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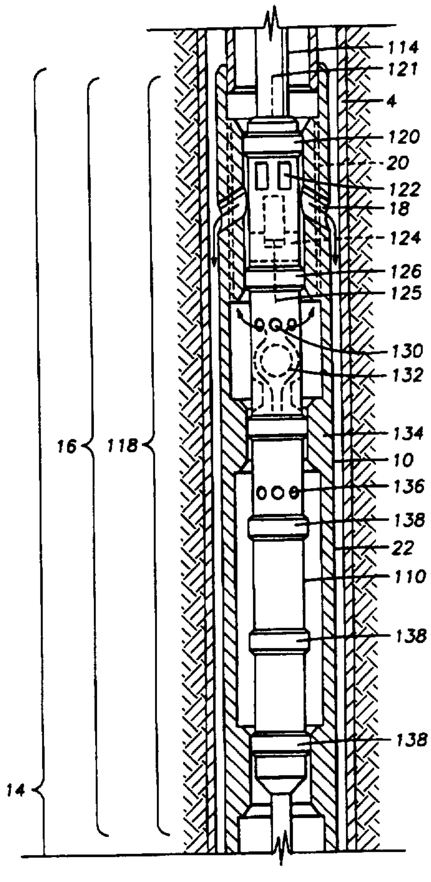
(54) Title: HIGH-RATE MULTIZONE GRAVEL PACK SYSTEM

(57) Abstract

A high-rate multizone gravel pack system is provided comprising an internal bypass assembly (118) carried on an inner equipment string (110) and an external bypass assembly (16) connected to an outer equipment string (10). During the gravel packing process the gravel slurry flows down an upper wash pipe (114), via outlet ports (122) of the internal bypass (118) and exit ports (18) of the external bypass into the annulus between outer equipment string (10) and casing (4). The carrier fluid returns through a prepack screen, a lower washpipe, via check valve (132) and outlet ports (130) into return channels of the external bypass assembly, and further into the annulus between inner and outer equipment strings (110, 10). The inner equipment string (110) with the inner bypass assembly (118) is repositioned within a second outer bypass assembly for gravel packing a second production zone. Formation pressure and lower wash pipe temperature are measured by probe (125) and the data stored in a retrievable memory gauge (124) for being downloaded to a surface computer system upon retrieval of the gauge for analysis of downhole conditions.



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HIGH-RATE MULTIZONE GRAVEL PACK SYSTEM

FIELD OF THE INVENTION

The field of the invention is circulating fluids and gravel packing formations in well bores.

BACKGROUND OF THE INVENTION

Gravel packing of a well is a recognized technique for preparing a formation for production and for improving a well's production characteristics. Gravel packing is generally carried out by pumping gravel-containing fluid down into the zone of the formation to be treated and filtering the returning fluid to insure that the gravel is deposited in the desired zone. The goal of gravel packing is to force gravel out of the well casing and into the producing formation. However, the gravel-containing fluid must be pumped through the interior of the down hole equipment string to prevent losses and contamination between the surface and the desired zone. At some point, it is necessary to use a bypass tool to switch the flow of gravel-containing fluid from the interior of the equipment string to the exterior of the string so that the fluid may be used to gravel pack the formation. The bypass tool must direct the downward-traveling fluid outward, and simultaneously direct the upward-traveling return fluid from the interior of the equipment string to the exterior for the return trip to the surface.

Current bypass tools restrict the maximum rate of flow to about fifteen barrels per minute. This restriction is caused by the fluid pathway used to exchange the positions of the fluid streams. The downward-flowing path requires a series of sharp turns which causes flow rate losses and subjects the tool to relatively high rates of erosion. This series of turns usually entails at least four right-angle turns to redirect the gravel bearing fluid from the tool's interior to its exterior. Because of this flow rate restriction, the pressure that can be used to gravel pack a formation is restricted. However, it is desirable in some cases to provide a gravel packing flow rate in excess of twenty barrels per minute or more to maintain higher gravel packing pressures. These higher pressures would allow gravel to be forced further into formation fractures, improving well production rates.

