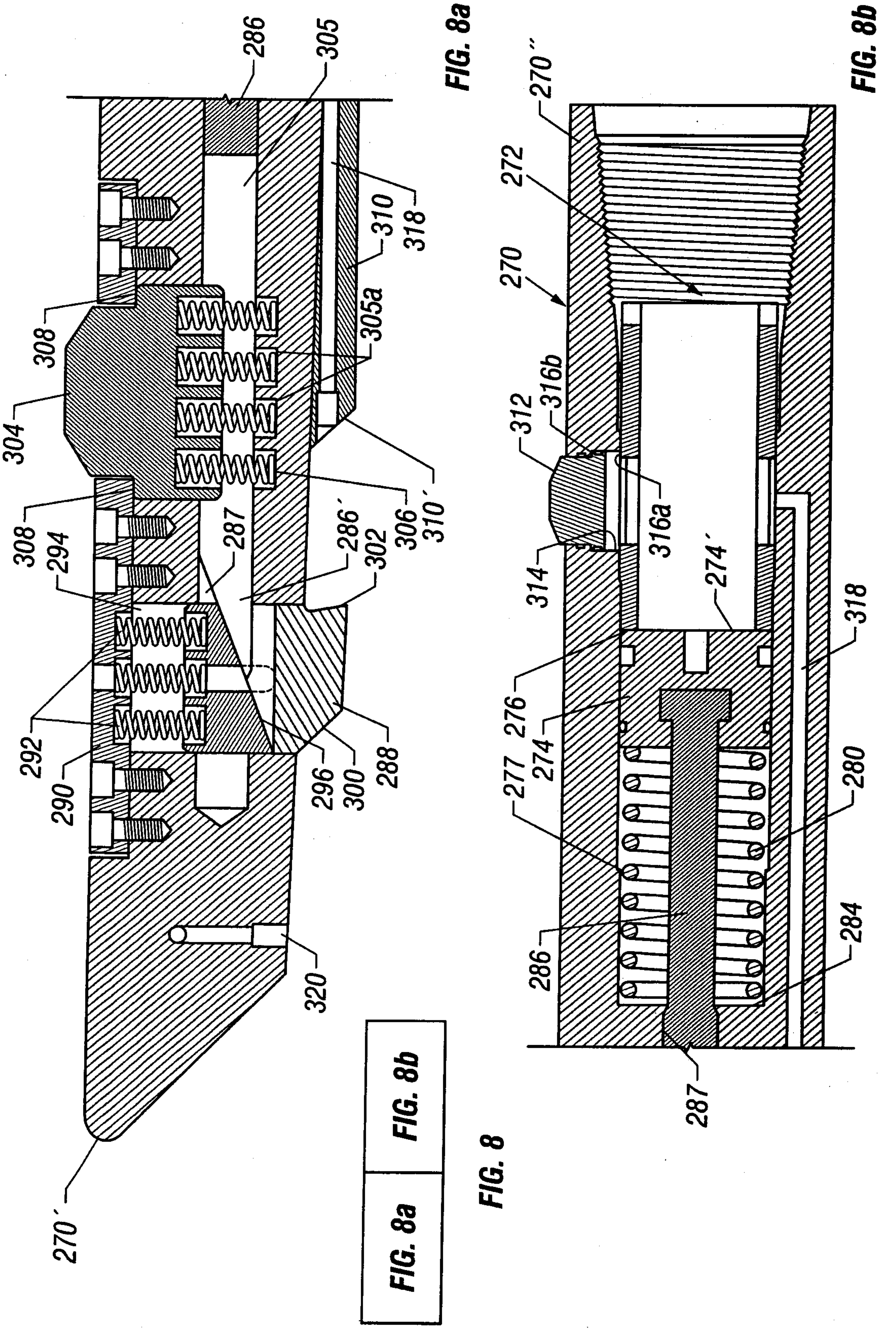
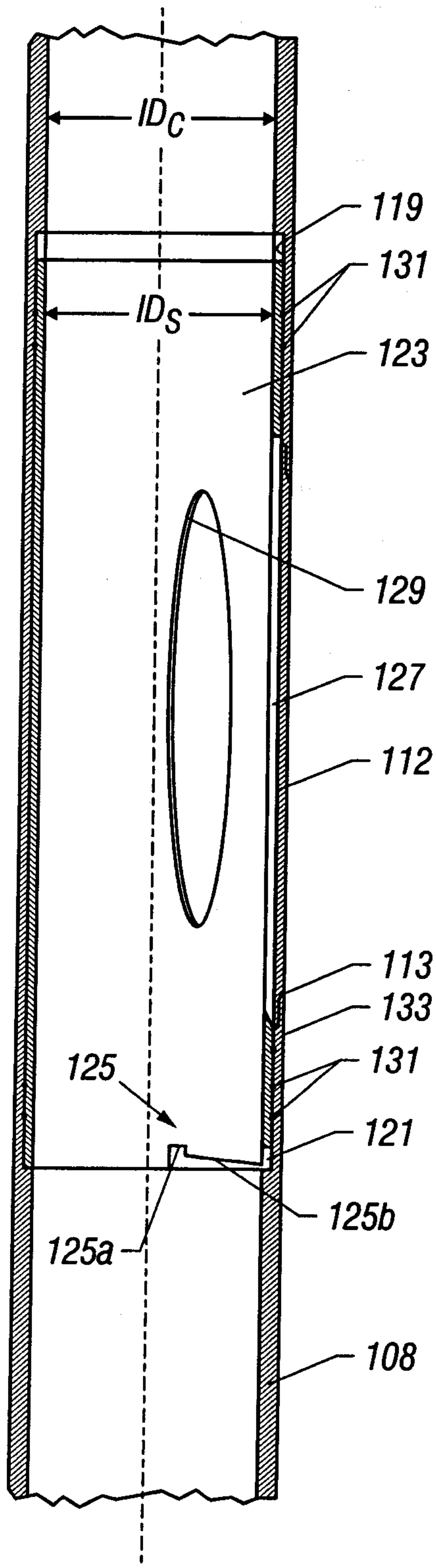


FIG. 8a

FIG. 8b

FIG. 8a	FIG. 8b

FIG. 8


ID_C
ID_S
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131
123
129
127
112
113
133
131
125
121
125b
125a
108

