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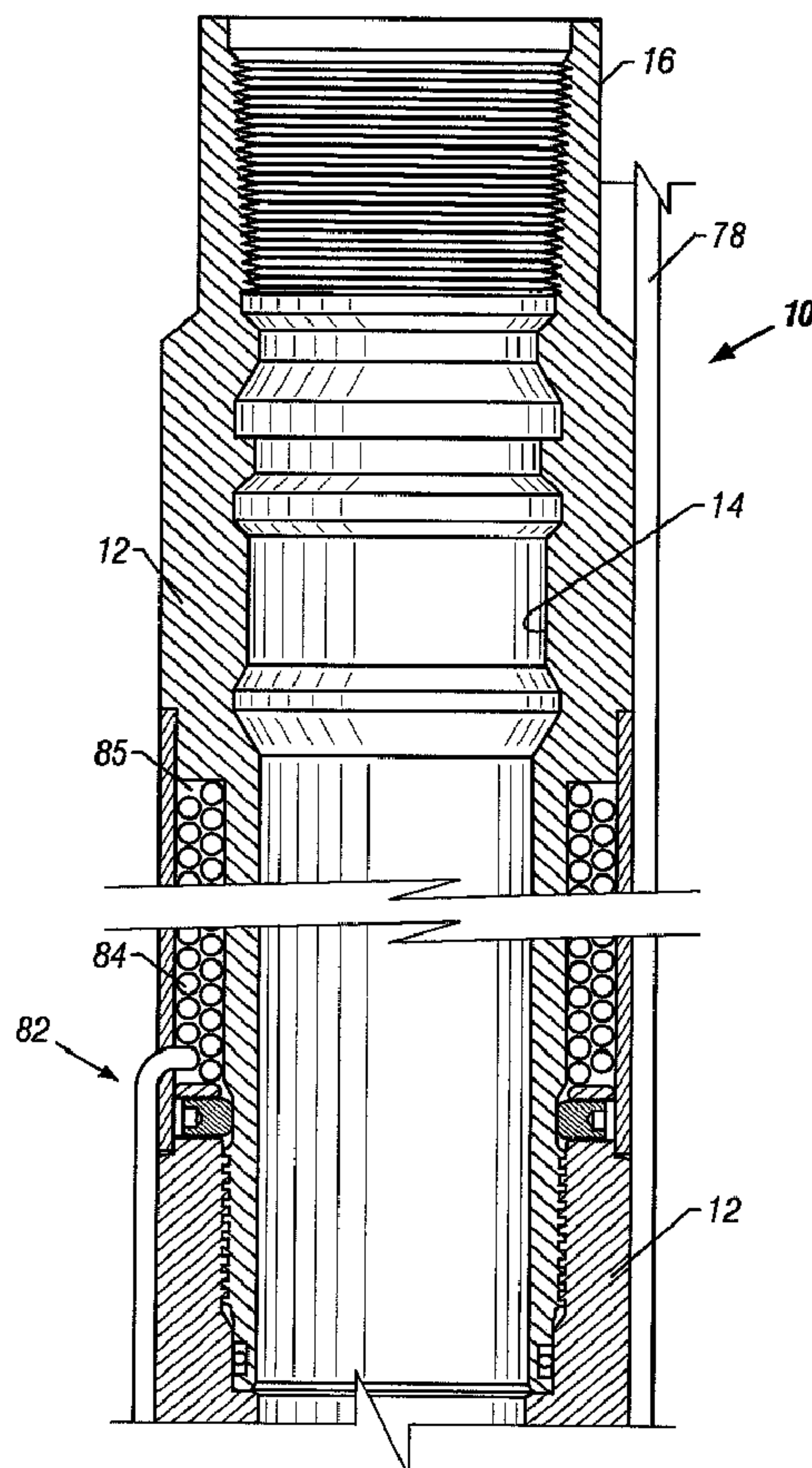
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An in-line flow control device for a well chokes flow through a conduit while allowing access therethrough.

ABSTRACT

An in-line flow control device for a well chokes flow through a conduit while allowing access therethrough.

METHOD AND APPARATUS FOR SELECTIVE INJECTION OR FLOW CONTROL WITH THROUGH-TUBING OPERATION CAPACITY

5 **Field of Invention.** The present invention relates to subsurface well equipment and, more particularly, to a method and apparatus for remotely controlling injection or production fluids in well completions which may include gravel pack.

Description of the Related Art. As is well known to those skilled in the art, certain hydrocarbon producing formations include sand. Unless filtered out, such
10 sand can become entrained or commingled with the hydrocarbons that are produced to the earth's surface. This is sometimes referred to as "producing sand", and can be undesirable for a number of reasons, including added production costs, and erosion of well tools within the completion, which could lead to the mechanical malfunctioning of such tools. Various approaches to combating this problem have
15 been developed. For example, the industry has developed sand screens which are connected to the production tubing adjacent the producing formation to prevent sand from entering the production tubing. In those cases where sand screens alone will not sufficiently filter out the sand, the industry has learned that a very effective way of filtering sand from entry into the production tubing is to fill, or pack, the well
20 annulus with gravel, hence the term "gravel pack" completions.

A drawback to gravel pack completions arises when it is desired to connect a remotely-controllable flow control device to the production tubing to regulate the

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flow of production fluids from the gravel-packed well annulus into the production tubing, or to regulate the flow of injection fluids from the production tubing into the gravel-packed well annulus. If the flow control device is
5 of the type that includes a flow port in the sidewall of the body establishing fluid communication between the well annulus and the interior of the tool (such as the flow control device disclosed in U.S. Patent No. 5,823,623), then the presence of gravel pack in the annulus adjacent the flow
10 port may present an obstacle to the proper functioning of the flow control device, to the extent that the gravel pack may prohibit laminar flow through the flow port. As such, it is an object of the present invention to provide a flow control device that will enable the remote control of flow
15 of production fluids and/or injection fluids in well completions where the annulus is packed with gravel. It is also an object of the present invention to provide such a tool that will enable the passage of wireline tools through the tool so that wireline intervention techniques may be
20 performed at locations in the well below the flow control device.

SUMMARY OF THE INVENTION

An in-line flow control device for a well chokes flow through a conduit while allowing access therethrough.

25 In one aspect, the invention provides a downhole flow control device, comprising: a body defining a first passageway and a second passageway; a closure member coupled to the body and movable to selectively, substantially prevent flow through the first passageway; and a sleeve
30 valve in the body selectively positionable at an open position, a closed position and a plurality of predetermined positions therebetween, the sleeve valve being adapted to

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regulate the flow through the second passageway, wherein the open position enables full bore flow.

In another aspect, the invention provides a downhole flow control device, comprising: a conduit defining
5 a first bore therethrough and an annular space; the conduit further defining at least one second bore in the annular space, the first bore and the at least one second bore being oriented in an axial direction; a sleeve member in the conduit selectively movable at predetermined increments
10 between an open position and a closed position to choke the flow through the second bore; and a flapper movable between an open position and a closed position to control flow in the first bore.

In another aspect, the invention provides a method
15 of controlling fluid flow in a wellbore, comprising: providing a body defining a first passageway and a second passageway; blocking flow through the first passageway with a closure member coupled to the body; directing fluid flow through the second passageway in the body around the closure
20 member; selectively choking, at and between full choke and no choke, the flow through the second passageway; and sizing the second passageway with a total flow area at least as great as the flow area of the first passageway, wherein the closure member comprises a flapper movable between an open
25 position and a closed position to control flow in the first passageway.

In another aspect, the invention provides a method of controlling fluid flow in a wellbore, comprising: providing a valve having a first passageway and a second
30 passageway; positioning a movable closure member to selectively and substantially prevent flow through the first passageway; locating a sleeve in the valve; and selectively

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positioning the sleeve at an open position, a closed position and a plurality of predetermined positions therebetween, the sleeve valve being adapted to regulate the flow through the second passageway, wherein the open
5 position enables full bore flow.

BRIEF DESCRIPTION OF THE DRAWINGS

Figures **1A-1J** taken together form a longitudinal sectional view of a specific embodiment of the flow control device of the present invention.

Figure 2 is a cross-sectional view taken along line 2-2 of Figure 1B.
Figure 3 is a cross-sectional view taken along line 3-3 of Figure 1E.
Figure 4 is a cross-sectional view taken along line 4-4 of Figure 1E.
Figure 5 is a cross-sectional view taken along line 5-5 of Figure 1E.
5 Figure 6 illustrates a planar projection of an outer cylindrical surface of a position holder shown in Figures 1C and 1D.

Figure 7 is a partial elevation view taken along line 7-7 of Figure 1I.
Figure 8 is a longitudinal sectional view, similar to Figures 1A and 1B,
showing an upper portion of another specific embodiment of the flow control device
10 of the present invention.

Figure 9 is a longitudinal sectional view, similar to Figure 8, showing an upper portion of another specific embodiment of the flow control device of the present invention.

Figure 10 is a schematic representation of a specific embodiment of a well
15 completion in which the flow control device of the present invention may be used.

Figure 11 is a partial cross sectional view of an alternative embodiment of the present invention.

Figure 12 is a partial cross sectional view of an alternative embodiment of the present invention.

20 While the invention will be described in connection with the preferred embodiments, it will be understood that it is not intended to limit the invention to those embodiments. On the contrary, it is intended to cover all alternatives,

modifications, and equivalents as may be included within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF THE INVENTION

5 For the purposes of this description, the terms “upper” and “lower,” “up
hole” and “downhole” and “upwardly” and “downwardly” are relative terms to
indicate position and direction of movement in easily recognized terms. Usually,
these terms are relative to a line drawn from an upmost position at the earth’s surface
to a point at the center of the earth, and would be appropriate for use in relatively
10 straight, vertical wellbores. However, when the wellbore is highly deviated, such as
from about 60 degrees from vertical, or horizontal, these terms do not make sense
and therefore should not be taken as limitations. These terms are only used for ease
of understanding as an indication of what the position or movement would be if
taken within a vertical wellbore.

15 Referring to the drawings in detail, wherein like numerals denote identical
elements throughout the several views, a specific embodiment of the downhole flow
control device of the present invention is referred to generally by the numeral 10.
Referring initially to Figure 1A, the device 10 may include a generally cylindrical
body member 12 having a first bore (or first passageway) 14 extending from a first
20 end 16 of the body member 12 and through a generally cylindrical extension member
17 (Figures 1E-1I) disposed within the body member 12, and a second bore (or
second passageway) 18 extending from a second end 20 of the body member 12 and

into an annular space **21** disposed about the extension member **17**. In a specific embodiment, the diameter of the second bore **18** is greater than the diameter of the first bore **14**. As shown in Figure **1E**, the body member **12** may also include a first valve seat **22** disposed within the first bore **14**, and the extension member **17** may include at least one flow port **24** establishing fluid communication between the annular space **21** and the first bore **14**.

With reference to Figures **1B-1F**, the device **10** may further include a first generally cylindrical sleeve member **26** movably disposed and remotely shiftable within the first bore **14**. The manner in which the first sleeve member **26** is shifted within the first bore **14** will be described below. Referring to Figure **1E**, the first sleeve member **26** may include a second valve seat **28** adapted for cooperable sealing engagement with the first valve seat **22** to regulate fluid flow through the at least one flow port **24**. The first sleeve member **26** may also include at least one flow slot **30**.

As shown in Figure **1H**, the device **10** may further include a closure member **32** disposed for movement between an open and a closed position to control fluid flow through the first bore **14**. The closure member **32** is shown in its closed position. In a specific embodiment, the closure member **32** may be a flapper having an arm **34** hingedly connected to the extension member **17**. The flapper **32** may be biased into its closed position by a hinge spring **36**. Other types of closure members **32** are within the scope of the present invention, including, for example, a ball valve.

As shown in Figures **1F-1H**, the device **10** may further include a second sleeve member **38** movably disposed and remotely shiftable within the first bore **14**

to move the closure member 32 between its open and closed positions. As shown in Figure 1E, the second sleeve member 38 may include an inner surface 40 having a locking profile 42 disposed therein for mating with a shifting tool (not shown). As shown in Figure 1G, the second sleeve member 38 may also include at least one rib 44 that is shown engaged with a first annular recess 46 in the first bore 14 of the extension member 17. In a specific embodiment, the second sleeve member 38 may include a plurality of ribs 44 disposed on a plurality of collet sections 48 in the second sleeve member 38 that may be disposed between a plurality of slots 50 in the second sleeve member 38. As will be more fully discussed below, the second sleeve member 38 may be shifted downwardly to engage the ribs 44 with a second annular recess 47 in the first bore 14 of the extension member 17. The second sleeve member 38 may further include at least one first equalizing port 52 for cooperating with at least one second equalizing port 54 in the extension member 17 to equalize pressure above and below the flapper 32 prior to shifting the second sleeve member 38 downwardly to open the flapper 32. The first equalizing port 52 establishes fluid communication between the inner surface 40 of the second sleeve member 38 and the first bore 14 of the extension member 17. The second equalizing port 54 establishes fluid communication between the first bore 14 of the extension member 17 and the annular space 21. A first annular seal 56 and a second annular seal 58 may be disposed within the first bore 14 of the extension member 17 and in sealing relationship about the second sleeve member 38. The second equalizing port 54 is disposed between the first and second annular seals 56 and 58. When the ribs 44 on

the second sleeve member 38 are engaged with the first annular recess 46 in the extension member 17, the first annular seal 56 is disposed between the first and second equalizing ports 52 and 54, and a distal end 39 of the second sleeve member 38 is spaced from the closure member 32.

5 When it is desired to open the flapper 32, to enable passage of wireline tools (not shown) to positions below the device 10, a wireline shifting tool (not shown) may be engaged with the locking profile 42 (Figure 1G) and used to shift the second sleeve member 38 downwardly until the distal end 39 (Figure 1H) of the second sleeve member 38 comes into contact with the flapper 32. This will align the first
10 and second equalizing ports 52 and 54, and thereby establish fluid communication between the annular space 21 and the inner surface 40 of the second sleeve member 38. In this manner, pressure may be equalized above and below the flapper 32 prior to opening of the flapper 32. The second sleeve member 38 may then continue downwardly to push the flapper 32 open, without having to overcome upward forces
15 imparted to the flapper 32 by pressure below the flapper 32. It is noted, with reference to Figure 1E, that pressure above and below the flapper 32 may also be equalized prior to opening of the flapper 32 by shifting the first sleeve member 26 to separate the first and second valve seats 22 and 28 to establish fluid communication between the annular space 21 and an inner surface 27 of the first sleeve member 26.

20 With reference to Figures 1I and 7, the device 10 may further include a cone member 60 connected to a distal end 62 of the extension member 17. In a specific embodiment, the cone member 60 may include a first and a second half-cone

member 64 and 66, each of which may be hingedly attached to the distal end 62 of the extension member 17, as by a first and a second hinge pin 68 and 70, respectively, and biased towards each other, as by first and second hinge springs 72 and 74, respectively. The springs 72 and 74 bias and hold the half-cone members 64 and 66 in mating relationship, or in a normally-closed position, to form a cone, as shown in Figure 1I. In this normally-closed position, the cone member 60 directs fluid flowing from the second end 20 of the body member 12 into the annular space 21, and functions to minimize turbulence as fluid flows into the annular space 21. In this regard, in a preferred embodiment, an angle α formed between a first outer surface 65 of the first half-cone member 64 and a second outer surface 67 of the second half-cone member 66 may be approximately forty-four (44) degrees when the half-cone members 64 and 66 are biased towards each other to form a cone, as shown in Figure 1I. When it is desired to pass a wireline tool through the device 10 from the first end 16 of the body member 12 to the second end 20 of the body member, then the second sleeve member 38 (Figures 1F-1H) may be shifted downwardly (by locating a wireline shifting tool (not shown) in the locking profile 42, as discussed above) from its position shown in Figures 1F-1H to a lower position (not shown) in which the first and second half-cone members 64 and 66 are separated and their respective inner surfaces 69 and 70 are disposed about the second sleeve member 38. With reference to Figure 1G, the ribs 44 on the second sleeve member 38 may be disposed within the second annular recess 47 in the extension member 17 when the second sleeve member 38 is in its lower position (not shown).

The manner in which the first sleeve member **26** is remotely shifted will now be described. Referring to Figures **1B – 1D**, in a specific embodiment, a piston **76** may be connected to, or a part of, the first sleeve member **26**, and may be sealably, slidably disposed within the first bore **14** of the body member **12**. In a specific
5 embodiment, the piston **76** may be an annular piston or at least one rod piston. A first hydraulic conduit **78** is connected between a source of hydraulic fluid (not shown), such as at the earth's surface (not shown), and the body member **12**, as at fitting **81**, and is in fluid communication with a first side **80** of the piston **76**, such as through a first passageway **79** in the body member **12**. The first sleeve member **26**
10 may be remotely shifted downwardly, or away from the first end **16** of the body member **12**, by application of pressurized fluid to the first side **80** of the piston **76**. A number of mechanisms for biasing the first sleeve member **26** upwardly, or towards the first end **16** of the body member **12**, may be provided within the scope of the present invention, including but not limited to another hydraulic conduit, pressurized
15 gas, spring force, and annulus pressure, and/or any combination thereof.