It is therefore desirable to have a bypass tool that allows higher flow rates, and accordingly higher treatment pressures, than present tools. This goal is accomplished by providing a tool which utilizes enlarged flow areas and direct exit ports to direct the flow of downward-traveling fluid from the interior to the exterior of the tool. In this way, the fluid is required to alter course only twice, rather than the usual four turns required by current bypass tools. Further, the amount of course alteration required by the slanted exit ports is substantially less than ninety degrees, resulting in greatly lessened flow rate losses compared to current bypass tools. The lower velocities for a given flow rate have the additional advantage of lessening erosion of the bypass tool.

A retrievable memory gauge is also provided to read pressure and temperature data during gravel packing. This gauge is designed to collect data without being disturbed by the fluid flow passing through the ports above the gauge.

A High-Rate Multizone Gravel Pack System is provided that allows significantly higher gravel packing flow rates for a tool of a given size than were previously available. This system includes a fluid bypass which greatly enhances flow rate and decreases damage to the bypass due to erosion compared to current tools. The system can be employed in a multi-stage arrangement which allows the gravel-packing of multiple production zones with a single trip into the well bore.

It is a goal of this invention to provide a bypass tool that incurs lower fluid pressure losses compared to present bypass tools.

It is a further goal of this invention to provide a bypass tool that allows higher gravel packing flow rates at a formation than are allowed by present bypass tools.

It is another goal of this invention to provide a bypass tool that is less subject to erosion than present bypass tools.

It is another goal of this invention to provide a multi-zone gravel packing system that allows gravel packing at high flow rates in multiple production zones with a single trip of the apparatus into the well bore.

It is another goal of this invention to provide a retrievable memory gauge capable of sensing and recording pressure and temperature during gravel packing without being disturbed by the fluid flow through the bypass tool.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1A-D is a partially cut away drawing of the High-Rate Multizone Gravel Pack System, showing the system in position to wash down a well bore.

Fig. 2A is a cut away side view of the external and internal bypass subassemblies showing flow paths in the circulating, or gravel packing, mode.

Fig. 2B is a cut away side view of an additional embodiment of the external and internal bypass subassemblies showing flow paths in the circulating, or gravel packing, mode.

Fig. 2C is a diagram of a prior art bypass tool, showing flow paths required to redirect flow from the interior to the exterior of the tool.

Fig. 3A-D is a partially cut away drawing of the High-Rate Multizone Gravel Pack System, showing the system in position to gravel pack a bottom zone.

Fig. 4A-D is a partially cut away drawing of the High-Rate Multizone Gravel Pack System, showing the system in position to reverse flow after gravel packing a bottom zone.

Fig. 5A-D is a partially cut away drawing of the High-Rate Multizone Gravel Pack System, showing the system in position to gravel pack an upper zone.

Fig. 6A-D is a partially cut away drawing of the High-Rate Multizone Gravel Pack System, showing the system in position to reverse flow after gravel packing an upper zone.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring to **Fig. 1A-D**, one embodiment of the High-Rate Multizone Gravel Pack System is shown. The High-Rate Multizone Gravel Pack System comprises an outer equipment string **10** and an inner equipment string **110**. The outer equipment string **10** comprises an upper packer **12**, such as Baker Model 'SC-9' (Product No. 488-20), circulation stages **14**, such as Baker S-22B Anchor Latch Seal Assembly, and a sump packer **40**, such as Baker Model 'D' (Product No. 415-13).

The High-Rate Multizone Gravel Pack System may have multiple circulation stages **14** in the outer equipment string **10** as shown in **Fig. 1A-D**. Each circulation stage **14** comprises an external bypass subassembly **16**, such as Baker Product No. 469-10, and pre-pack screens **30**, such as Baker Product No. 486-19. Each circulation stage **14** except for the bottom-most circulation stage **15** also comprises an isolation package **31**. The isolation package **31** comprises an upper seal bore **32**, such as Baker Product No. 485-34, an isolation packer **34**, such as Baker Product No. 488-03, and a lower seal bore **36**, such as Baker Product No. 485-34. Additionally, the upper-most circulation stage **13** comprises a knock out isolation valve **26**, such as Baker Product No. 487-35.