FIG. 9

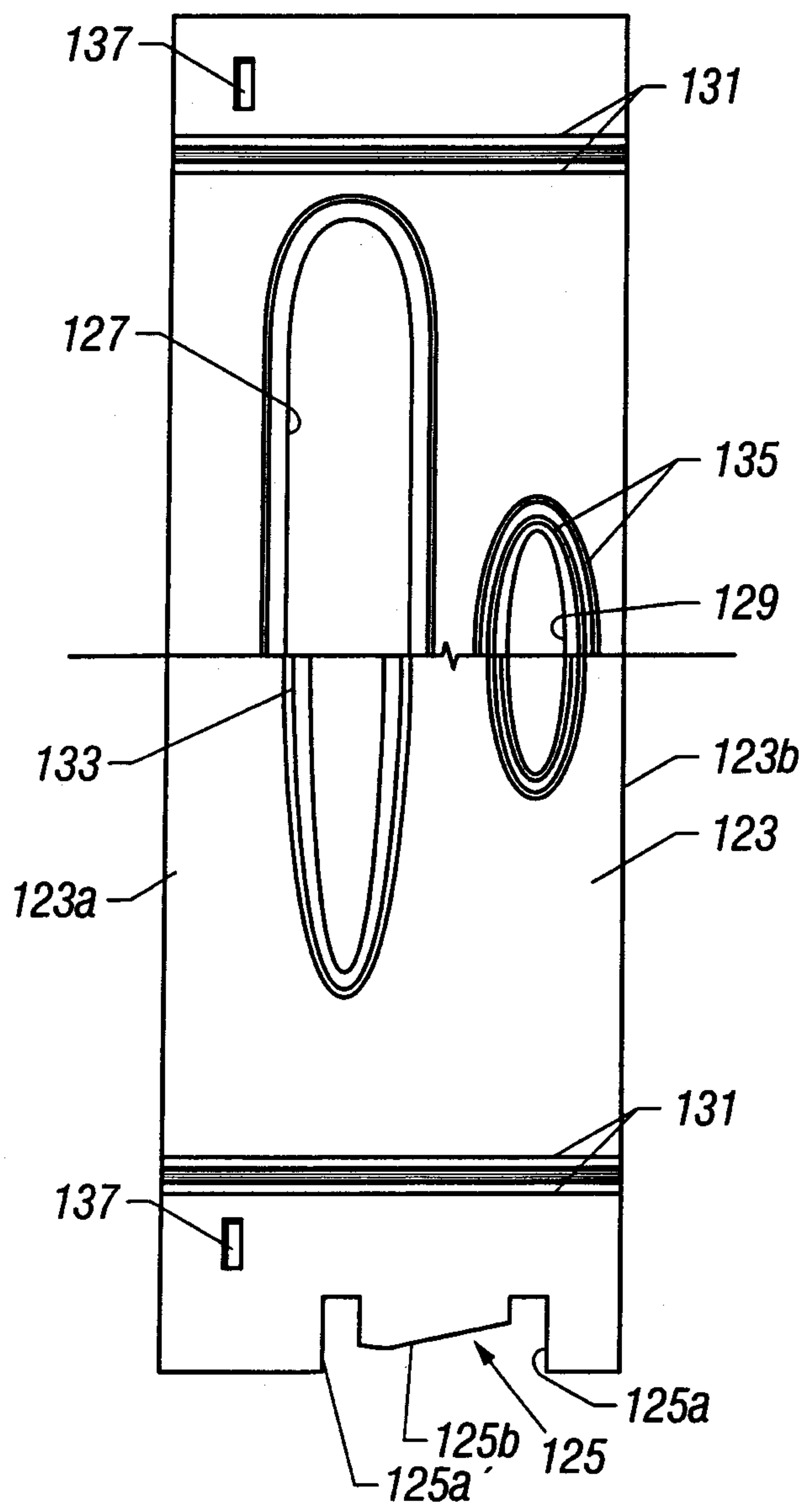


FIG. 10

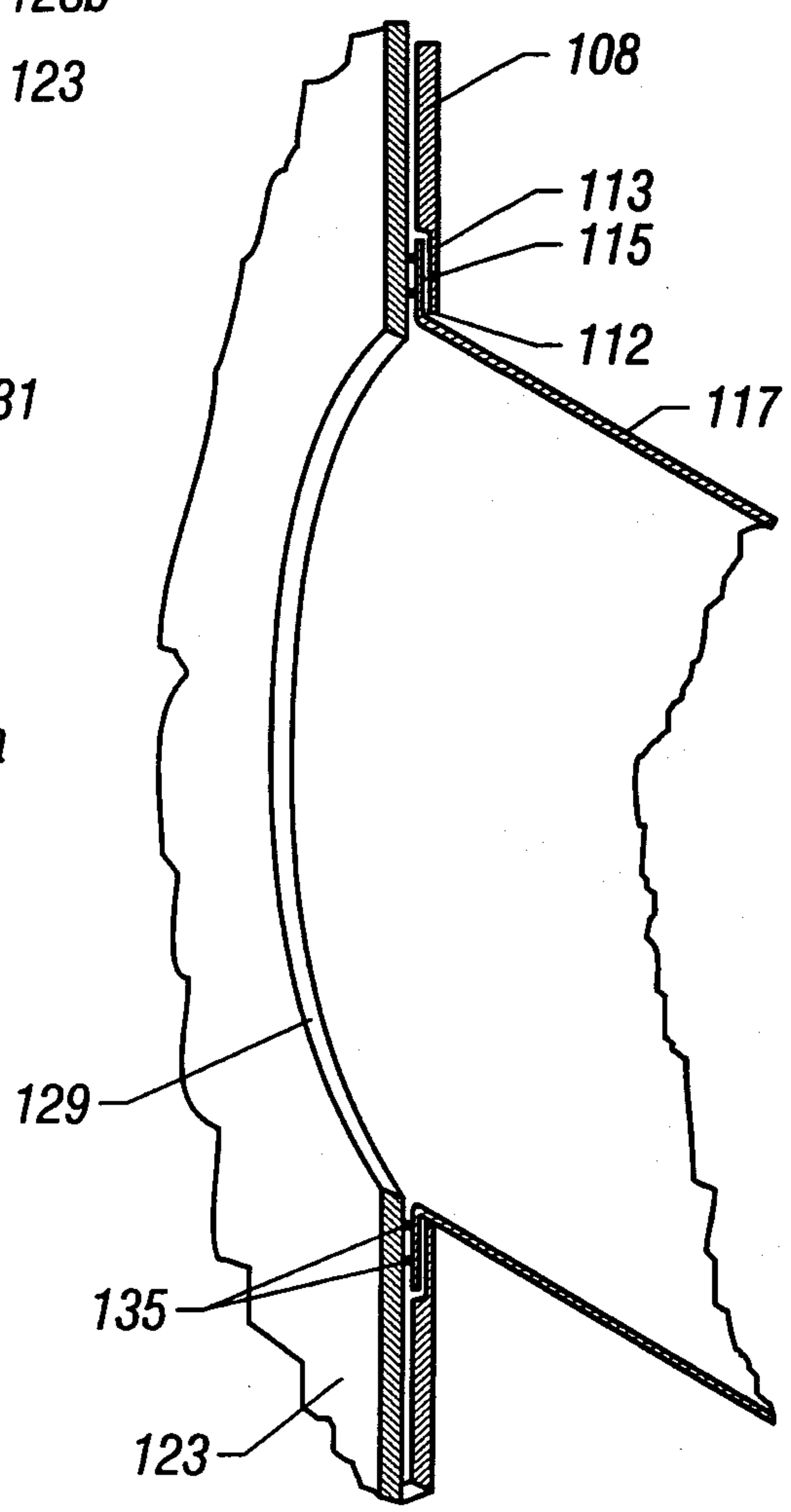


FIG. 11A

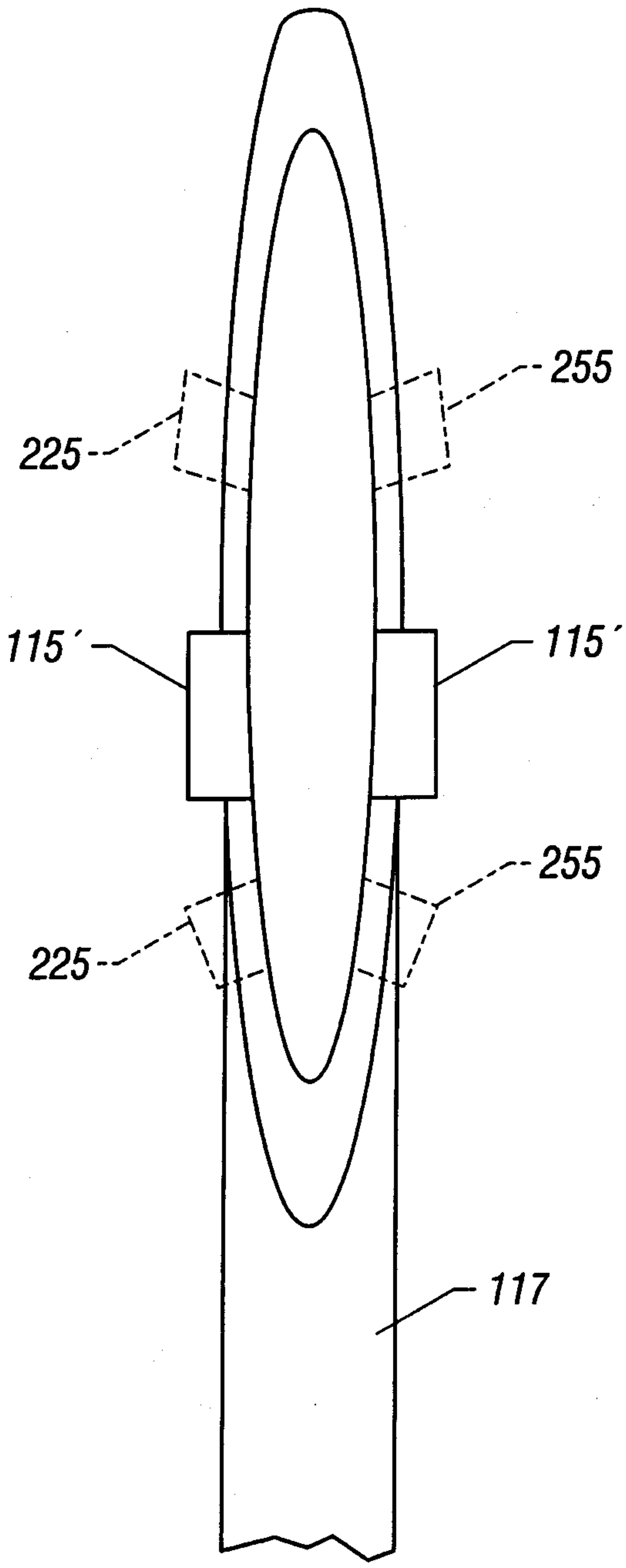
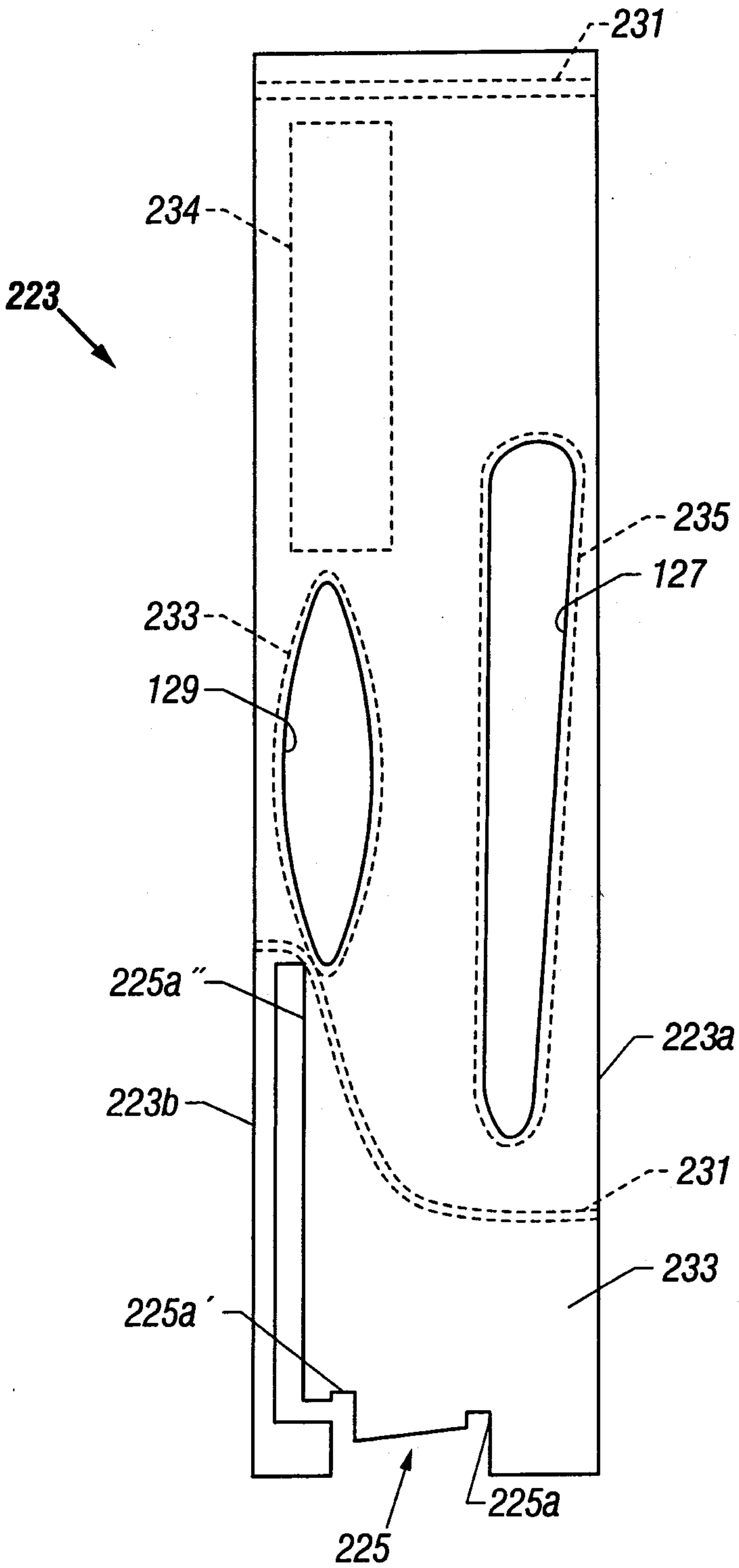


FIG. 11B

FIG. 11C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127
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129
225a″
223a
223b
231
233
225a′
225a
225