In a specific embodiment, as shown in Figure **1A**, the biasing mechanism may include a source of pressurized gas, such as pressurized nitrogen, which may be contained within a sealed chamber, such as a gas conduit **82**. An upper portion **84** of the gas conduit **82** may be coiled within a housing **85** formed within the body
20 member **12**, and a lower portion **86** of the gas conduit **82** (Figure **1B**) may extend outside the body member **12** and terminate at a fitting **88** connected to the body member **12**. The gas conduit **82** is in fluid communication with a second side **90** of

the piston 76, such as through a second passageway 92 in the body member 12.

Appropriate seals are provided to contain the pressurized gas. As shown in Figure 3, the body member 12 may include a charging port 94, which may include a dill core valve, through which pressurized gas may be introduced into the device 10.

5 Another biasing mechanism is shown in Figure 8, which is a view similar to Figures 1A and 1B, and illustrates an upper portion of another specific embodiment of the present invention, which is referred to generally by the numeral 10'. The lower portion of this embodiment is the same as shown in Figures 1C-1I. In this embodiment, a second hydraulic conduit 96 is connected between a source of
10 hydraulic fluid (not shown), such as at the earth's surface (not shown), and the body member 12', and is in fluid communication with the second side 90' of the piston 76', such as through the second passageway 92' in the body member 12'. As such, in this embodiment, hydraulic fluid is used instead of pressurized gas to bias the first sleeve member 26' towards the first end 16' of the body member 12'.

15 Another biasing mechanism is shown in Figure 9, which is a view similar to Figure 8, and illustrates an upper portion of another specific embodiment of the present invention, which is referred to generally by the numeral 10". The lower portion of this embodiment is as shown in Figures 1C-1I. In this embodiment, a spring 98 is disposed within the first bore 14", about the first sleeve member 26",
20 and between an annular shoulder 100 on the body member 12" and the second side 90" of the piston 76". As such, in this embodiment, force of the spring 98 is used instead of pressurized gas or hydraulic fluid to bias the first sleeve member 26"

toward the first end 16" of the body member 12". Alternatively, as shown in Figure 9, the device 10" may also include a port 102 in the body member 12" connected to a conduit 104 through which hydraulic fluid or pressurized gas may also be applied to the second side 90" of the piston 76" to assist the spring 98 in biasing the first sleeve member 26" toward the first end 16" of the body member 12". In this regard, if hydraulic fluid is desired, the conduit 104 may be a hydraulic conduit, such as the second hydraulic conduit 96 shown in Figure 8. Alternatively, if pressurized gas is desired, the conduit 104 may be a gas conduit, such as the gas conduit 82 shown in Figures 1A-1B. In another specific embodiment, instead of using hydraulic fluid or pressurized gas, the port 102 may be in communication with annulus pressure, which may be used to bias the first sleeve member 26" toward the first end 16" of the body member 12", either by itself, or in combination with the spring 98.

Referring now to Figures 1C-1D and 6, the device 10 of the present invention may also include a position holder to enable an operator at the earth's surface (not shown) to remotely locate and maintain the first sleeve member 26 in a plurality of discrete positions, thereby providing the operator with the ability to remotely regulate fluid flow through the at least one flow port 24 in the extension member 17 (Figure 1E), and/or through the at least one flow slot 30 in the first sleeve member 26 (Figure 1E). The position holder may be provided in a variety of configurations. In a specific embodiment, as shown in Figures 1C-1D and 6, the position holder may include an indexing cylinder 106 having a recessed profile 108 (Figure 6), and be adapted so that a retaining member 110 (Figure 1D) may be biased into cooperable

engagement with the recessed profile **108**, as will be more fully explained below. In a specific embodiment, one of the position holder **106** and the retaining member **110** may be connected to the first sleeve member **26**, and the other of the position holder **106** and the retaining member **110** may be connected to the body member **12**. In a
5 specific embodiment, the recessed profile **108** may be formed in the first sleeve member **26**, or it may be formed in the indexing cylinder **106** disposed about the first sleeve member **26**. In this embodiment, the indexing cylinder **106** and the first sleeve member **26** are fixed to each other so as to prevent longitudinal movement relative to each other. As to relative rotatable movement between the two, however,
10 the indexing cylinder **106** and the first sleeve member **26** may be fixed so as to prevent relative rotatable movement between the two, or the indexing cylinder **106** may be slidably disposed about the first sleeve member **26** so as to permit relative rotatable movement. In the specific embodiment shown in Figure **1C-1D**, in which the recessed profile **108** is formed in the indexing cylinder **106**, the indexing cylinder
15 **106** is disposed for rotatable movement relative to the first sleeve member **26**, as per roller bearings **112** and **114**, and ball bearings **116** and **118**.

In a specific embodiment, with reference to Figure **1C-1D**, the retaining member **110** may include an elongate body **120** having a cam finger **122** at a distal end thereof and a hinge bore **124** at a proximal end thereof. A hinge pin **126** is
20 disposed within the hinge bore **124** and connected to the body member **12**. In this manner, the retaining member **110** may be hingedly connected to the body member **12**. A biasing member **128**, such as a spring, may be provided to bias the retaining

member **110** into engagement with the recessed profile **108**. Other embodiments of the retaining member **110** are within the scope of the present invention. For example, the retaining member **110** may be a spring-loaded detent pin (not shown).

The recessed profile **108** will now be described with reference to Figure 6,
5 which illustrates a planar projection of the recessed profile **108** in the indexing cylinder **106**. As shown in Figure 6, the recessed profile **108** preferably includes a plurality of axial slots **130** of varying length disposed circumferentially around the indexing cylinder **106**, in substantially parallel relationship, each of which are adapted to selectively receive the cam finger **122** on the retaining member **110**.
10 While the specific embodiment shown includes twelve axial slots **130**, this number should not be taken as a limitation. Rather, it should be understood that the present invention encompasses a recessed profile **108** having any number of axial slots **130**. Each axial slot **130** includes a lower portion **132** and an upper portion **134**. The upper portion **134** is recessed, or deeper, relative to the lower portion **132**, and an
15 inclined shoulder **136** separates the lower and upper portions **132** and **134**. An upwardly ramped slot **138** leads from the upper portion **134** of each axial slot **130** to the elevated lower portion **132** of an immediately neighboring axial slot **130**, with the inclined shoulder **136** defining the lower wall of each upwardly ramped slot **138**.

In operation, the first sleeve member **26** is normally biased upwardly, so that
20 the cam finger **122** of the retaining member **110** is positioned against the bottom of the lower portion **132** of one of the axial slots **130**. When it is desired to change the position of the first sleeve member **26**, hydraulic pressure should be applied from the

first hydraulic conduit **78** (Figure **1B**) to the first side **80** of the piston **76** for a period long enough to shift the cam finger **122** into engagement with the recessed upper portion **134** of the axial slot **130**. Hydraulic pressure should then be removed so that the first sleeve member **26** is biased upwardly, thereby causing the cam finger **122** to
5 engage the inclined shoulder **136** and move up the upwardly ramped slot **138** and into the lower portion **132** of the immediately neighboring axial slot **130** having a different length. It is noted that, in the specific embodiment shown, the indexing cylinder **106** will rotate relative to the retaining member **110**, which is hingedly secured to the body member **12**. By applying and removing pressurized fluid from
10 the first side **80** of the piston **76**, the cam finger **122** may be moved into the axial slot **130** having the desired length corresponding to the desired position of the first sleeve member **26**. This enables an operator at the earth's surface to shift the first sleeve member **26** into a plurality of discrete positions and control the distance between the first and second valve seats **22** and **28** (Figure **1E**), and thereby regulate fluid flow
15 through the at least one flow port **24** and/or the at least one flow slot **30**.

Methods of using the flow control device **10** of the present invention will be now be explained in connection with a specific embodiment of a well completion denoted generally by the numeral **140**, as illustrated in Figure **10**. Referring now to Figure **10**, the well completion **140** may include a production tubing **142** extending
20 from the earth's surface (not shown) and disposed within a well casing **144**, with a first packer **146** connected to the tubing **142** and disposed above a first hydrocarbon formation **148**, and a second packer **150** connected to the tubing **142** and disposed

between the first hydrocarbon formation **148** and a second hydrocarbon formation **152**. A well annulus **154** may be packed with gravel **155**. A first sand screen **156** may be connected to the tubing **142** adjacent the first formation **148**, and a second sand screen **158** may be connected to the tubing **142** adjacent the second formation **152**. A first flow control device **10a** of the present invention may be connected to the tubing **142** and disposed between the first packer **146** and the first formation **148**, and a second flow control device **10b** of the present invention may be connected to the tubing **142** and disposed between the first formation **148** and the second packer **150**. A first hydraulic conduit **160** may be connected from a source of pressurized fluid (not shown), such as at the earth's surface (not shown), to the first flow control device **10a**, and a second hydraulic conduit **162** may be connected from a source of pressurized fluid (not shown), such as at the earth's surface (not shown), to the second flow control device **10b**.

In a specific embodiment, the pressure within the first formation **148** may be greater than the pressure within the second formation **152**. In this case, it may be desirable to restrict fluid communication between the first and second formations **148** and **152**, otherwise hydrocarbons from the first formation **148** would flow into the second formation **152** instead of to the earth's surface. To this end, the first sleeve member **26** (Figures **1A-1G**) within the second flow control device **10b** may be remotely shifted upwardly to bring the first and second valve seats **22** and **28** into sealing contact, thereby preventing fluid communication between the first and second formations **148** and **152**. The first sleeve member **26** in the first flow control

device **10a** may be remotely shifted to regulate fluid flow from the first formation **148** to the earth's surface. The first and second flow control devices **10a** and **10b** may be remotely manipulated as required depending upon which formation is to be produced, and/or whether wireline intervention techniques are to be performed.

5 The flow control device **10** of the present invention may be used to produce hydrocarbons from a formation, such as formation **148** or **152**, to the earth's surface, or to inject chemicals from the earth's surface (not shown) into the well annulus **154**, and/or into a hydrocarbon formation, such as formation **148** or **152**. If the device **10** is to be used for producing fluids, then the device **10** should be positioned with the
10 first end **16** of the device **10** (Figure **1A**) above the second end **20** of the device **10** (Figure **1I**). But if the device **10** is to be used to inject chemicals, then the device **10** should be positioned "upside down" so that the second end **20** is above the first end **16**.

 Figure **11** discloses an alternative embodiment of the present invention. As
15 shown in the figure, the device **10** has a body **12** defining a first bore **14** therethrough. A second bore **18** in the annular space **21** of the body **12** provides an alternate pathway through the body **12**. As in the previously described embodiment, flow through the second bore **18**, which may be annular or one or more discrete passageways in the annular space **21**, is controlled by a sleeve valve. The sleeve
20 valve comprises a sleeve member **26** having a plurality of sleeve ports **200** therein (the sleeve ports may be replaced by the flow slots **30** of the previous embodiments or other similar openings). However, in the embodiment shown in Figure **11**, the

sleeve ports **200** comprise a plurality of discrete holes through the sleeve member **26**.

The sleeve ports **200** have a size selected to produce a specific flow area when opened to the flow port(s) **24** between the first bore **14** and the second bore(s) **18**.

For example, Figure **11** shows the sleeve member **26** in the fully open position in

5 which all of the sleeve ports are positioned above the valve seat **22** in fluid communication with the flow port **24**. In this position, the flow may be, in one example, full bore flow in which the flow area through the sleeve ports **200** is approximately at least as great as the flow area of the first bore **14** or the second bore

18. The sleeve ports **200** are spaced longitudinally so that sleeve member may be
10 positioned with the valve seat **22** between sets of sleeve ports **200** to define different preselected flow areas through the sleeve member. The position holder or indexing mechanism shown generally at **202** defines the discrete positions of the sleeve member **26**. The indexing mechanism may be the indexing sleeve described previously, another j-slot type indexer, or some other type of known indexer.

15 Applying and removing pressure to the sleeve member **26** via the control line (or hydraulic conduit) **78** provides for selective positioning of the sleeve member **26**. As mentioned previously, the sleeve member **26** generally has a biasing member such as a pressurized balance gas in a gas conduit **82** to bias the sleeve member **26** in a give direction to facilitate operation.

20 The embodiment describe of the present invention described in connection with Figure **1** for example generally describes the present invention as including a flapper valve in the first bore **14**, although the description clearly states that other

closure members **32** may be used (such as ball valves). The embodiment shown in Figure **11** discloses a removable plug **204** as the closure member **32**. In general, the plug includes a locating and positioning locator **206** (such as a profile and lock) to accurately position the plug in the well, and specifically the body **12**. The plug
5 includes a seal **208** that abuts the first bore **14** which may include a polished bore receptacle to essentially block flow through the first bore **14**. Note however that when the present description refers to closing a valve or blocking flow, some leakage or planned flow through the valve may be acceptable. Thus, in the present description, "closed" or "blocked" allows for some flow such as five or ten percent
10 flow. The plug **204** is position between the inlet to the second bore **18** and the flow ports **18** so that, when the plug is in place, the fluid is routed through the second bore **18** and the flow ports **24**. In this way, the fluid through the device **10** is regulated by the sleeve member **26** which may be, for example, controlled from the surface or a downhole controller. The plug **204** may be retrieved from the device **10** by a
15 retrieving tool (not shown) which may be run into the well on a standard carrier line (e.g., wireline, slickline, coiled tubing). To facilitate positioning and retrieval, the plug may use locking dogs, one or more collets, or other known positioning devices.

Figure **12** shows the sleeve member **26** in the closed position with the flow ports **24** below the valve seat **22**. The selective plug **204** is positioned in the device
20 **10** in the nipple **212** having a selective profile as shown as the locator **206**.

Note that the first bore **14** generally provides access through the device (or valve) **10** when the closure member **32** is open or removed and may therefore be

referred to as the access bore or passageway. Thereby, tools may be passed through the device **10** to, for example, re-enter the well. As an example, a wireline, slickline, or coiled tubing deployed tool could be run through the device **10** when the first bore **13** is open. Likewise, the second bore provides for fluid flow when the first bore **14** is closed and may therefore be referred to as a bypass or bypass flowpath or passageway.

Although described generally as a hydraulically controlled valve, the device could also be controlled electrically by replacing the hydraulic components with motors or solenoids or the like and electrical communication lines.

It is to be understood that the invention is not limited to the exact details of construction, operation, exact materials or embodiments shown and described, as obvious modifications and equivalents will be apparent to one skilled in the art. For example, while the device **10** has been described as being remotely controlled via at least one hydraulic conduit (e.g., conduit **78** in Figure 1A), the device **10** could just as easily be remotely controlled via an electrical conductor and still be within the scope of the present invention. Additionally, while the device **10** of the present invention has been described for use in well completions which include gravel pack in the well annulus, the device **10** may also be used in well completions lacking gravel pack and still be within the scope of the present invention. Accordingly, the invention is therefore to be limited only by the scope of the appended claims.

METHOD AND APPARATUS FOR SELECTIVE INJECTION OR FLOW CONTROL WITH THROUGH-TUBING OPERATION CAPACITY

5 **Field of Invention.** The present invention relates to subsurface well
equipment and, more particularly, to a method and apparatus for remotely controlling
injection or production fluids in well completions which may include gravel pack.

Description of the Related Art. As is well known to those skilled in the art,
certain hydrocarbon producing formations include sand. Unless filtered out, such
10 sand can become entrained or commingled with the hydrocarbons that are produced
to the earth's surface. This is sometimes referred to as "producing sand", and can be
undesirable for a number of reasons, including added production costs, and erosion
of well tools within the completion, which could lead to the mechanical
malfunctioning of such tools. Various approaches to combating this problem have
15 been developed. For example, the industry has developed sand screens which are
connected to the production tubing adjacent the producing formation to prevent sand
from entering the production tubing. In those cases where sand screens alone will
not sufficiently filter out the sand, the industry has learned that a very effective way
of filtering sand from entry into the production tubing is to fill, or pack, the well
20 annulus with gravel, hence the term "gravel pack" completions.

A drawback to gravel pack completions arises when it is desired to connect a
remotely-controllable flow control device to the production tubing to regulate the

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flow of production fluids from the gravel-packed well annulus into the production tubing, or to regulate the flow of injection fluids from the production tubing into the gravel-packed well annulus. If the flow control device is
5 of the type that includes a flow port in the sidewall of the body establishing fluid communication between the well annulus and the interior of the tool (such as the flow control device disclosed in U.S. Patent No. 5,823,623), then the presence of gravel pack in the annulus adjacent the flow
10 port may present an obstacle to the proper functioning of the flow control device, to the extent that the gravel pack may prohibit laminar flow through the flow port. As such, it is an object of the present invention to provide a flow control device that will enable the remote control of flow
15 of production fluids and/or injection fluids in well completions where the annulus is packed with gravel. It is also an object of the present invention to provide such a tool that will enable the passage of wireline tools through the tool so that wireline intervention techniques may be
20 performed at locations in the well below the flow control device.