The inner equipment string **110** comprises a setting tool **112**, such as Baker Model 'SC' (Product No. 445-21), an upper wash pipe **114**, an indicating collet **116**, such as Baker Model 'A' (Product No. 445-34), an internal bypass subassembly **118**, and a lower wash pipe **140**.

Referring to **Fig. 2A**, the external bypass subassembly **16** and internal bypass subassembly **118** are shown in detail. The external bypass subassembly **16** comprises high-rate exit ports **18**, return channels **20**, and a bypass extension **22**. The internal bypass subassembly **118** comprises a first seal ring **120**, an inner fluid pathway **121**, first outlet ports **122**, a memory gauge/landing assembly **124**, a probe **125**, a second seal ring **126**, second outlet ports **130**, a low bottom hole pressure check valve **132**, a third seal ring **134**, bypass **136**, and lower seal rings **138**.

This preferred embodiment provides a large improvement over the prior art in cross-sectional area of the inner fluid pathway and accordingly allows much lower flow velocities. For example, a prior art bypass tool with a four-inch outside diameter ("OD") has an inner fluid pathway with a cross-sectional area of 1.77 square inches, or approximately 14% of the total cross-sectional area (12.56 square inches) of the inner bypass subassembly. The configuration of the present invention for a four-inch OD tool allows an inner fluid pathway with a cross-sectional area of 7.07 square inches, or approximately 56% of the cross-sectional area of the inner bypass subassembly. The following table shows comparisons of prior art tools of several OD sizes with the same-sized inner bypass subassemblies of the present invention:

Tool OD	Tool XSA	Prior art XSA	Prior art %	New XSA	New %
4	12.56	1.77	14	7.07	56
4.75	17.72	2.75	16	7.07	40
6	28.27	4.01	14	18.65	66

In the above table, internal bypass subassembly OD's are stated in inches, XSA stands for "cross-sectional area," cross-sectional areas are stated in square inches, the percentages are calculated by dividing the number in the corresponding "XSA" column by the corresponding number in the "Tool XSA" column, and the columns "New XSA" and "New %" represent values for bypass tools of the present invention.

An alternative configuration of the present invention is shown in **Fig. 2B**. This configuration provides an external bypass subassembly **16**, an internal bypass subassembly **118**, inner fluid pathway **121**, high rate exit ports **18**, and return channels **20**. Because the return channels **20** are not located in the external bypass subassembly **16**, the cross-sectional area of the inner fluid pathway **121** is not as large as in the preferred embodiment described above. However, this configuration would be useful when working with formations where there are large fluid losses into the formation, while still providing a large improvement in flow velocity over the prior art. Unless there are large fluid losses into the formation, this configuration would experience increased backpressure.

In contrast to the above described configurations, referring to **Fig. 2C**, a prior art bypass tool is shown. There, the upward-flowing fluid return channels **214** are in the same portion of the tool as the downward-flowing fluid channels **210**. This prior art design requires dividing the tool's cross-sectional area between downward- and upward-flowing channels. In the preferred embodiment of the present invention, positioning the return channels **20** in the external bypass subassembly **16** allows greater downward flow area in the internal bypass subassembly **118**. Further, in the prior art design shown in **Fig. 2C**, the downward-flowing fluid pathway **210** requires a series of four right-angle turns **212** to redirect the liquid flow from the interior to the exterior of the tool. This reduced area pathway results in substantially higher pressure losses and greater tool erosion than does the design of the present invention.

Referring again to **Fig. 1A-D**, one embodiment of the High-Rate Multizone Gravel Pack System is shown in position to wash down a well bore **2**. The well bore **2** comprises a casing **4** with perforations **6** into production zones **8**. The sump packer **40** is set by conventional methods, either by electric line or mechanical setting tools.