FIG. 12

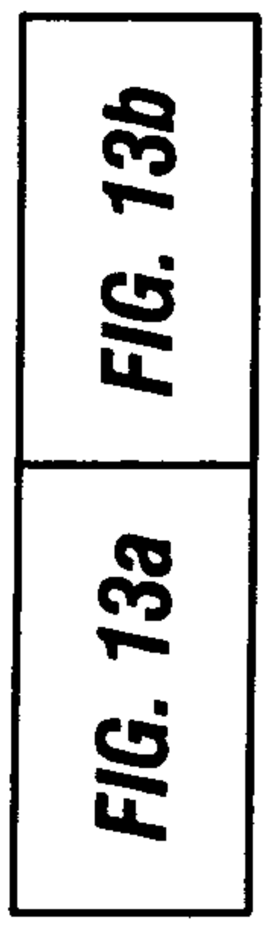


FIG. 13

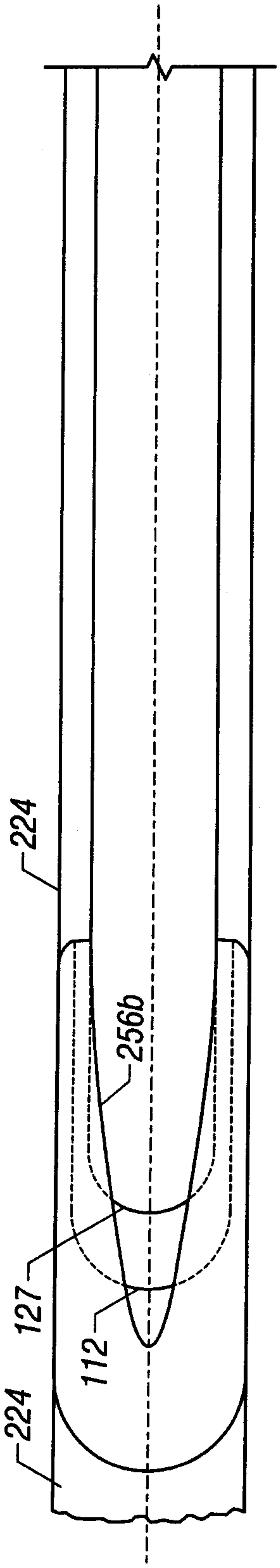


FIG. 13a

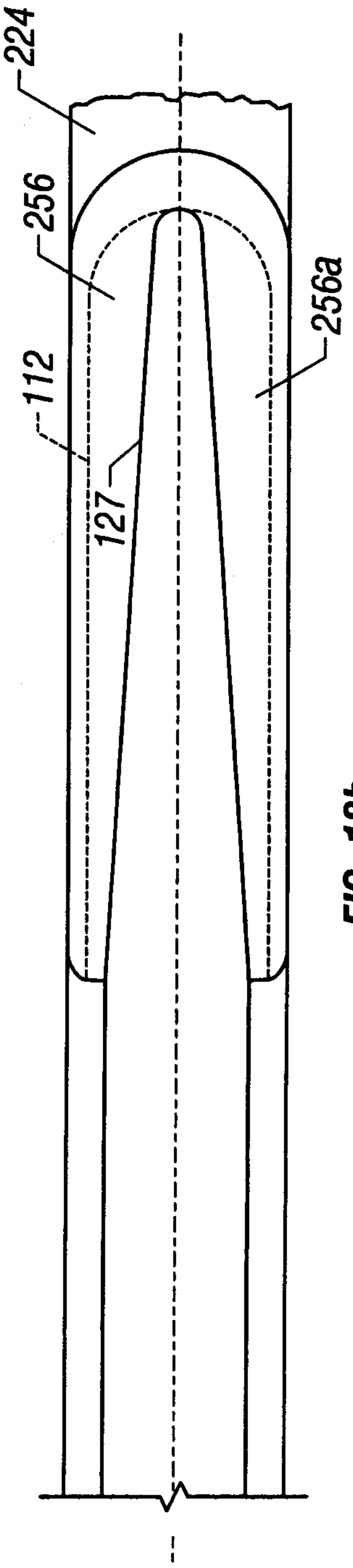


FIG. 13b

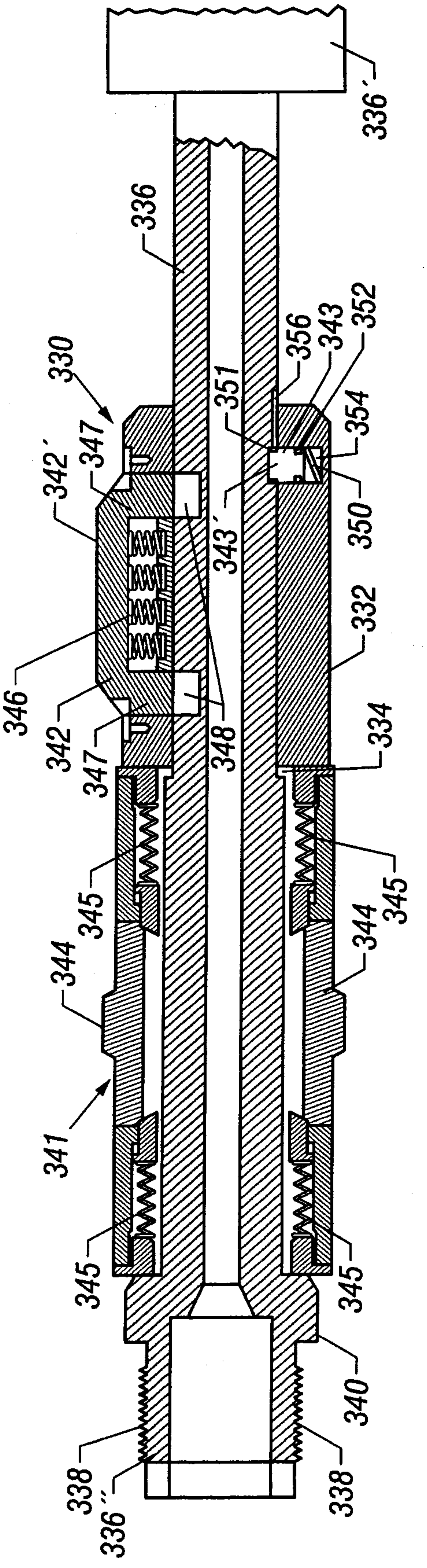

336´
336
330
342´
347
342
346
348
347
356
343
352
351
354
343´
350
332
334
345
344
341
340
338
336´´