SUMMARY OF THE INVENTION

An in-line flow control device for a well chokes flow through a conduit while allowing access therethrough.

25 In one aspect, the invention provides a downhole flow control device, comprising: a body defining a first passageway and a second passageway; a closure member coupled to the body and movable to selectively, substantially prevent flow through the first passageway; and a sleeve
30 valve in the body selectively positionable at an open position, a closed position and a plurality of predetermined positions therebetween, the sleeve valve being adapted to

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regulate the flow through the second passageway, wherein the open position enables full bore flow.

In another aspect, the invention provides a downhole flow control device, comprising: a conduit defining
5 a first bore therethrough and an annular space; the conduit further defining at least one second bore in the annular space, the first bore and the at least one second bore being oriented in an axial direction; and a sleeve member in the conduit selectively movable at predetermined increments
10 between an open position and a closed position to choke the flow through the second bore.

In another aspect, the invention provides a method of controlling fluid flow in a wellbore, comprising:
providing a body defining a first passageway and a second
15 passageway; blocking flow through the first passageway with a closure member coupled to the body; directing fluid flow through the second passageway in the body around the closure member; selectively choking, at and between full choke and no choke, the flow through the second passageway; and sizing
20 the second passageway with a total flow area at least as great as the flow area of the first passageway.

In another aspect, the invention provides a method of controlling fluid flow in a wellbore, comprising:
providing a valve having a closable access bore
25 therethrough; flowing fluid through the valve via a bypass passageway in the valve; providing a choke selectively positionable at and between an open position and a closed position in the valve to selectively choke the fluid flow through the valve; and biasing the choke toward the closed
30 position.

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BRIEF DESCRIPTION OF THE DRAWINGS

Figures **1A-1J** taken together form a longitudinal sectional view of a specific embodiment of the flow control device of the present invention.

Figure 2 is a cross-sectional view taken along line 2-2 of Figure 1B.

Figure 3 is a cross-sectional view taken along line 3-3 of Figure 1E.

Figure 4 is a cross-sectional view taken along line 4-4 of Figure 1E.

Figure 5 is a cross-sectional view taken along line 5-5 of Figure 1E.

5 Figure 6 illustrates a planar projection of an outer cylindrical surface of a position holder shown in Figures 1C and 1D.

Figure 7 is a partial elevation view taken along line 7-7 of Figure 1I.

Figure 8 is a longitudinal sectional view, similar to Figures 1A and 1B, showing an upper portion of another specific embodiment of the flow control device
10 of the present invention.

Figure 9 is a longitudinal sectional view, similar to Figure 8, showing an upper portion of another specific embodiment of the flow control device of the present invention.

Figure 10 is a schematic representation of a specific embodiment of a well
15 completion in which the flow control device of the present invention may be used.

Figure 11 is a partial cross sectional view of an alternative embodiment of the present invention.

Figure 12 is a partial cross sectional view of an alternative embodiment of the present invention.

20 While the invention will be described in connection with the preferred embodiments, it will be understood that it is not intended to limit the invention to those embodiments. On the contrary, it is intended to cover all alternatives,

modifications, and equivalents as may be included within the spirit and scope of the invention as defined by the appended claims.

DETAILED DESCRIPTION OF THE INVENTION

5 For the purposes of this description, the terms “upper” and “lower,” “up hole” and “downhole” and “upwardly” and “downwardly” are relative terms to indicate position and direction of movement in easily recognized terms. Usually, these terms are relative to a line drawn from an upmost position at the earth’s surface to a point at the center of the earth, and would be appropriate for use in relatively
10 straight, vertical wellbores. However, when the wellbore is highly deviated, such as from about 60 degrees from vertical, or horizontal, these terms do not make sense and therefore should not be taken as limitations. These terms are only used for ease of understanding as an indication of what the position or movement would be if taken within a vertical wellbore.

15 Referring to the drawings in detail, wherein like numerals denote identical elements throughout the several views, a specific embodiment of the downhole flow control device of the present invention is referred to generally by the numeral 10. Referring initially to Figure 1A, the device 10 may include a generally cylindrical body member 12 having a first bore (or first passageway) 14 extending from a first
20 end 16 of the body member 12 and through a generally cylindrical extension member 17 (Figures 1E-1I) disposed within the body member 12, and a second bore (or second passageway) 18 extending from a second end 20 of the body member 12 and

into an annular space **21** disposed about the extension member **17**. In a specific embodiment, the diameter of the second bore **18** is greater than the diameter of the first bore **14**. As shown in Figure **1E**, the body member **12** may also include a first valve seat **22** disposed within the first bore **14**, and the extension member **17** may
5 include at least one flow port **24** establishing fluid communication between the annular space **21** and the first bore **14**.

With reference to Figures **1B-1F**, the device **10** may further include a first generally cylindrical sleeve member **26** movably disposed and remotely shiftable within the first bore **14**. The manner in which the first sleeve member **26** is shifted
10 within the first bore **14** will be described below. Referring to Figure **1E**, the first sleeve member **26** may include a second valve seat **28** adapted for cooperable sealing engagement with the first valve seat **22** to regulate fluid flow through the at least one flow port **24**. The first sleeve member **26** may also include at least one flow slot **30**.

As shown in Figure **1H**, the device **10** may further include a closure member
15 **32** disposed for movement between an open and a closed position to control fluid flow through the first bore **14**. The closure member **32** is shown in its closed position. In a specific embodiment, the closure member **32** may be a flapper having an arm **34** hingedly connected to the extension member **17**. The flapper **32** may be biased into its closed position by a hinge spring **36**. Other types of closure members
20 **32** are within the scope of the present invention, including, for example, a ball valve.

As shown in Figures **1F-1H**, the device **10** may further include a second sleeve member **38** movably disposed and remotely shiftable within the first bore **14**

to move the closure member 32 between its open and closed positions. As shown in Figure 1E, the second sleeve member 38 may include an inner surface 40 having a locking profile 42 disposed therein for mating with a shifting tool (not shown). As shown in Figure 1G, the second sleeve member 38 may also include at least one rib 44 that is shown engaged with a first annular recess 46 in the first bore 14 of the extension member 17. In a specific embodiment, the second sleeve member 38 may include a plurality of ribs 44 disposed on a plurality of collet sections 48 in the second sleeve member 38 that may be disposed between a plurality of slots 50 in the second sleeve member 38. As will be more fully discussed below, the second sleeve member 38 may be shifted downwardly to engage the ribs 44 with a second annular recess 47 in the first bore 14 of the extension member 17. The second sleeve member 38 may further include at least one first equalizing port 52 for cooperating with at least one second equalizing port 54 in the extension member 17 to equalize pressure above and below the flapper 32 prior to shifting the second sleeve member 38 downwardly to open the flapper 32. The first equalizing port 52 establishes fluid communication between the inner surface 40 of the second sleeve member 38 and the first bore 14 of the extension member 17. The second equalizing port 54 establishes fluid communication between the first bore 14 of the extension member 17 and the annular space 21. A first annular seal 56 and a second annular seal 58 may be disposed within the first bore 14 of the extension member 17 and in sealing relationship about the second sleeve member 38. The second equalizing port 54 is disposed between the first and second annular seals 56 and 58. When the ribs 44 on

the second sleeve member 38 are engaged with the first annular recess 46 in the extension member 17, the first annular seal 56 is disposed between the first and second equalizing ports 52 and 54, and a distal end 39 of the second sleeve member 38 is spaced from the closure member 32.

5 When it is desired to open the flapper 32, to enable passage of wireline tools (not shown) to positions below the device 10, a wireline shifting tool (not shown) may be engaged with the locking profile 42 (Figure 1G) and used to shift the second sleeve member 38 downwardly until the distal end 39 (Figure 1H) of the second sleeve member 38 comes into contact with the flapper 32. This will align the first
10 and second equalizing ports 52 and 54, and thereby establish fluid communication between the annular space 21 and the inner surface 40 of the second sleeve member 38. In this manner, pressure may be equalized above and below the flapper 32 prior to opening of the flapper 32. The second sleeve member 38 may then continue downwardly to push the flapper 32 open, without having to overcome upward forces
15 imparted to the flapper 32 by pressure below the flapper 32. It is noted, with reference to Figure 1E, that pressure above and below the flapper 32 may also be equalized prior to opening of the flapper 32 by shifting the first sleeve member 26 to separate the first and second valve seats 22 and 28 to establish fluid communication between the annular space 21 and an inner surface 27 of the first sleeve member 26.

20 With reference to Figures 1I and 7, the device 10 may further include a cone member 60 connected to a distal end 62 of the extension member 17. In a specific embodiment, the cone member 60 may include a first and a second half-cone

member 64 and 66, each of which may be hingedly attached to the distal end 62 of the extension member 17, as by a first and a second hinge pin 68 and 70, respectively, and biased towards each other, as by first and second hinge springs 72 and 74, respectively. The springs 72 and 74 bias and hold the half-cone members 64 and 66 in mating relationship, or in a normally-closed position, to form a cone, as shown in Figure 1I. In this normally-closed position, the cone member 60 directs fluid flowing from the second end 20 of the body member 12 into the annular space 21, and functions to minimize turbulence as fluid flows into the annular space 21. In this regard, in a preferred embodiment, an angle α formed between a first outer surface 65 of the first half-cone member 64 and a second outer surface 67 of the second half-cone member 66 may be approximately forty-four (44) degrees when the half-cone members 64 and 66 are biased towards each other to form a cone, as shown in Figure 1I. When it is desired to pass a wireline tool through the device 10 from the first end 16 of the body member 12 to the second end 20 of the body member, then the second sleeve member 38 (Figures 1F-1H) may be shifted downwardly (by locating a wireline shifting tool (not shown) in the locking profile 42, as discussed above) from its position shown in Figures 1F-1H to a lower position (not shown) in which the first and second half-cone members 64 and 66 are separated and their respective inner surfaces 69 and 70 are disposed about the second sleeve member 38. With reference to Figure 1G, the ribs 44 on the second sleeve member 38 may be disposed within the second annular recess 47 in the extension member 17 when the second sleeve member 38 is in its lower position (not shown).

The manner in which the first sleeve member **26** is remotely shifted will now be described. Referring to Figures **1B – 1D**, in a specific embodiment, a piston **76** may be connected to, or a part of, the first sleeve member **26**, and may be sealably, slidably disposed within the first bore **14** of the body member **12**. In a specific
5 embodiment, the piston **76** may be an annular piston or at least one rod piston. A first hydraulic conduit **78** is connected between a source of hydraulic fluid (not shown), such as at the earth's surface (not shown), and the body member **12**, as at fitting **81**, and is in fluid communication with a first side **80** of the piston **76**, such as through a first passageway **79** in the body member **12**. The first sleeve member **26**
10 may be remotely shifted downwardly, or away from the first end **16** of the body member **12**, by application of pressurized fluid to the first side **80** of the piston **76**. A number of mechanisms for biasing the first sleeve member **26** upwardly, or towards the first end **16** of the body member **12**, may be provided within the scope of the present invention, including but not limited to another hydraulic conduit, pressurized
15 gas, spring force, and annulus pressure, and/or any combination thereof.

In a specific embodiment, as shown in Figure **1A**, the biasing mechanism may include a source of pressurized gas, such as pressurized nitrogen, which may be contained within a sealed chamber, such as a gas conduit **82**. An upper portion **84** of the gas conduit **82** may be coiled within a housing **85** formed within the body
20 member **12**, and a lower portion **86** of the gas conduit **82** (Figure **1B**) may extend outside the body member **12** and terminate at a fitting **88** connected to the body member **12**. The gas conduit **82** is in fluid communication with a second side **90** of

the piston 76, such as through a second passageway 92 in the body member 12.

Appropriate seals are provided to contain the pressurized gas. As shown in Figure 3, the body member 12 may include a charging port 94, which may include a dill core valve, through which pressurized gas may be introduced into the device 10.

5 Another biasing mechanism is shown in Figure 8, which is a view similar to Figures 1A and 1B, and illustrates an upper portion of another specific embodiment of the present invention, which is referred to generally by the numeral 10'. The lower portion of this embodiment is the same as shown in Figures 1C-1I. In this embodiment, a second hydraulic conduit 96 is connected between a source of
10 hydraulic fluid (not shown), such as at the earth's surface (not shown), and the body member 12', and is in fluid communication with the second side 90' of the piston 76', such as through the second passageway 92' in the body member 12'. As such, in this embodiment, hydraulic fluid is used instead of pressurized gas to bias the first sleeve member 26' towards the first end 16' of the body member 12'.

15 Another biasing mechanism is shown in Figure 9, which is a view similar to Figure 8, and illustrates an upper portion of another specific embodiment of the present invention, which is referred to generally by the numeral 10". The lower portion of this embodiment is as shown in Figures 1C-1I. In this embodiment, a spring 98 is disposed within the first bore 14", about the first sleeve member 26",
20 and between an annular shoulder 100 on the body member 12" and the second side 90" of the piston 76". As such, in this embodiment, force of the spring 98 is used instead of pressurized gas or hydraulic fluid to bias the first sleeve member 26"

toward the first end 16" of the body member 12". Alternatively, as shown in Figure 9, the device 10" may also include a port 102 in the body member 12" connected to a conduit 104 through which hydraulic fluid or pressurized gas may also be applied to the second side 90" of the piston 76" to assist the spring 98 in biasing the first sleeve member 26" toward the first end 16" of the body member 12". In this regard, if hydraulic fluid is desired, the conduit 104 may be a hydraulic conduit, such as the second hydraulic conduit 96 shown in Figure 8. Alternatively, if pressurized gas is desired, the conduit 104 may be a gas conduit, such as the gas conduit 82 shown in Figures 1A-1B. In another specific embodiment, instead of using hydraulic fluid or pressurized gas, the port 102 may be in communication with annulus pressure, which may be used to bias the first sleeve member 26" toward the first end 16" of the body member 12", either by itself, or in combination with the spring 98.

Referring now to Figures 1C-1D and 6, the device 10 of the present invention may also include a position holder to enable an operator at the earth's surface (not shown) to remotely locate and maintain the first sleeve member 26 in a plurality of discrete positions, thereby providing the operator with the ability to remotely regulate fluid flow through the at least one flow port 24 in the extension member 17 (Figure 1E), and/or through the at least one flow slot 30 in the first sleeve member 26 (Figure 1E). The position holder may be provided in a variety of configurations. In a specific embodiment, as shown in Figures 1C-1D and 6, the position holder may include an indexing cylinder 106 having a recessed profile 108 (Figure 6), and be adapted so that a retaining member 110 (Figure 1D) may be biased into cooperable

engagement with the recessed profile **108**, as will be more fully explained below. In a specific embodiment, one of the position holder **106** and the retaining member **110** may be connected to the first sleeve member **26**, and the other of the position holder **106** and the retaining member **110** may be connected to the body member **12**. In a
5 specific embodiment, the recessed profile **108** may be formed in the first sleeve member **26**, or it may be formed in the indexing cylinder **106** disposed about the first sleeve member **26**. In this embodiment, the indexing cylinder **106** and the first sleeve member **26** are fixed to each other so as to prevent longitudinal movement relative to each other. As to relative rotatable movement between the two, however,
10 the indexing cylinder **106** and the first sleeve member **26** may be fixed so as to prevent relative rotatable movement between the two, or the indexing cylinder **106** may be slidably disposed about the first sleeve member **26** so as to permit relative rotatable movement. In the specific embodiment shown in Figure **1C-1D**, in which the recessed profile **108** is formed in the indexing cylinder **106**, the indexing cylinder
15 **106** is disposed for rotatable movement relative to the first sleeve member **26**, as per roller bearings **112** and **114**, and ball bearings **116** and **118**.

In a specific embodiment, with reference to Figure **1C-1D**, the retaining member **110** may include an elongate body **120** having a cam finger **122** at a distal end thereof and a hinge bore **124** at a proximal end thereof. A hinge pin **126** is
20 disposed within the hinge bore **124** and connected to the body member **12**. In this manner, the retaining member **110** may be hingedly connected to the body member **12**. A biasing member **128**, such as a spring, may be provided to bias the retaining

member **110** into engagement with the recessed profile **108**. Other embodiments of the retaining member **110** are within the scope of the present invention. For example, the retaining member **110** may be a spring-loaded detent pin (not shown).

The recessed profile **108** will now be described with reference to Figure 6,
5 which illustrates a planar projection of the recessed profile **108** in the indexing cylinder **106**. As shown in Figure 6, the recessed profile **108** preferably includes a plurality of axial slots **130** of varying length disposed circumferentially around the indexing cylinder **106**, in substantially parallel relationship, each of which are adapted to selectively receive the cam finger **122** on the retaining member **110**.
10 While the specific embodiment shown includes twelve axial slots **130**, this number should not be taken as a limitation. Rather, it should be understood that the present invention encompasses a recessed profile **108** having any number of axial slots **130**. Each axial slot **130** includes a lower portion **132** and an upper portion **134**. The upper portion **134** is recessed, or deeper, relative to the lower portion **132**, and an
15 inclined shoulder **136** separates the lower and upper portions **132** and **134**. An upwardly ramped slot **138** leads from the upper portion **134** of each axial slot **130** to the elevated lower portion **132** of an immediately neighboring axial slot **130**, with the inclined shoulder **136** defining the lower wall of each upwardly ramped slot **138**.

In operation, the first sleeve member **26** is normally biased upwardly, so that
20 the cam finger **122** of the retaining member **110** is positioned against the bottom of the lower portion **132** of one of the axial slots **130**. When it is desired to change the position of the first sleeve member **26**, hydraulic pressure should be applied from the

first hydraulic conduit **78** (Figure **1B**) to the first side **80** of the piston **76** for a period long enough to shift the cam finger **122** into engagement with the recessed upper portion **134** of the axial slot **130**. Hydraulic pressure should then be removed so that the first sleeve member **26** is biased upwardly, thereby causing the cam finger **122** to
5 engage the inclined shoulder **136** and move up the upwardly ramped slot **138** and into the lower portion **132** of the immediately neighboring axial slot **130** having a different length. It is noted that, in the specific embodiment shown, the indexing cylinder **106** will rotate relative to the retaining member **110**, which is hingedly secured to the body member **12**. By applying and removing pressurized fluid from
10 the first side **80** of the piston **76**, the cam finger **122** may be moved into the axial slot **130** having the desired length corresponding to the desired position of the first sleeve member **26**. This enables an operator at the earth's surface to shift the first sleeve member **26** into a plurality of discrete positions and control the distance between the first and second valve seats **22** and **28** (Figure **1E**), and thereby regulate fluid flow
15 through the at least one flow port **24** and/or the at least one flow slot **30**.

Methods of using the flow control device **10** of the present invention will be now be explained in connection with a specific embodiment of a well completion denoted generally by the numeral **140**, as illustrated in Figure **10**. Referring now to Figure **10**, the well completion **140** may include a production tubing **142** extending
20 from the earth's surface (not shown) and disposed within a well casing **144**, with a first packer **146** connected to the tubing **142** and disposed above a first hydrocarbon formation **148**, and a second packer **150** connected to the tubing **142** and disposed

between the first hydrocarbon formation **148** and a second hydrocarbon formation **152**. A well annulus **154** may be packed with gravel **155**. A first sand screen **156** may be connected to the tubing **142** adjacent the first formation **148**, and a second sand screen **158** may be connected to the tubing **142** adjacent the second formation **152**. A first flow control device **10a** of the present invention may be connected to the tubing **142** and disposed between the first packer **146** and the first formation **148**, and a second flow control device **10b** of the present invention may be connected to the tubing **142** and disposed between the first formation **148** and the second packer **150**. A first hydraulic conduit **160** may be connected from a source of pressurized fluid (not shown), such as at the earth's surface (not shown), to the first flow control device **10a**, and a second hydraulic conduit **162** may be connected from a source of pressurized fluid (not shown), such as at the earth's surface (not shown), to the second flow control device **10b**.

In a specific embodiment, the pressure within the first formation **148** may be greater than the pressure within the second formation **152**. In this case, it may be desirable to restrict fluid communication between the first and second formations **148** and **152**, otherwise hydrocarbons from the first formation **148** would flow into the second formation **152** instead of to the earth's surface. To this end, the first sleeve member **26** (Figures **1A-1G**) within the second flow control device **10b** may be remotely shifted upwardly to bring the first and second valve seats **22** and **28** into sealing contact, thereby preventing fluid communication between the first and second formations **148** and **152**. The first sleeve member **26** in the first flow control

device **10a** may be remotely shifted to regulate fluid flow from the first formation **148** to the earth's surface. The first and second flow control devices **10a** and **10b** may be remotely manipulated as required depending upon which formation is to be produced, and/or whether wireline intervention techniques are to be performed.

5 The flow control device **10** of the present invention may be used to produce hydrocarbons from a formation, such as formation **148** or **152**, to the earth's surface, or to inject chemicals from the earth's surface (not shown) into the well annulus **154**, and/or into a hydrocarbon formation, such as formation **148** or **152**. If the device **10** is to be used for producing fluids, then the device **10** should be positioned with the
10 first end **16** of the device **10** (Figure **1A**) above the second end **20** of the device **10** (Figure **1I**). But if the device **10** is to be used to inject chemicals, then the device **10** should be positioned "upside down" so that the second end **20** is above the first end **16**.

 Figure **11** discloses an alternative embodiment of the present invention. As
15 shown in the figure, the device **10** has a body **12** defining a first bore **14** therethrough. A second bore **18** in the annular space **21** of the body **12** provides an alternate pathway through the body **12**. As in the previously described embodiment, flow through the second bore **18**, which may be annular or one or more discrete passageways in the annular space **21**, is controlled by a sleeve valve. The sleeve
20 valve comprises a sleeve member **26** having a plurality of sleeve ports **200** therein (the sleeve ports may be replaced by the flow slots **30** of the previous embodiments or other similar openings). However, in the embodiment shown in Figure **11**, the

sleeve ports **200** comprise a plurality of discrete holes through the sleeve member **26**.

The sleeve ports **200** have a size selected to produce a specific flow area when opened to the flow port(s) **24** between the first bore **14** and the second bore(s) **18**.

For example, Figure **11** shows the sleeve member **26** in the fully open position in

5 which all of the sleeve ports are positioned above the valve seat **22** in fluid communication with the flow port **24**. In this position, the flow may be, in one example, full bore flow in which the flow area through the sleeve ports **200** is approximately at least as great as the flow area of the first bore **14** or the second bore

18. The sleeve ports **200** are spaced longitudinally so that sleeve member may be
10 positioned with the valve seat **22** between sets of sleeve ports **200** to define different preselected flow areas through the sleeve member. The position holder or indexing mechanism shown generally at **202** defines the discrete positions of the sleeve member **26**. The indexing mechanism may be the indexing sleeve described previously, another j-slot type indexer, or some other type of known indexer.

15 Applying and removing pressure to the sleeve member **26** via the control line (or hydraulic conduit) **78** provides for selective positioning of the sleeve member **26**. As mentioned previously, the sleeve member **26** generally has a biasing member such as a pressurized balance gas in a gas conduit **82** to bias the sleeve member **26** in a give direction to facilitate operation.

20 The embodiment describe of the present invention described in connection with Figure **1** for example generally describes the present invention as including a flapper valve in the first bore **14**, although the description clearly states that other

closure members **32** may be used (such as ball valves). The embodiment shown in Figure **11** discloses a removable plug **204** as the closure member **32**. In general, the plug includes a locating and positioning locator **206** (such as a profile and lock) to accurately position the plug in the well, and specifically the body **12**. The plug
5 includes a seal **208** that abuts the first bore **14** which may include a polished bore receptacle to essentially block flow through the first bore **14**. Note however that when the present description refers to closing a valve or blocking flow, some leakage or planned flow through the valve may be acceptable. Thus, in the present description, "closed" or "blocked" allows for some flow such as five or ten percent
10 flow. The plug **204** is position between the inlet to the second bore **18** and the flow ports **18** so that, when the plug is in place, the fluid is routed through the second bore **18** and the flow ports **24**. In this way, the fluid through the device **10** is regulated by the sleeve member **26** which may be, for example, controlled from the surface or a downhole controller. The plug **204** may be retrieved from the device **10** by a
15 retrieving tool (not shown) which may be run into the well on a standard carrier line (e.g., wireline, slickline, coiled tubing). To facilitate positioning and retrieval, the plug may use locking dogs, one or more collets, or other known positioning devices.

Figure **12** shows the sleeve member **26** in the closed position with the flow ports **24** below the valve seat **22**. The selective plug **204** is positioned in the device
20 **10** in the nipple **212** having a selective profile as shown as the locator **206**.

Note that the first bore **14** generally provides access through the device (or valve) **10** when the closure member **32** is open or removed and may therefore be

referred to as the access bore or passageway. Thereby, tools may be passed through the device **10** to, for example, re-enter the well. As an example, a wireline, slickline, or coiled tubing deployed tool could be run through the device **10** when the first bore **13** is open. Likewise, the second bore provides for fluid flow when the first bore **14** is closed and may therefore be referred to as a bypass or bypass flowpath or passageway.

Although described generally as a hydraulically controlled valve, the device could also be controlled electrically by replacing the hydraulic components with motors or solenoids or the like and electrical communication lines.

It is to be understood that the invention is not limited to the exact details of construction, operation, exact materials or embodiments shown and described, as obvious modifications and equivalents will be apparent to one skilled in the art. For example, while the device **10** has been described as being remotely controlled via at least one hydraulic conduit (e.g., conduit **78** in Figure 1A), the device **10** could just as easily be remotely controlled via an electrical conductor and still be within the scope of the present invention. Additionally, while the device **10** of the present invention has been described for use in well completions which include gravel pack in the well annulus, the device **10** may also be used in well completions lacking gravel pack and still be within the scope of the present invention. Accordingly, the invention is therefore to be limited only by the scope of the appended claims.

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CLAIMS:

1. A downhole flow control device, comprising:

 a body defining a first passageway and a second
passageway;

5 a closure member coupled to the body and movable
to selectively, substantially prevent flow through the first
passageway; and

 a sleeve valve in the body selectively
positionable at an open position, a closed position and a
10 plurality of predetermined positions therebetween, the
sleeve valve being adapted to regulate the flow through the
second passageway, wherein the open position enables full
bore flow.
2. The device of claim 1, wherein the closure member
15 is a flapper valve.
3. The device of claim 2, wherein the flapper valve
is controlled from the surface via a control line.
4. A downhole flow control device, comprising:

 a conduit defining a first bore therethrough and
20 an annular space;

 the conduit further defining at least one second
bore in the annular space, the first bore and the at least
one second bore being oriented in an axial direction;

 a sleeve member in the conduit selectively movable
25 at predetermined increments between an open position and a
closed position to choke the flow through the second bore;
and

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a flapper movable between an open position and a closed position to control flow in the first bore.

5. The device of claim 4, wherein the sleeve member defines a plurality of sleeve ports therethrough, the sleeve
5 ports selected to provide a predetermined flow area depending upon the position of the sleeve member.

6. The device of claim 4, wherein the second bore has opposing ends in fluid communication with the first bore.

7. The device of claim 6, wherein the flapper is
10 positioned between the opposing ends of the second bore.

8. A method of controlling fluid flow in a wellbore, comprising:

providing a body defining a first passageway and a second passageway;

15 blocking flow through the first passageway with a closure member coupled to the body;

directing fluid flow through the second passageway in the body around the closure member;

20 selectively choking, at and between full choke and no choke, the flow through the second passageway; and

sizing the second passageway with a total flow area at least as great as the flow area of the first passageway, wherein the closure member comprises a flapper movable between an open position and a closed position to
25 control flow in the first passageway.

9. A method of controlling fluid flow in a wellbore, comprising:

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providing a valve having a first passageway and a second passageway;

positioning a movable closure member to selectively and substantially prevent flow through the first
5 passageway;

locating a sleeve in the valve; and

selectively positioning the sleeve at an open position, a closed position and a plurality of predetermined positions therebetween, the sleeve valve being adapted to
10 regulate the flow through the second passageway, wherein the open position enables full bore flow.

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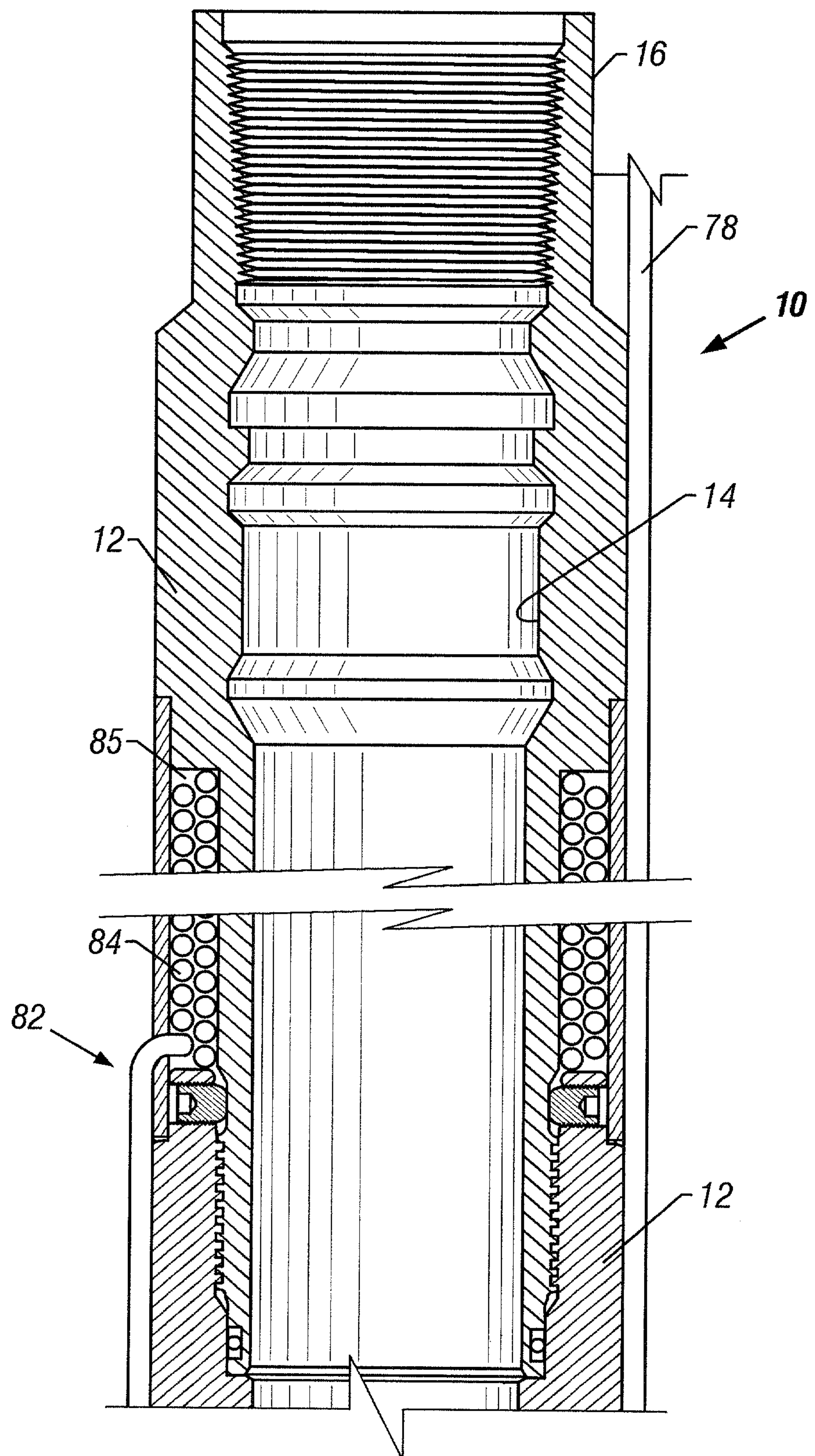