FIG. 14

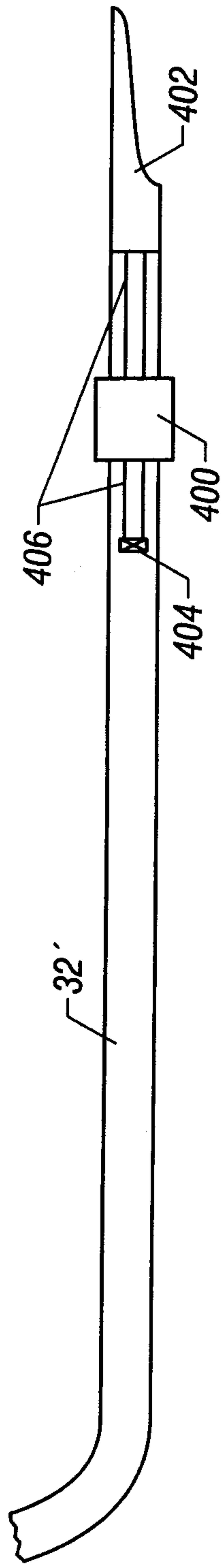


FIG. 15

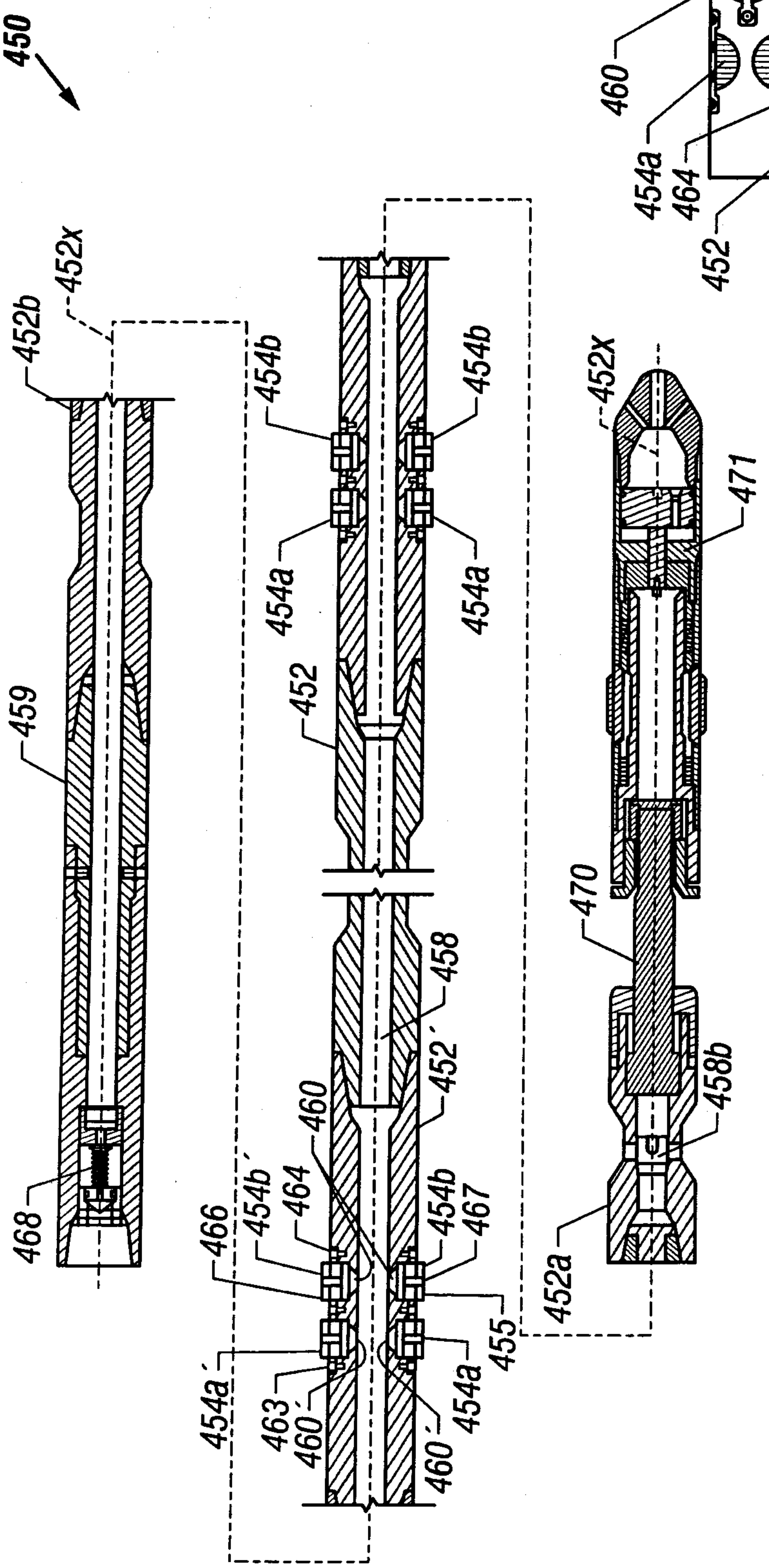


FIG. 16A

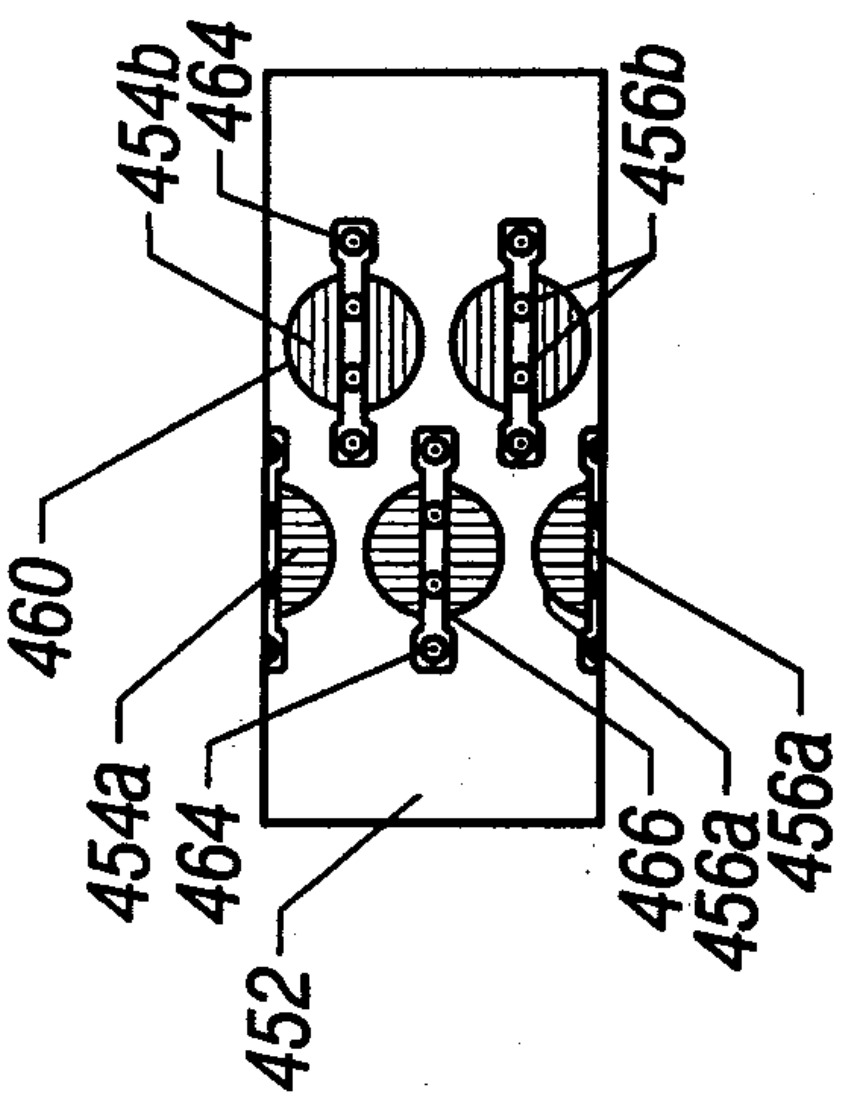


FIG. 16B