FIG. 1A

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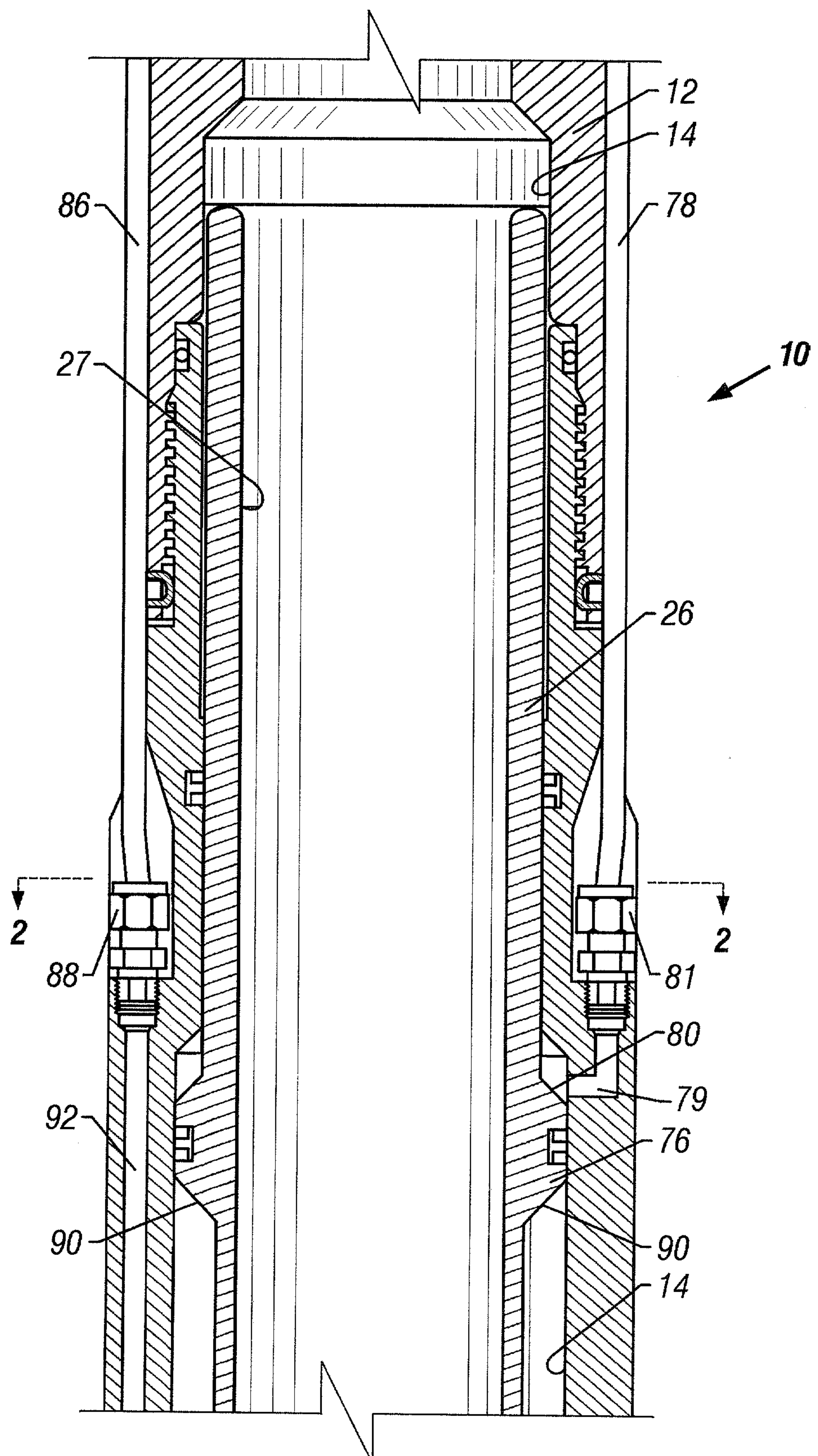


FIG. 1B

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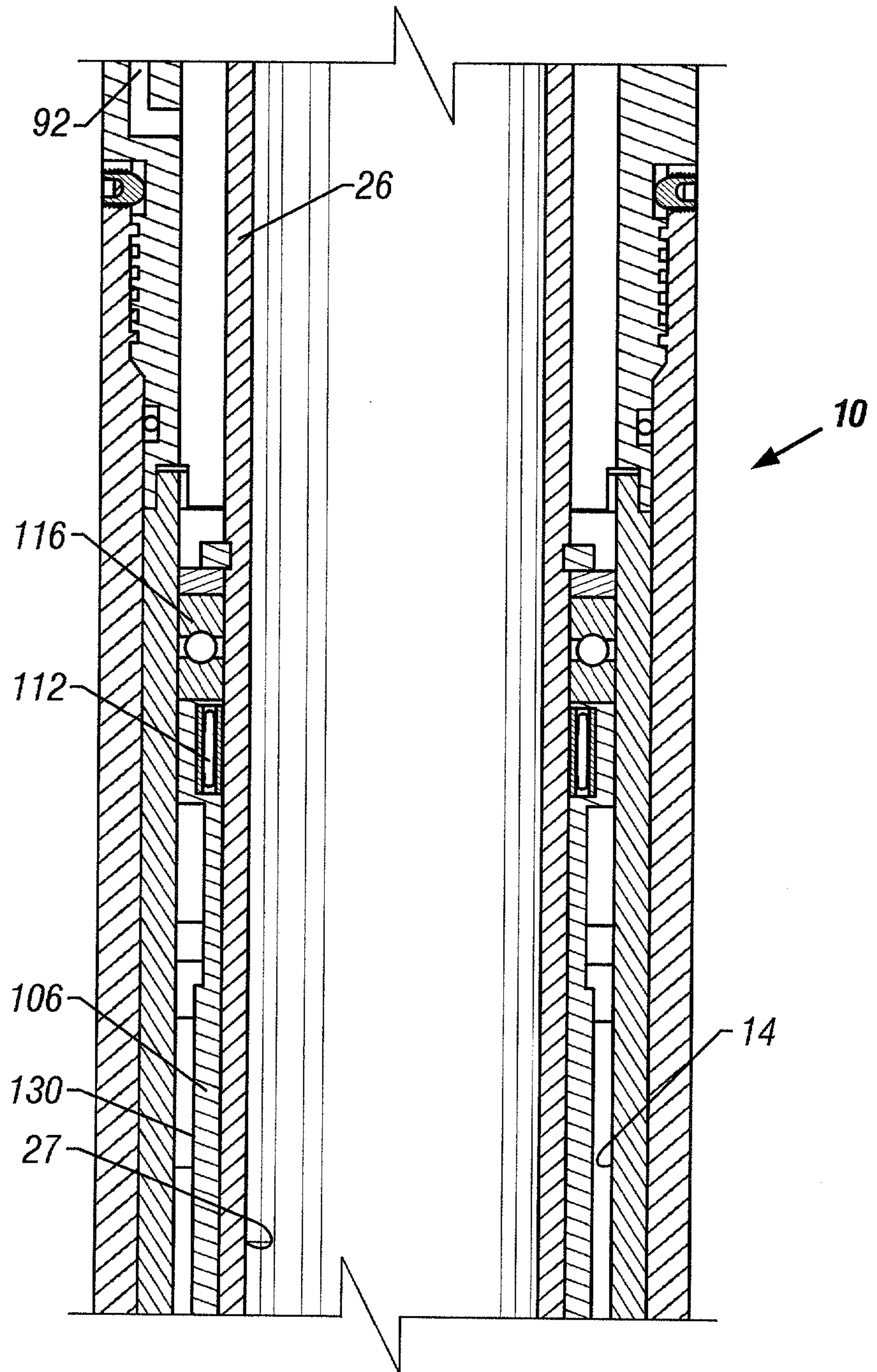


FIG. 1C

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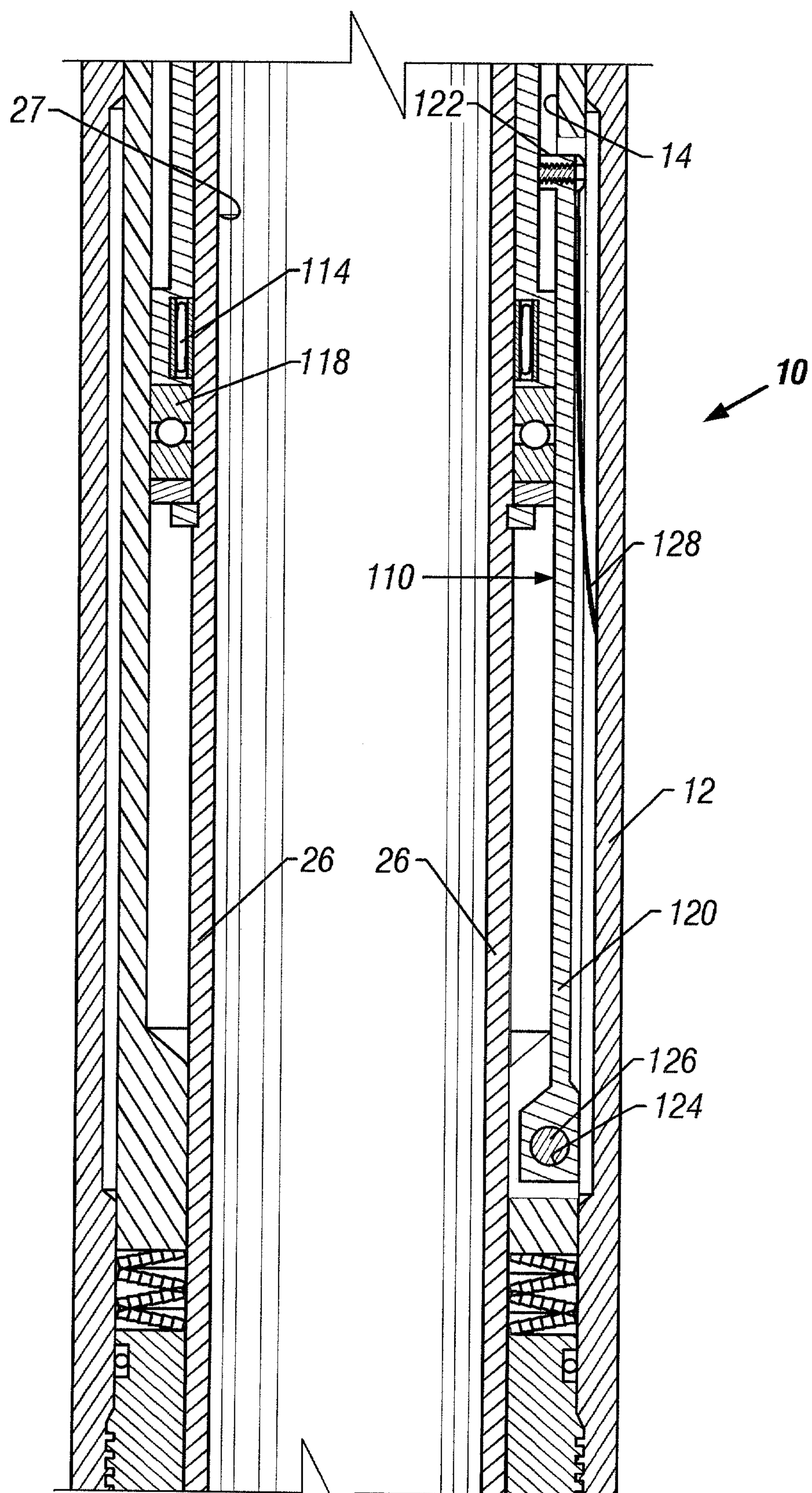


FIG. 1D

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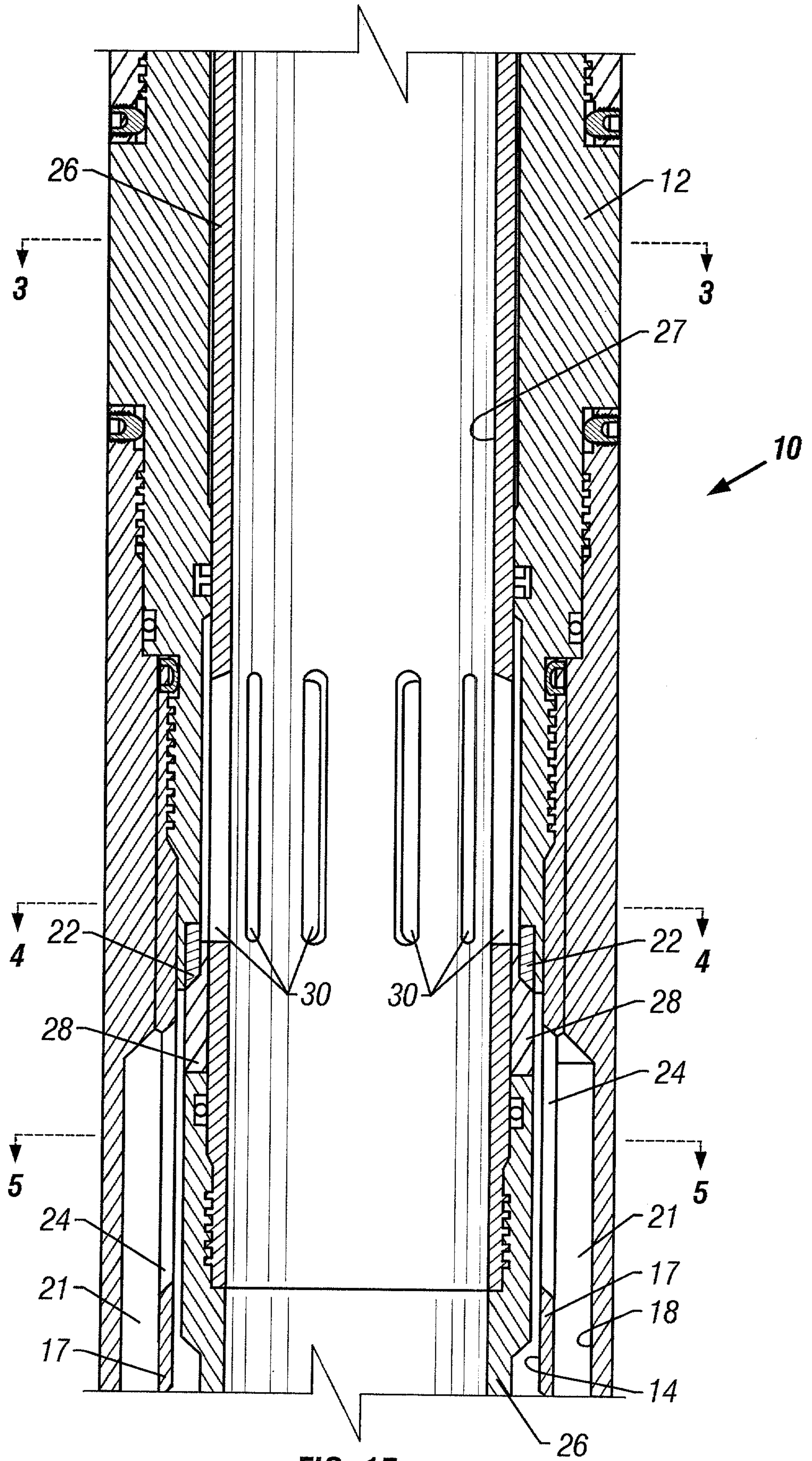


FIG. 1E

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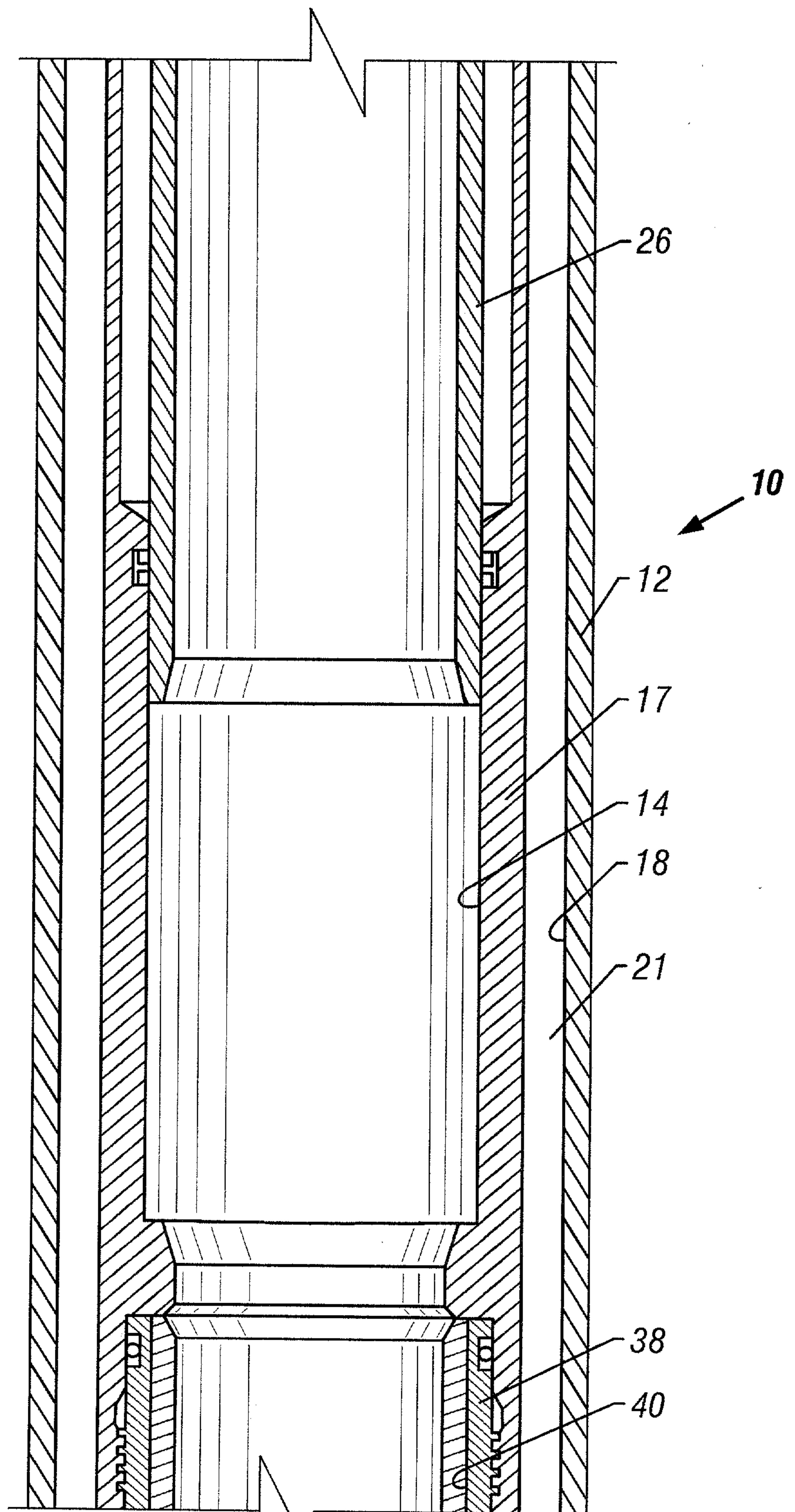