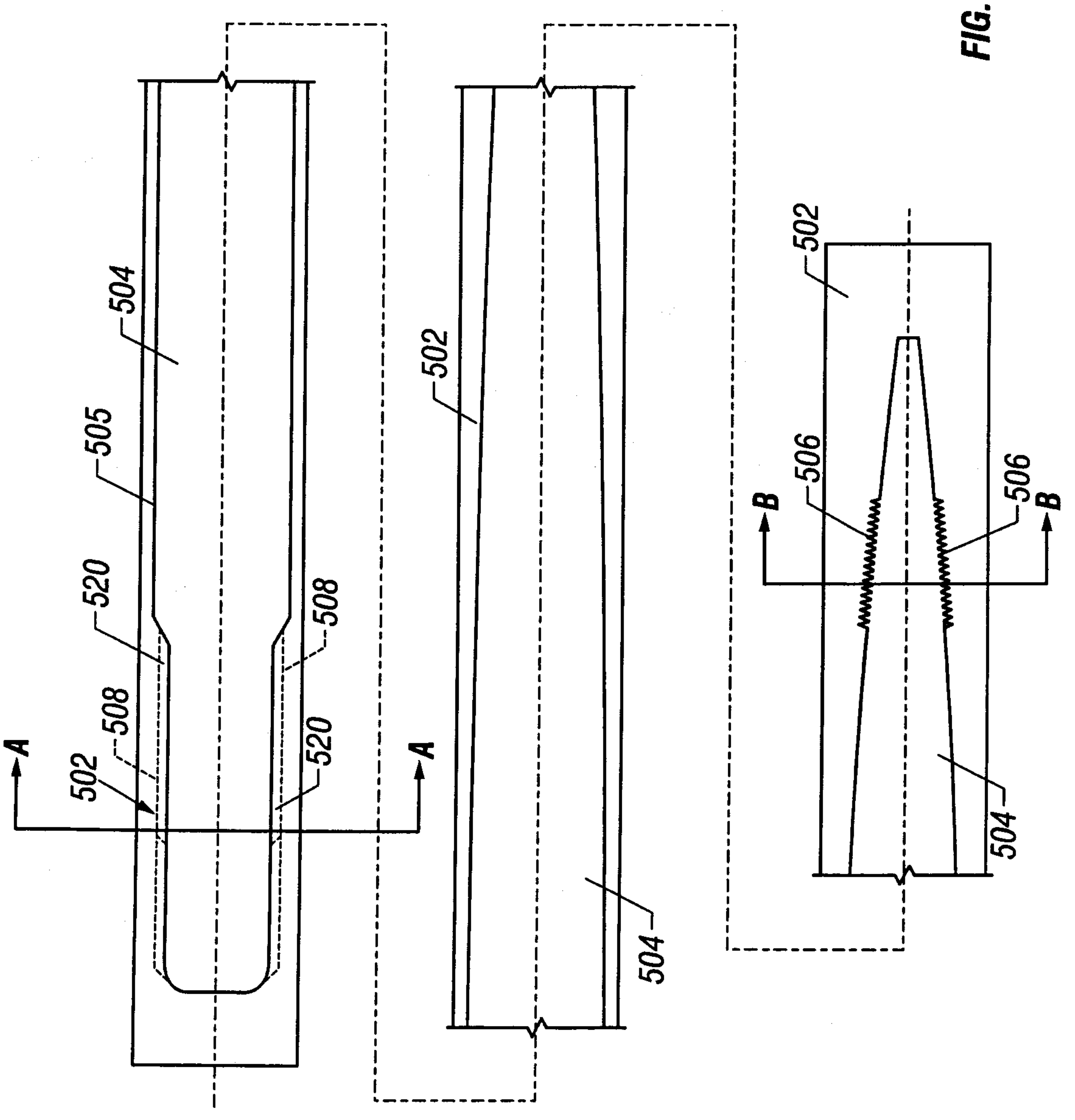


FIG. 17

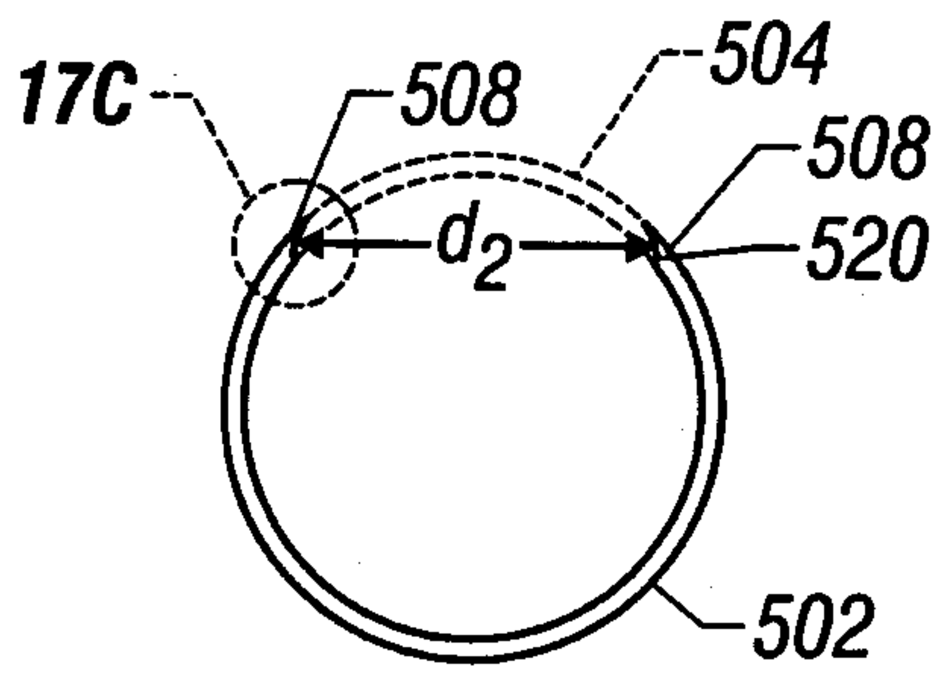


FIG. 17A

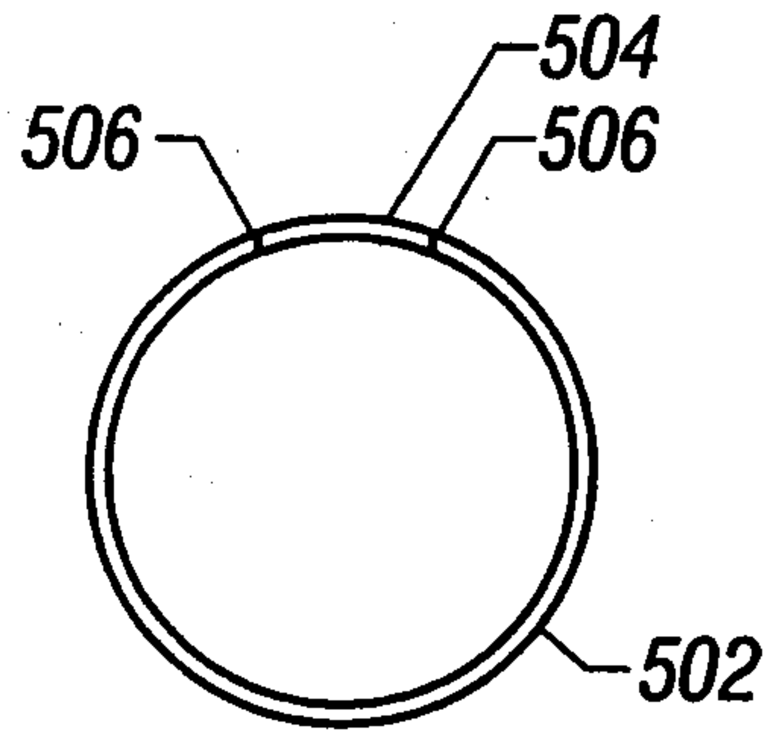


FIG. 17B

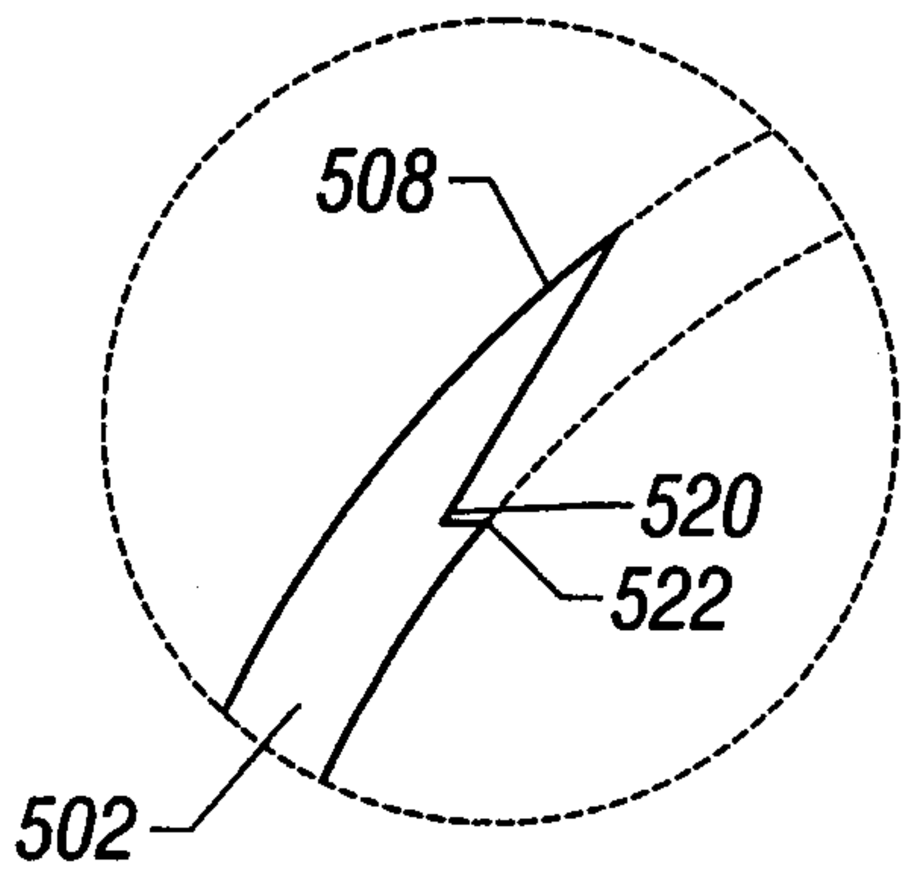