FIG. 1F

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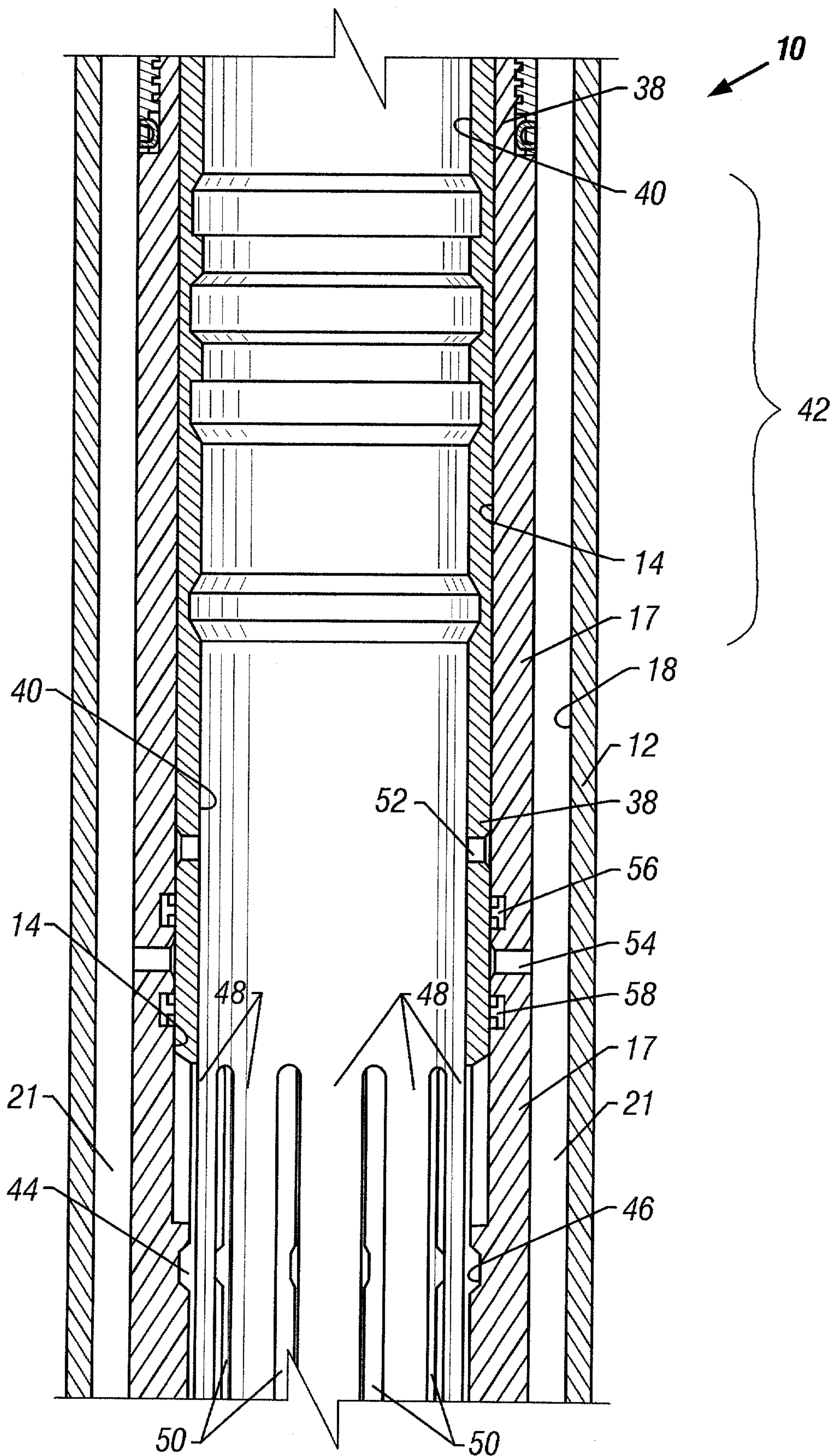


FIG. 1G

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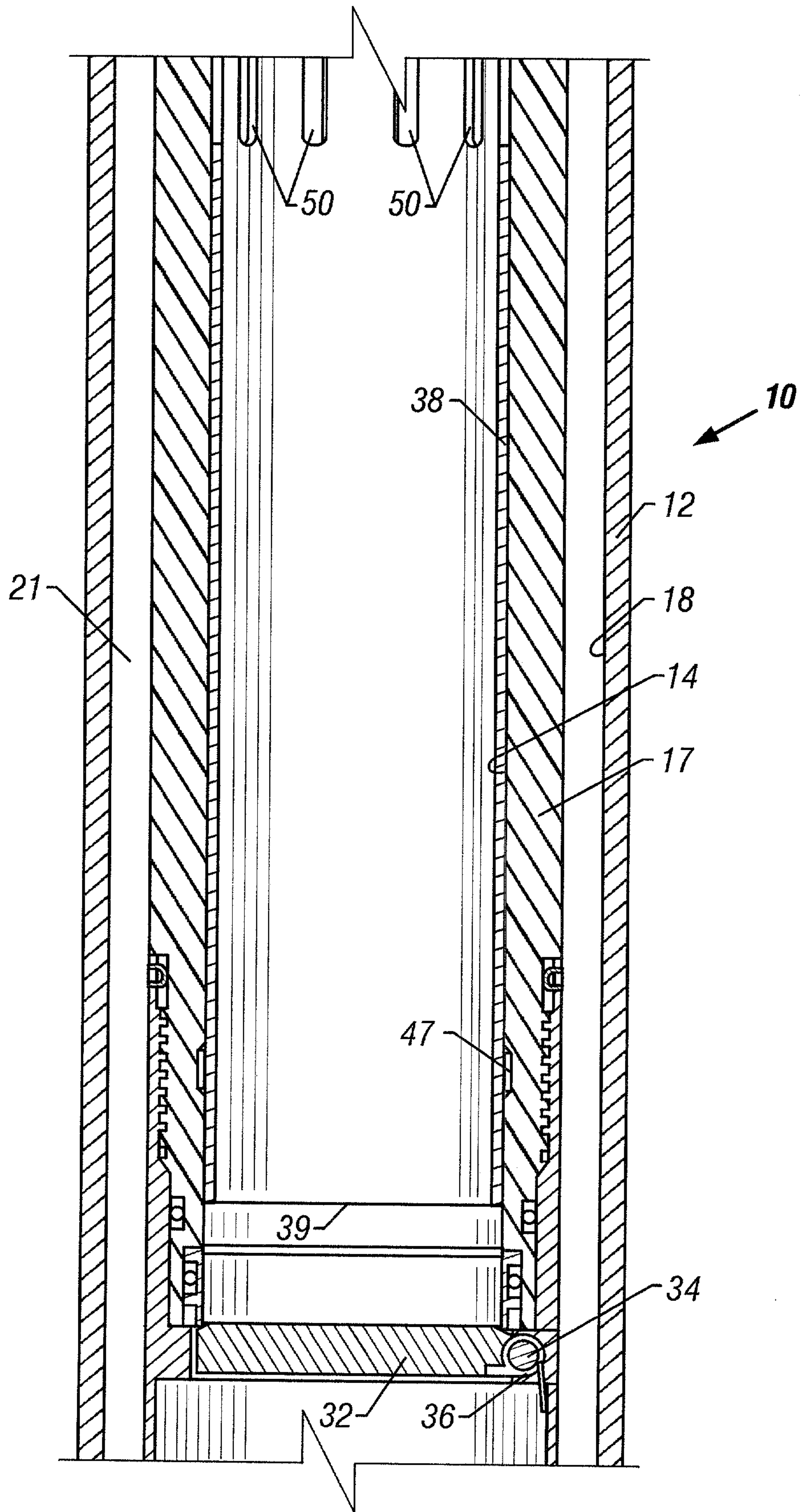


FIG. 1H

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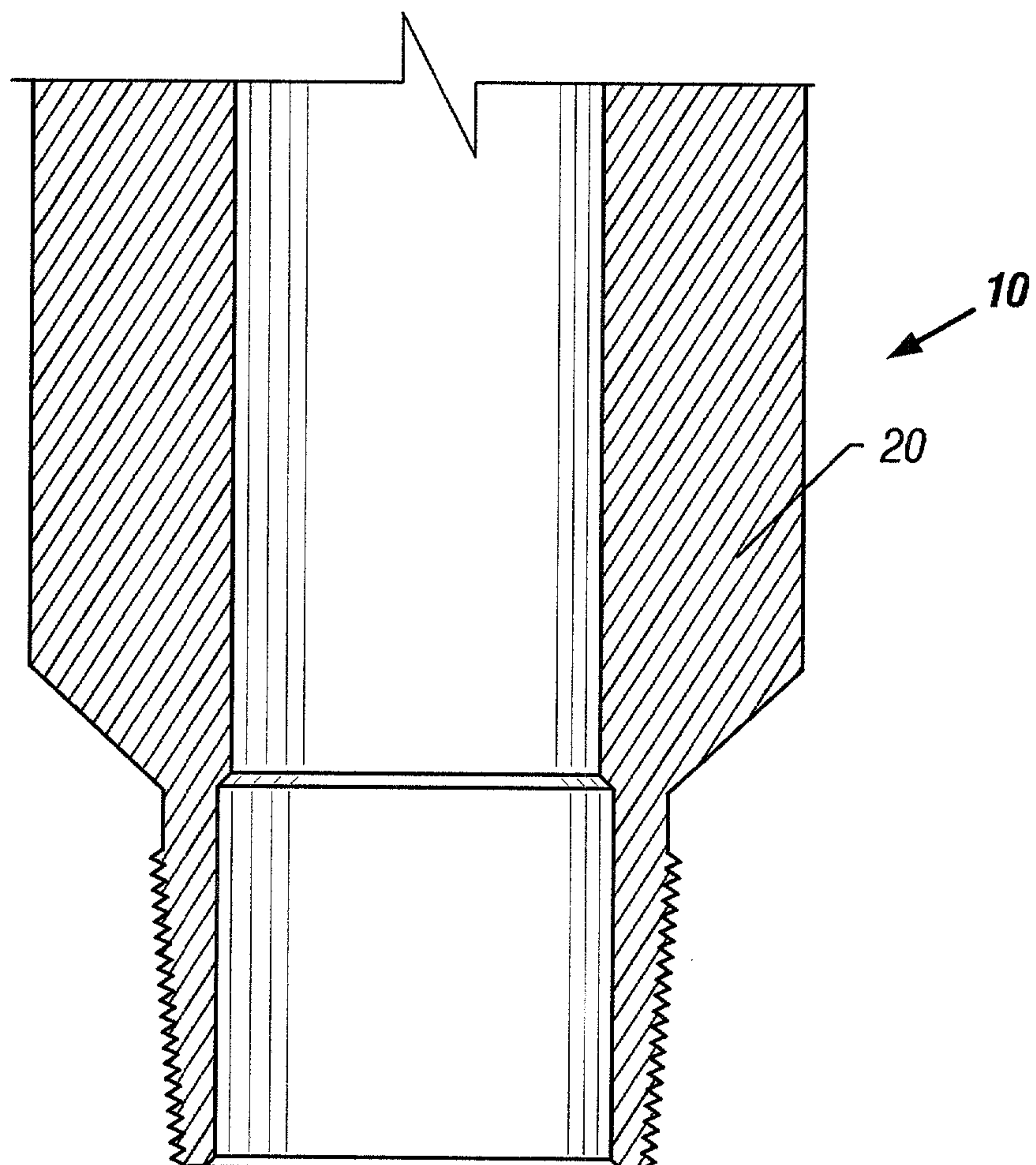