FIG. 17C

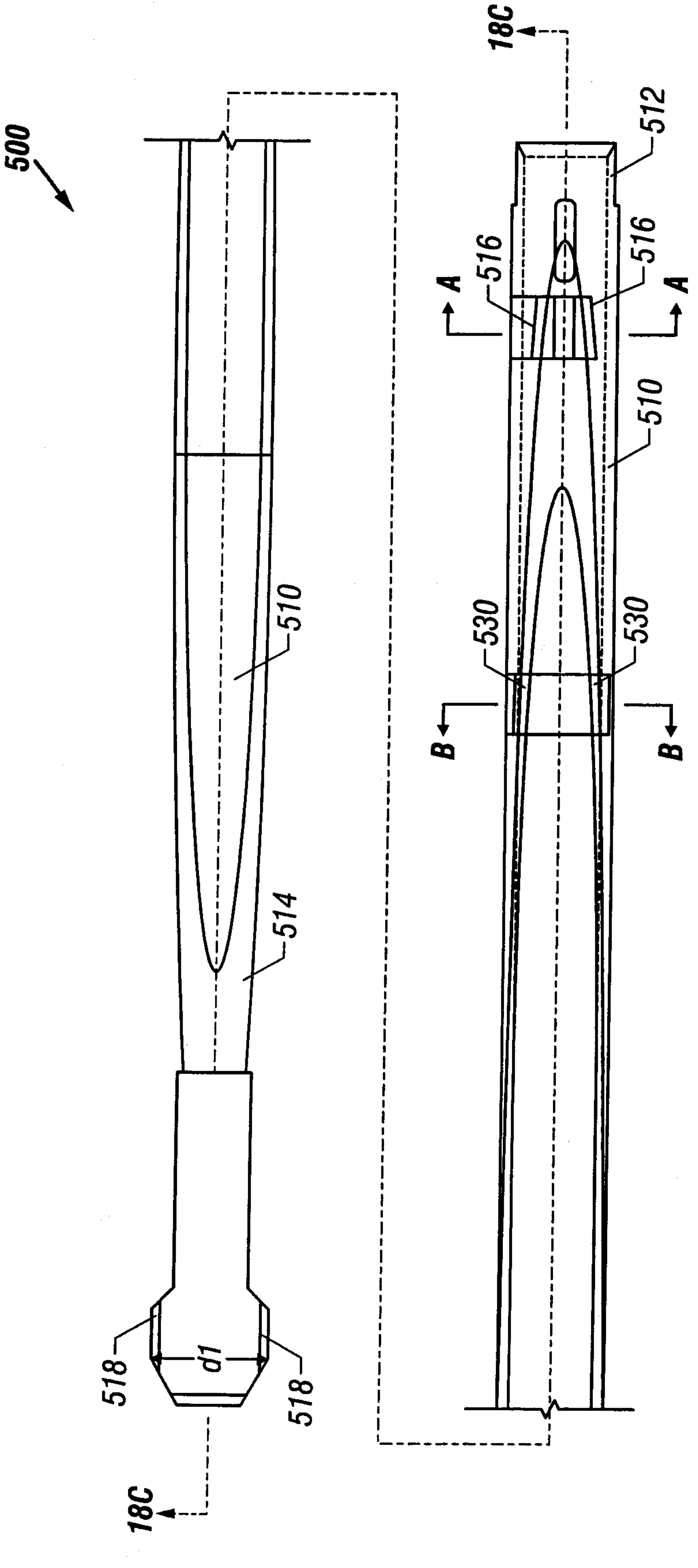


FIG. 18

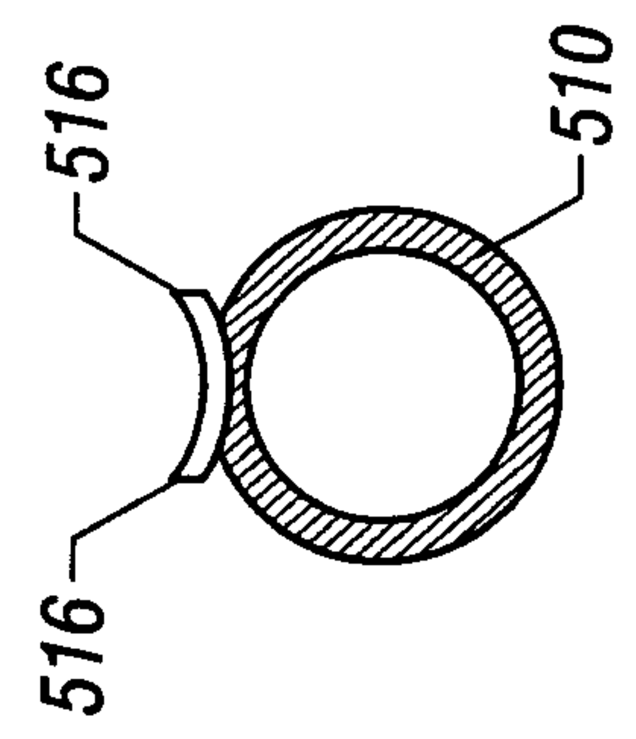


FIG. 18A

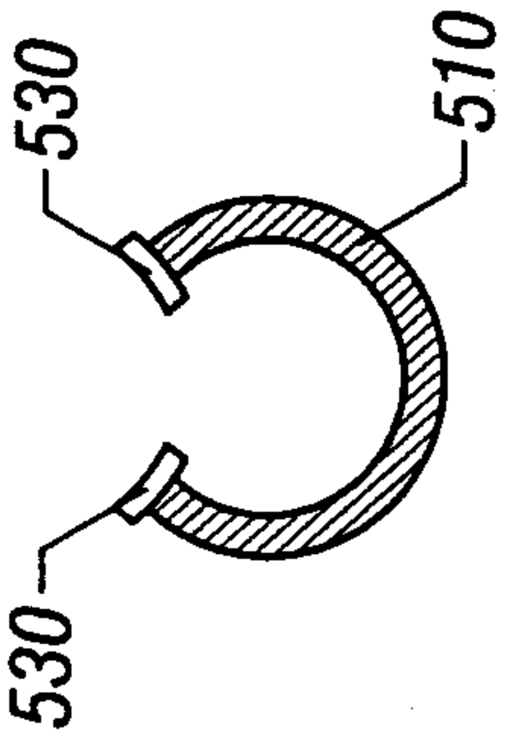