FIG. 1J

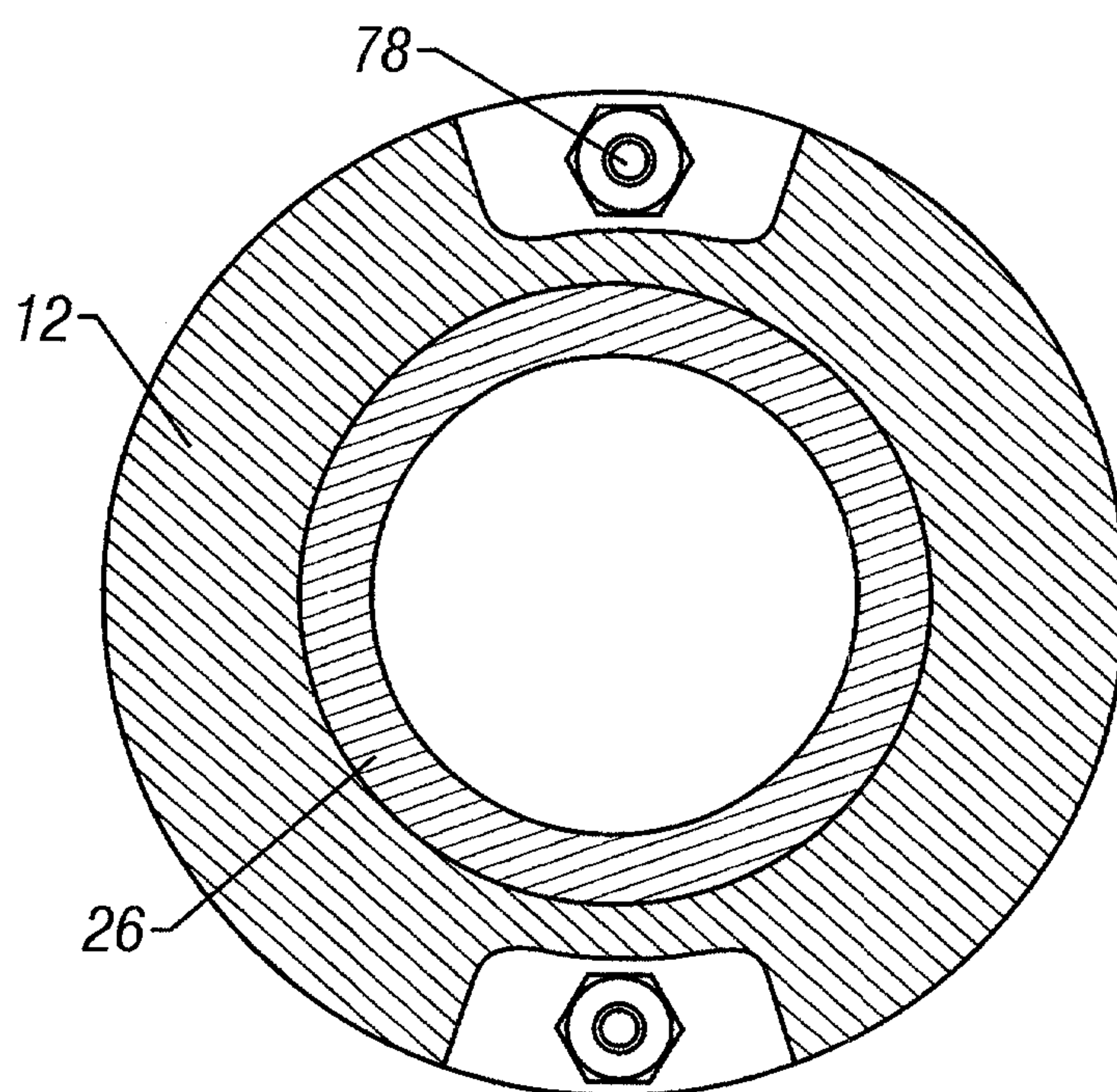


FIG. 2

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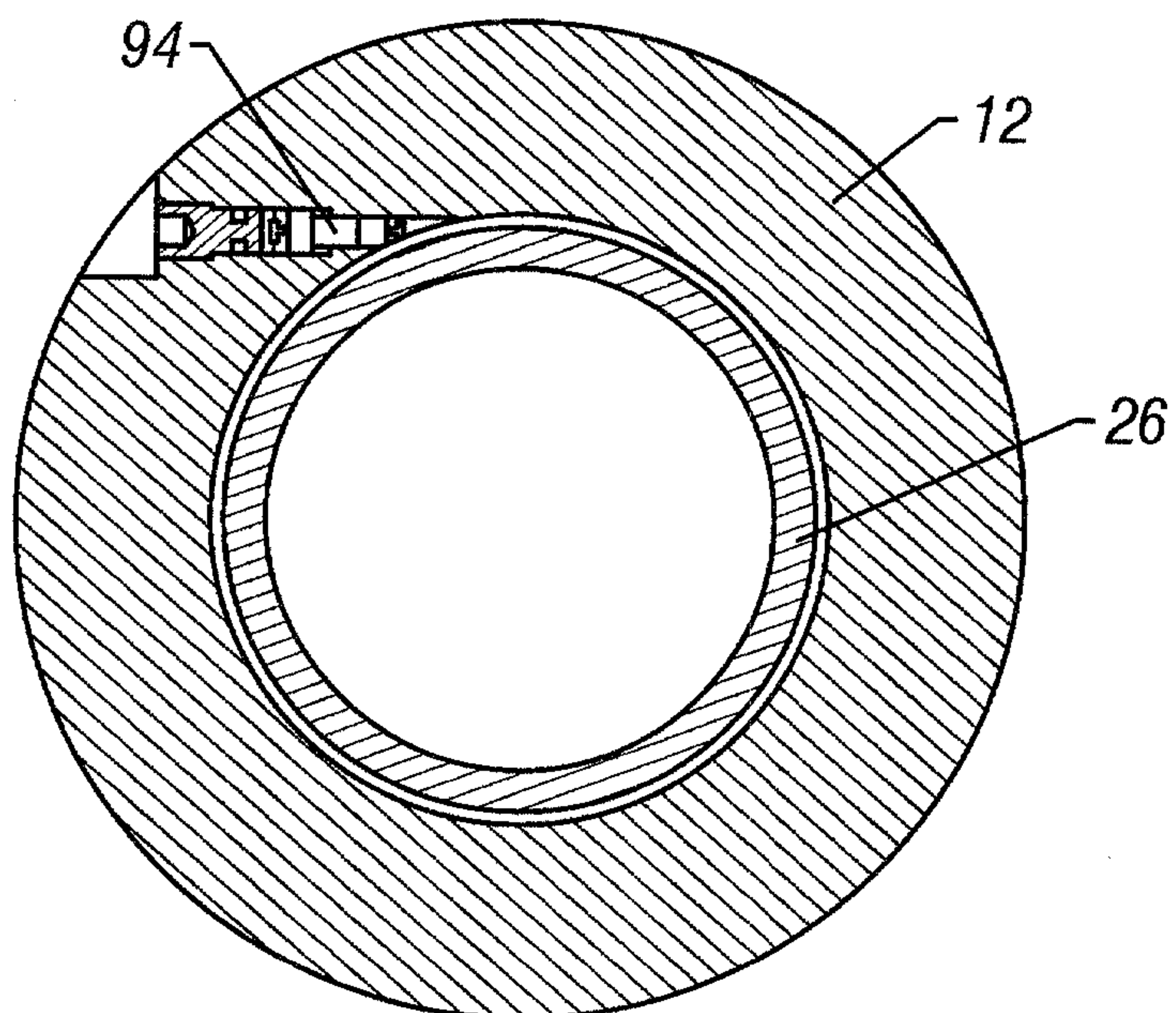


FIG. 3

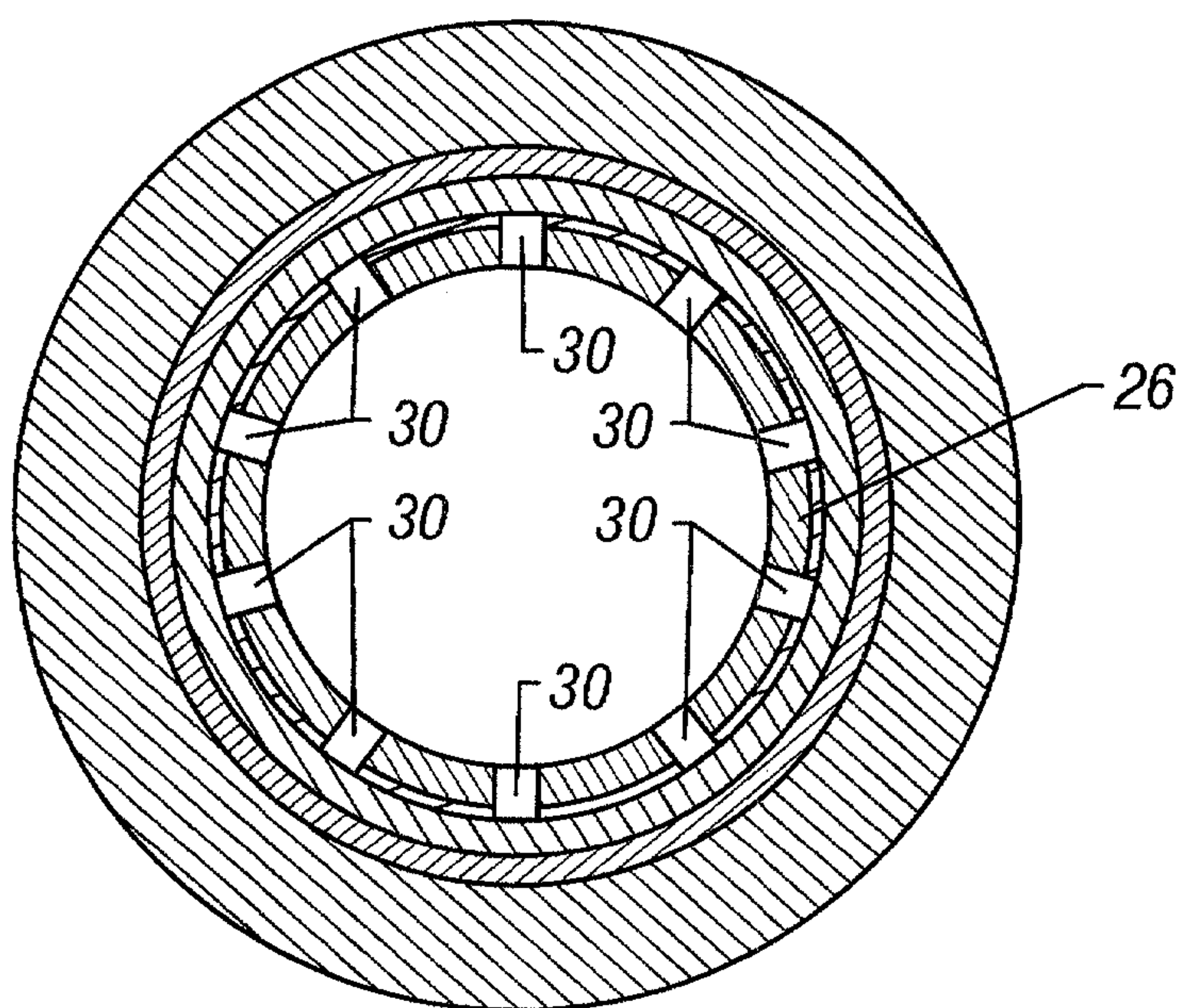


FIG. 4

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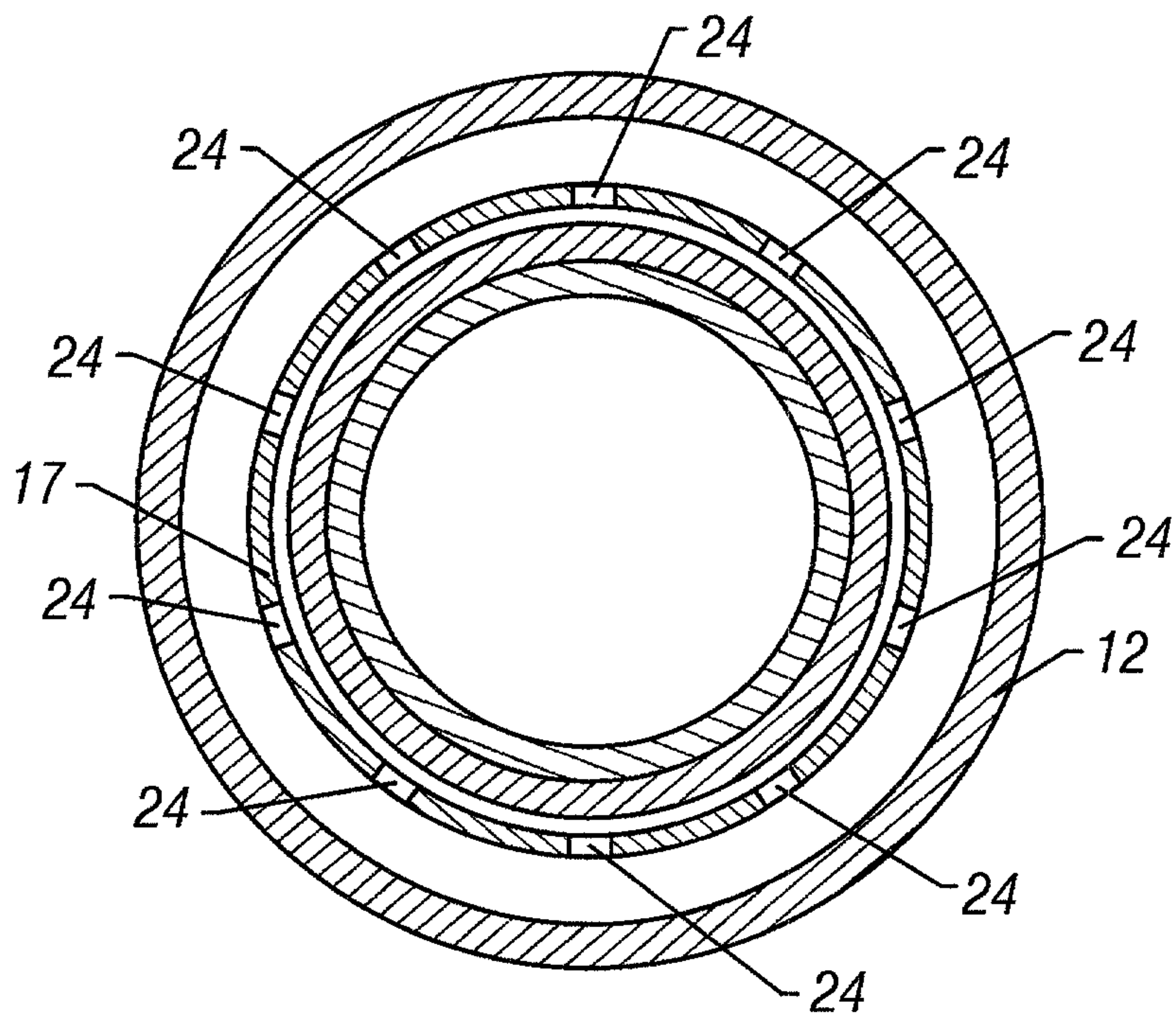


FIG. 5

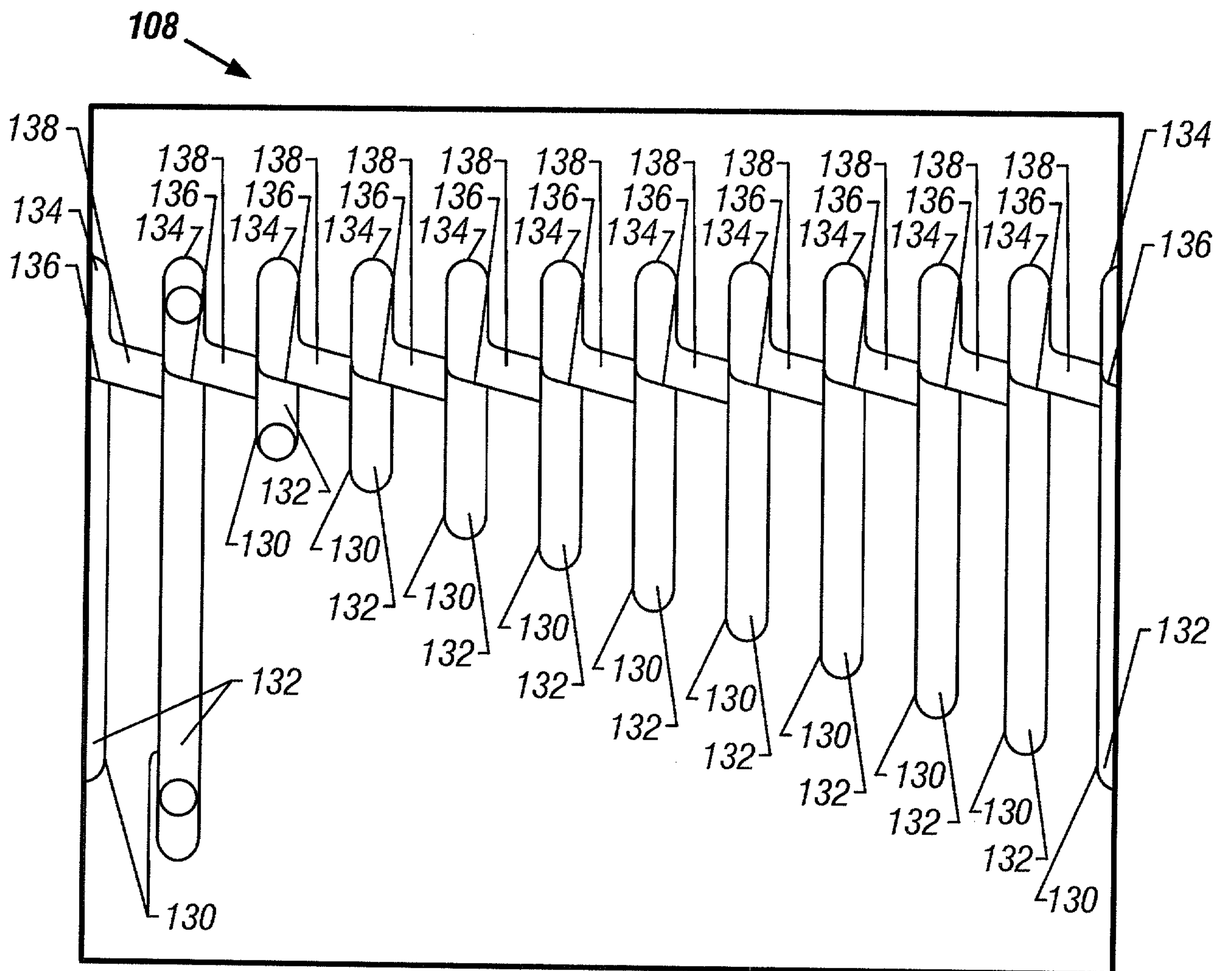


FIG. 6

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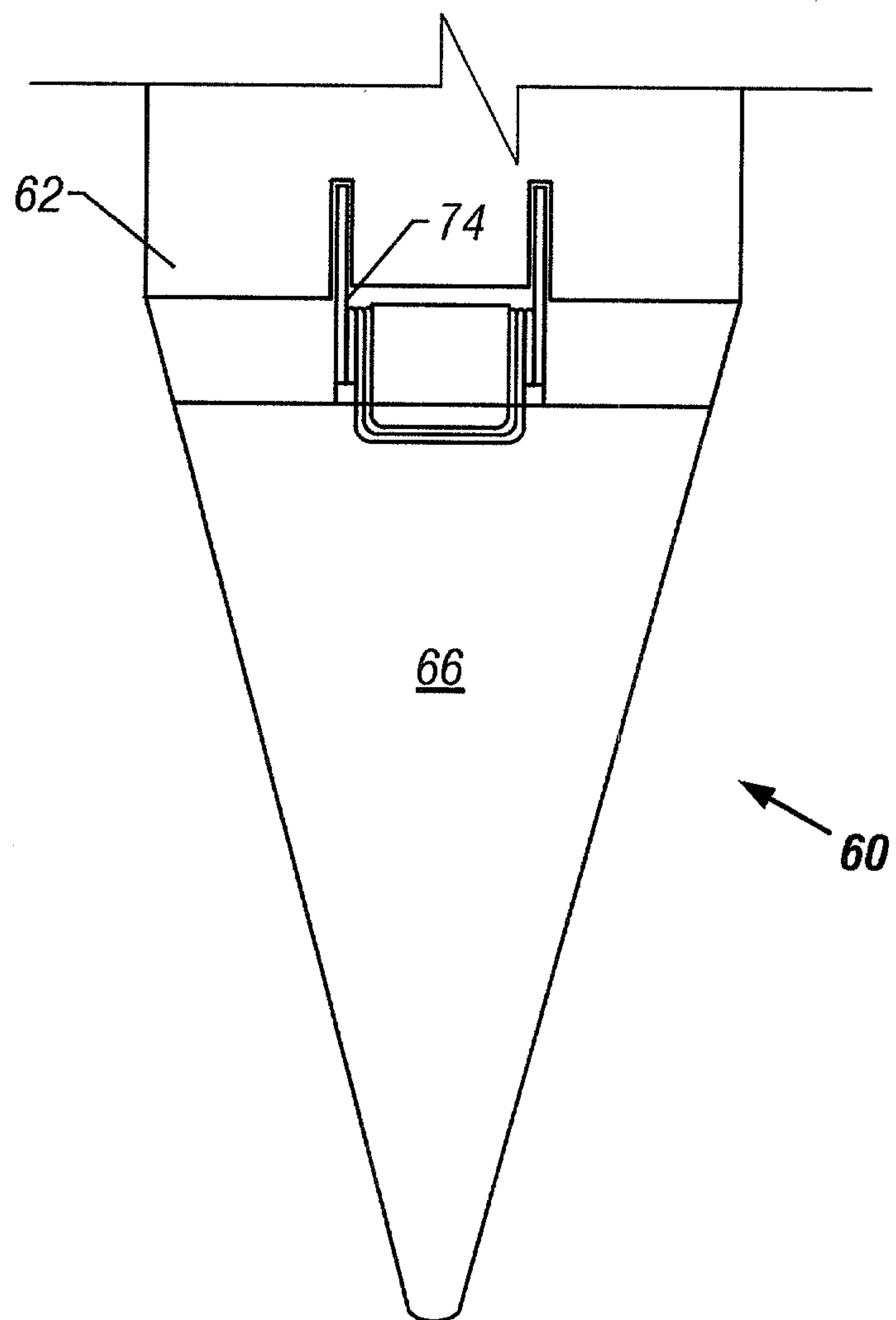