FIG. 18B

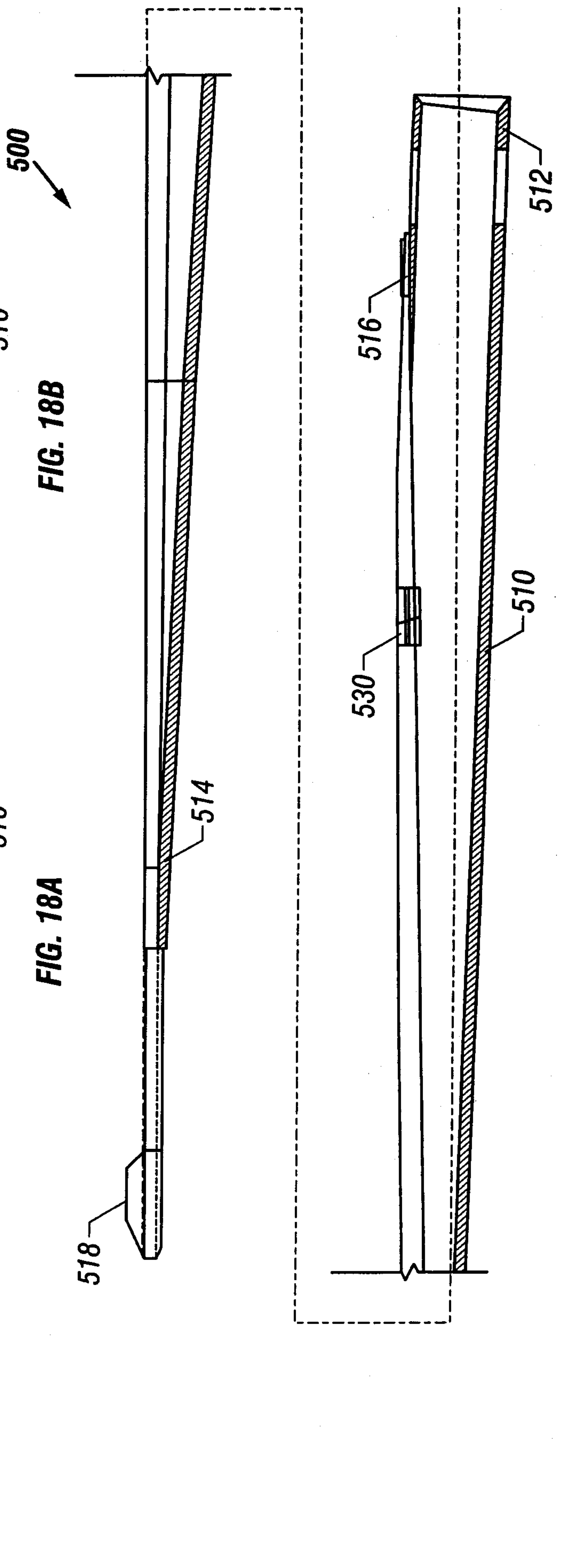


FIG. 18C

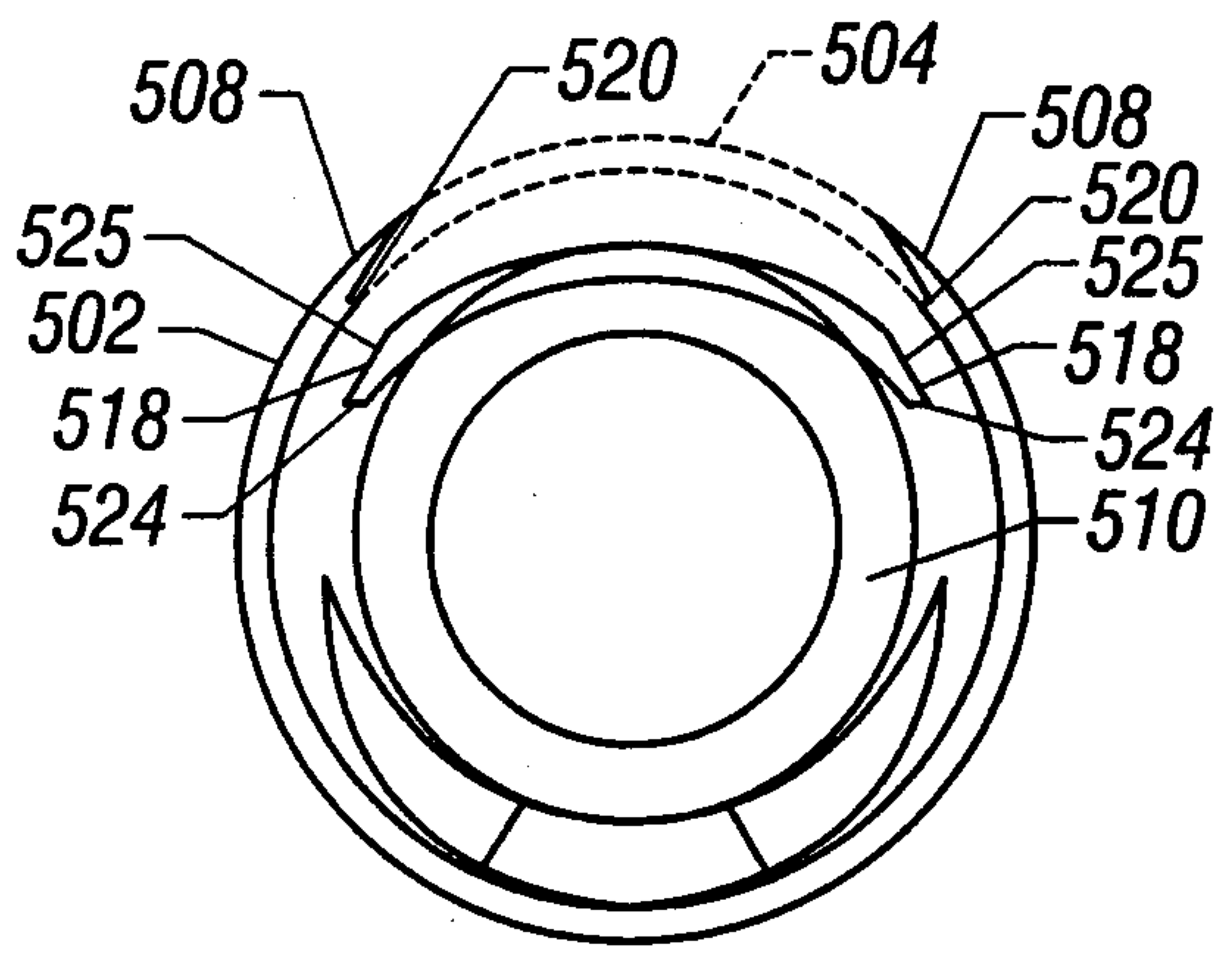


FIG. 19A

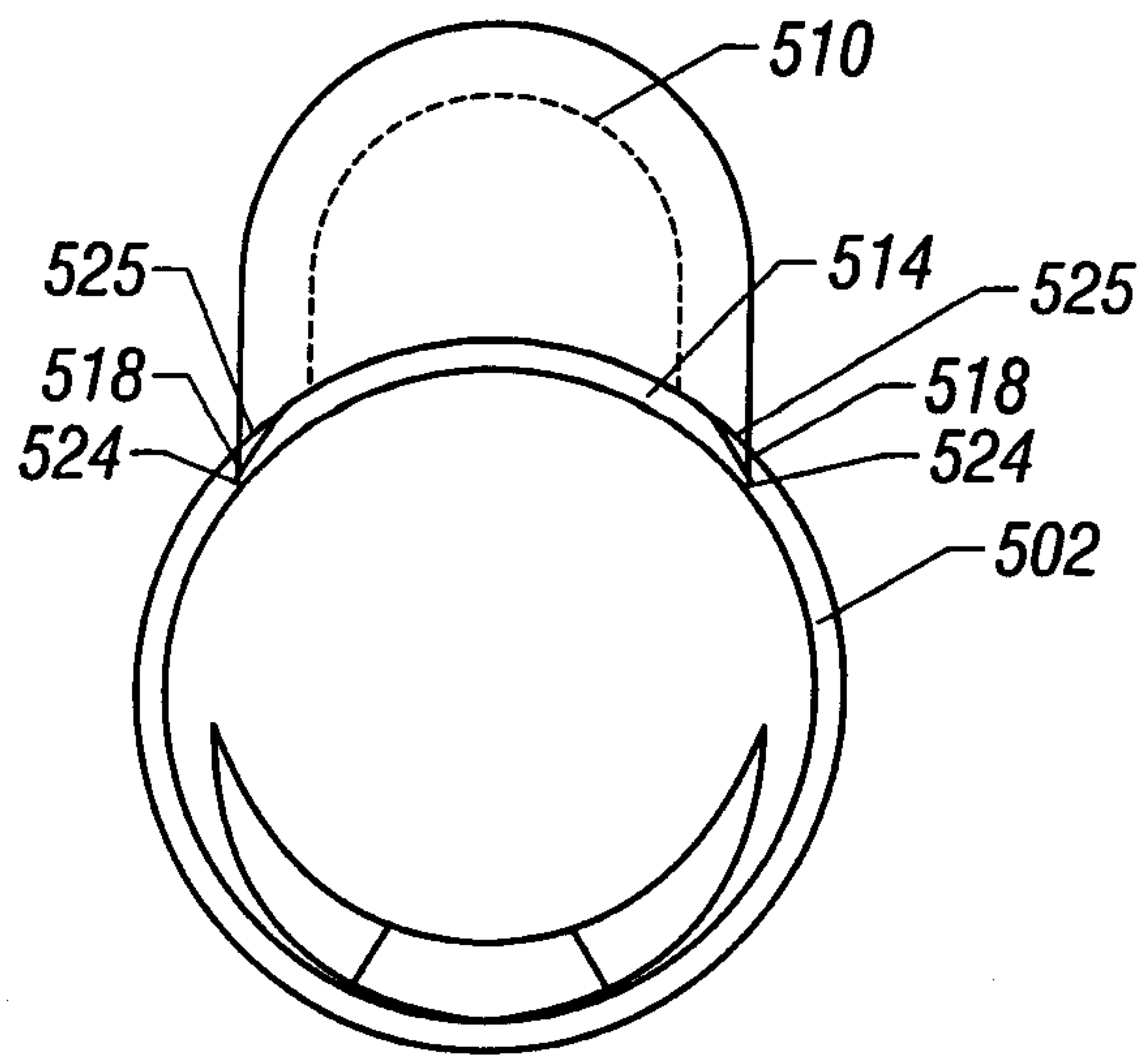
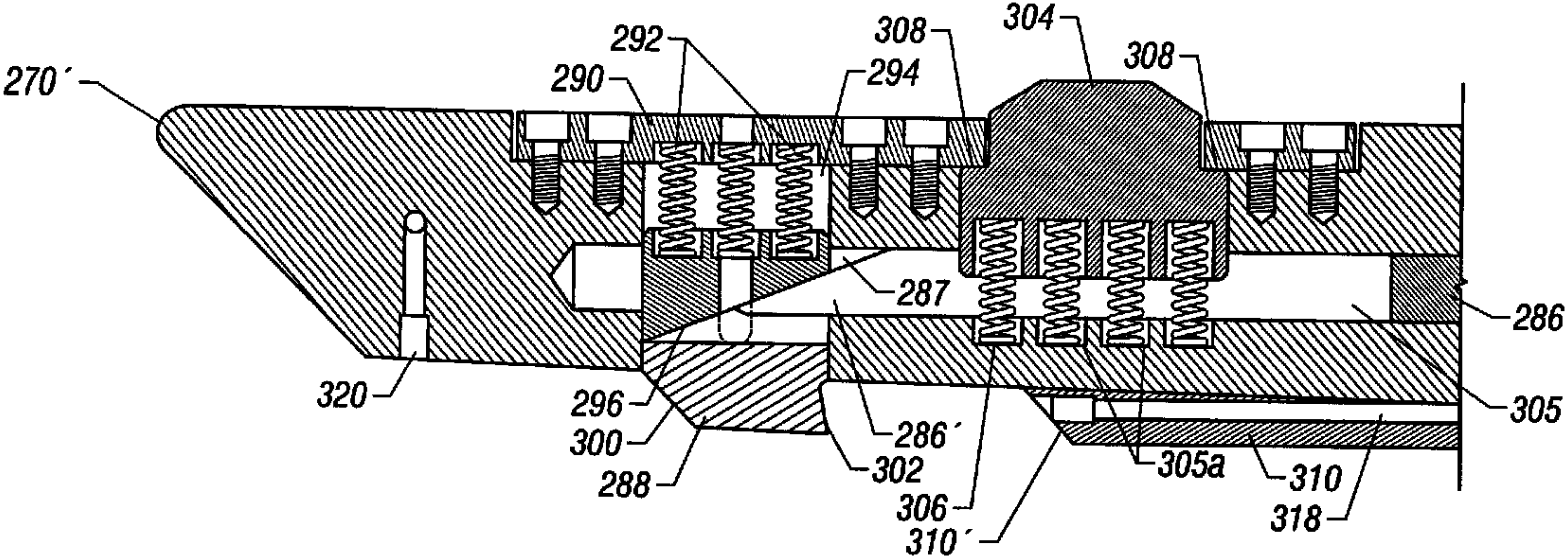