FIG. 7

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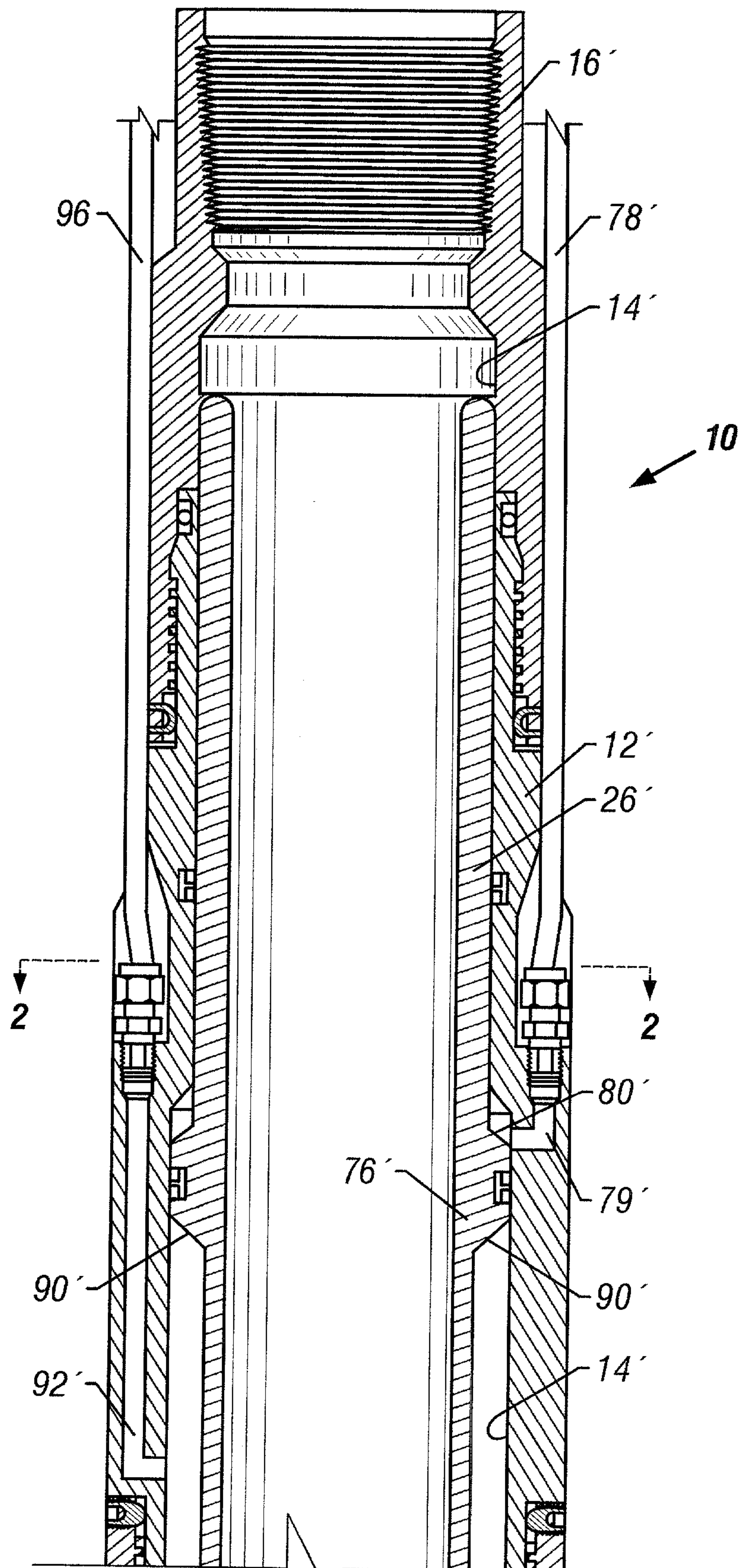


FIG. 8

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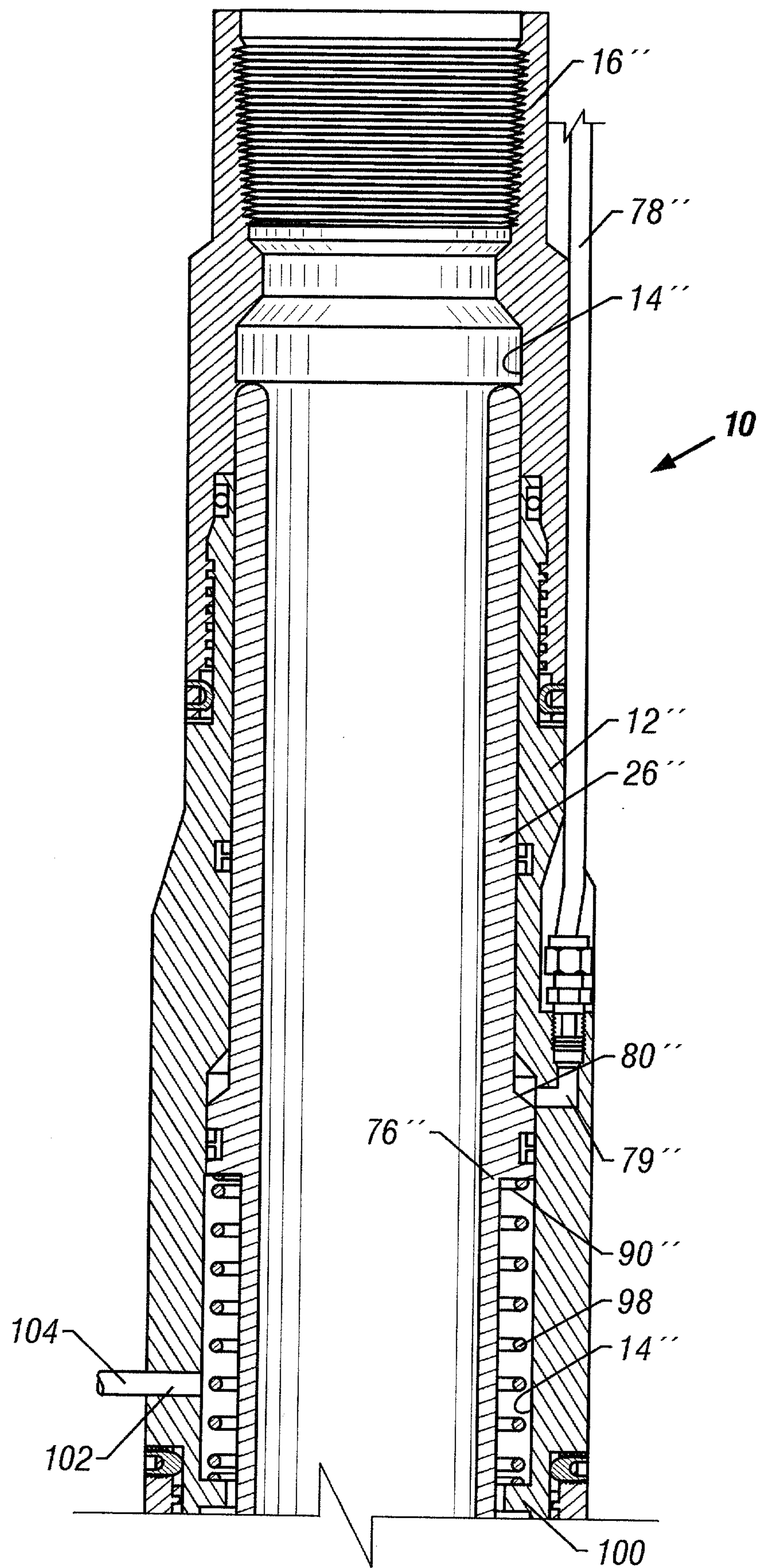


FIG. 9

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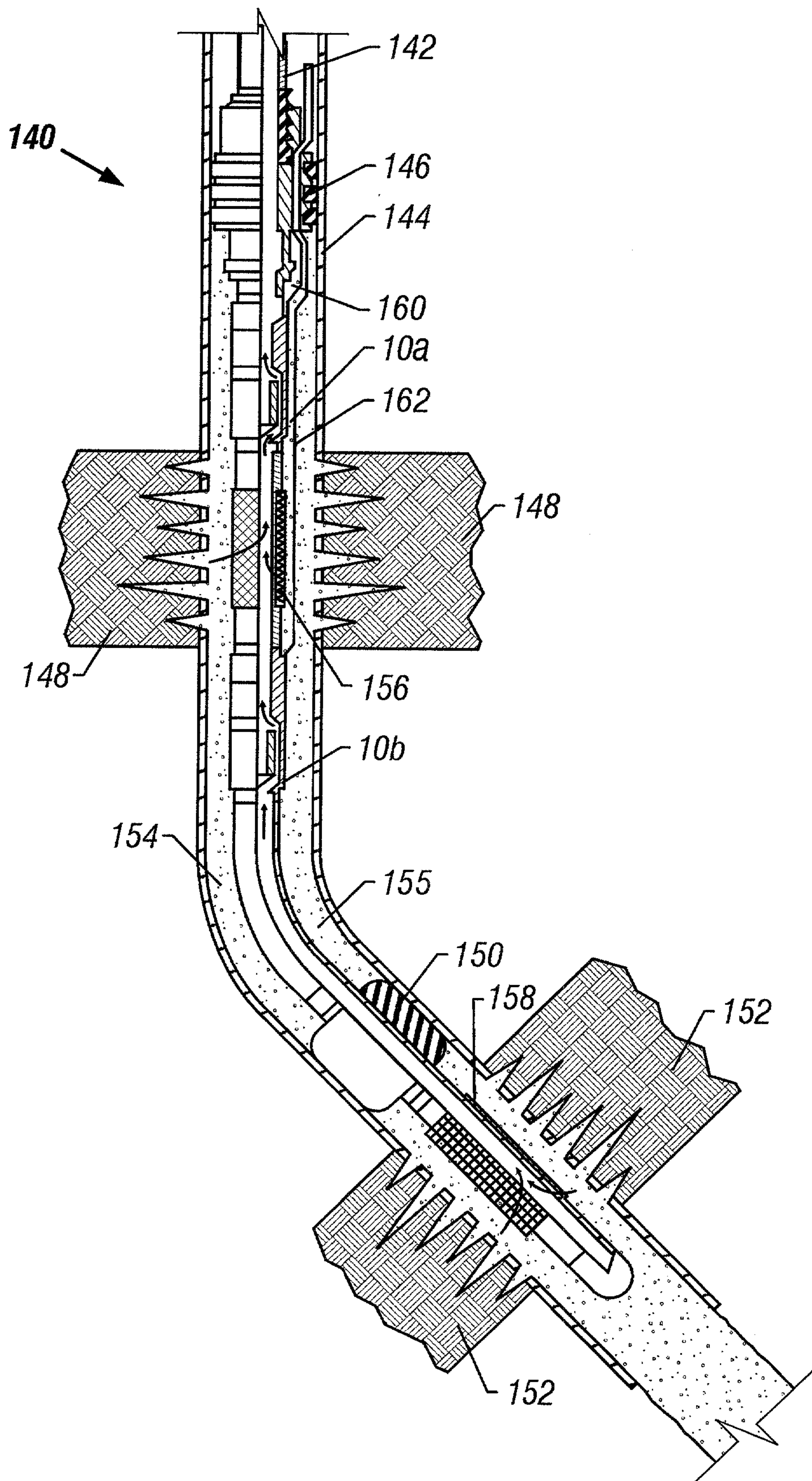


FIG. 10

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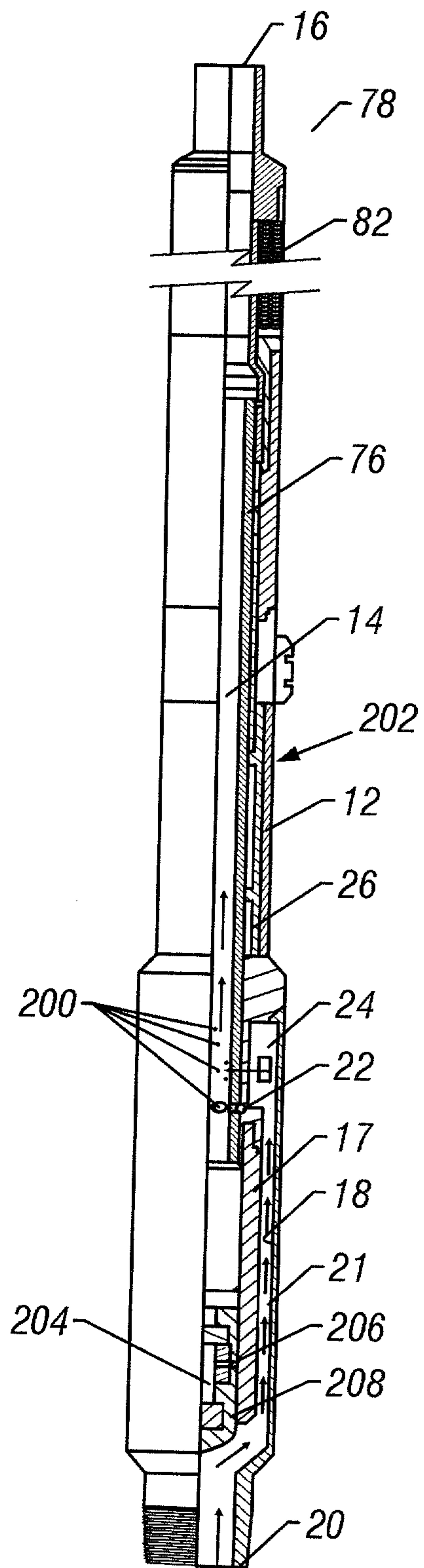


FIG. 11

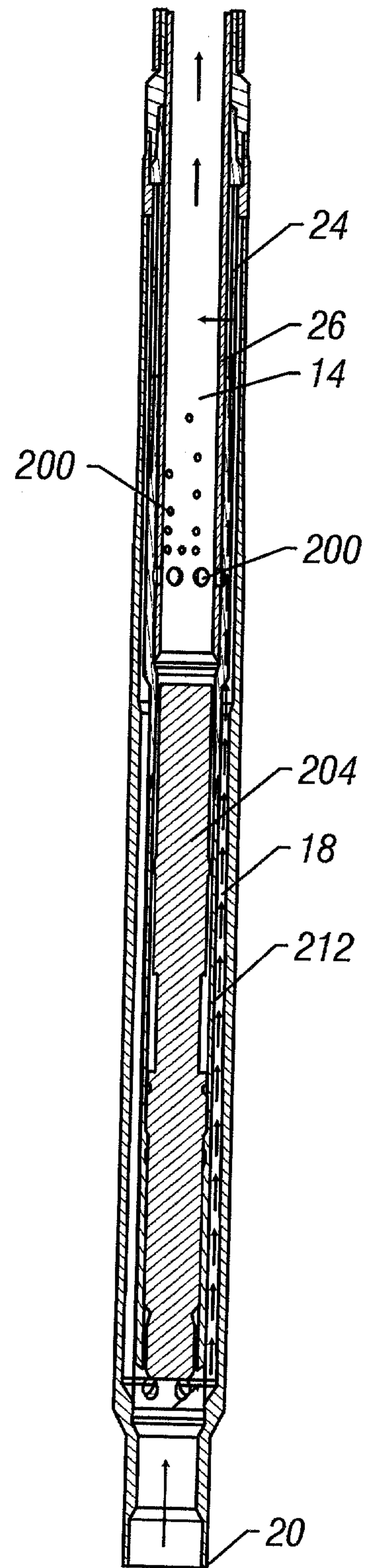


FIG. 12