FIG. 19B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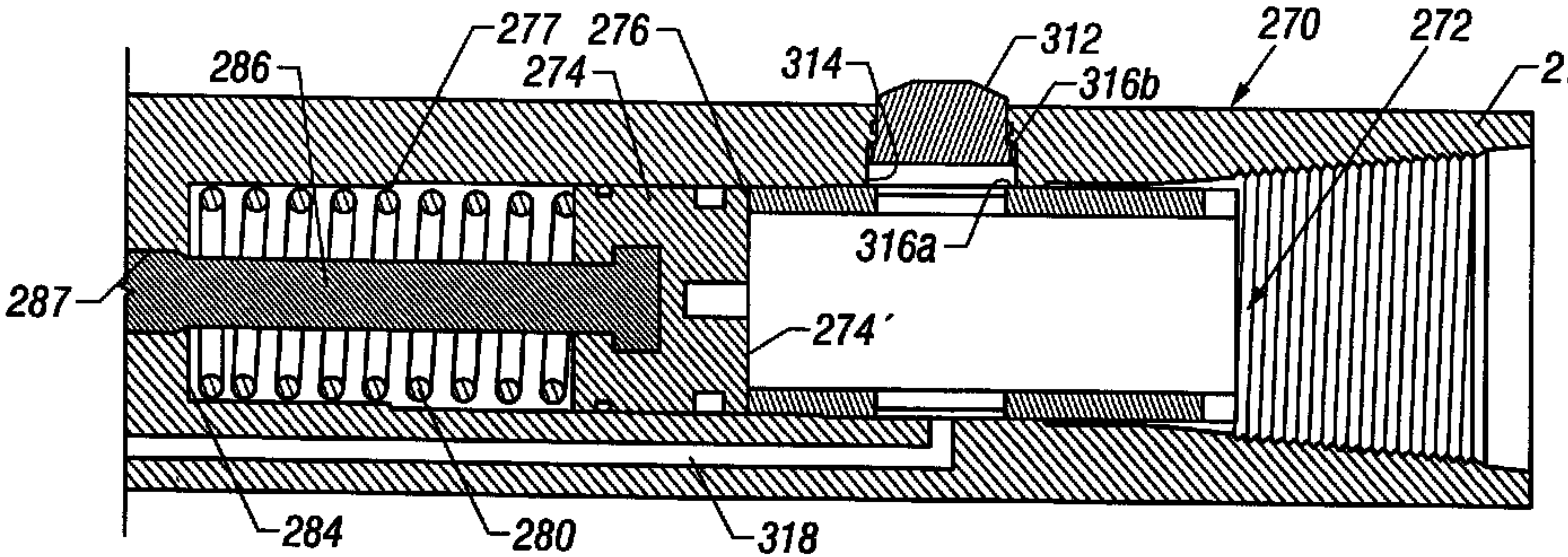
a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b