The outer equipment string **10** is disconnected from the sump packer **40**, and the outer equipment string **10** and the inner equipment string **110** are lowered into position using the setting tool **112**. The upper packer **12** and the isolation packers **34** on the circulation stages **14** are not set at this point, providing a fluid flow path in the annulus between the casing **4** and the outer equipment string **10**. Fluid is pumped down the inner equipment string **110**, passing through the upper wash pipe **114** and into the inner fluid pathway **121** of the internal bypass subassembly **118**. The internal by-bass subassembly **118** is positioned so that the first seal ring **120** and the lower seal rings **138** form seals with the bypass extension **22**. Fluid flows out of the inner fluid pathway **121** through the first outlet ports **122**, through the annulus between the internal bypass subassembly **118** and the bypass extension **22**, into the bypass **136**, then through the lower wash pipe **140**. The fluid exits the bottom of the lower wash pipe **140** and returns to the surface through the annulus between the casing **4** and the outer equipment string **10**. The fluid is prevented from flowing upward in the annulus between the outer equipment string **10** and the inner equipment string **110** by the seal formed between the lower seal rings **138** of the internal bypass subassembly **118** and the bypass extension **22**.

After the wash-down phase depicted in **Fig. 1A-D** is completed, the upper packer **12** and each isolation packer **34** are set. The upper packer **12** can be set by the hydraulic setting tool **112**. This is usually accomplished by dropping a ball or by pressuring up against the well bore **2**. Each isolation packer **34** is set by raising the inner equipment string **110** (using the setting tool **112**) into position so that the first seal ring **120** of the internal bypass subassembly **118** forms a seal within the respective upper seal bore **32** in the isolation package **31**, and the third seal ring **134** of the internal bypass subassembly **118** forms a seal within the respective lower seal bore **36** in the isolation package **31**. Fluid pressure can then be used by pumping fluid through the upper wash pipe **114**, the inner fluid pathway **121**, and the first outlet ports **122** of the internal bypass subassembly **118** to inflate and set the isolation packer **34**.

With the upper packer 12 and isolation packers 34 set, the High-Rate Multizone Gravel Pack System can be used to gravel pack the production zones **8**. Referring to **Fig. 3A-D** and **Fig. 5A-D**, the inner equipment string **110** is lowered to position in the desired circulation stage **14**. The indicating collet **116** identifies the proper position by indicating its contact with the next-higher circulation stage's **14** isolation packer **34**, or, in the case of the top-most circulation stage **13**, with the upper packer **12**. In this position, the internal bypass subassembly **118** is in the same position as is reflected in **Fig. 2**. In position for gravel packing, the first seal ring **120** of the internal bypass subassembly **118** forms a seal near the top of the external bypass subassembly **16**, but below the uppermost openings of the return channels **20**. The first outlet ports **122** are aligned with the high-rate exit ports **18**. The second seal ring **126** forms a seal with the external bypass subassembly **16** below the high-rate exit ports **18**. The second outlet ports **130** are positioned below the lowermost openings of the return channels **20**. The third seal ring **134** and the bottom-most of the lower seal rings **138** form seals with the bypass extension **22**.

Gravel packing is accomplished by pumping fluid containing the gravel packing material down through the upper wash pipe **114** and into the inner fluid pathway **121** of the internal bypass sub-assembly **118**. The fluid exits the inner fluid pathway **121** through the first outlet ports **122** and flows through the high-rate exit ports **18** of the external bypass subassembly **16**. The fluid then flows down through the annulus between the outer equipment string **10** and the casing **4** and is forced out of the casing **4** under pressure through the perforations **6** into the formation **8**. Fluid is prevented from flowing further down hole by the isolation packer **34** if the gravel packing opera tion is being carried out at any circulation stage **14** except the bottom-most circulation stage **15**, or by the sump packer **40** if the gravel packing is being carried out at the bottom-most circulation stage **15**. Fluid is therefore forced to return through the pre-pack screens **30**, which filter substantially all remaining gravel-packing material out of the fluid. The fluid flows up through the lower wash pipe **140** into the internal bypass subassembly **118**. The fluid flows upwards through the low bottom hole pressure check valve **132**, out the second outlet ports **130**, and into and through the return channels **20** of the external bypass subassembly **16**. After exiting the return channels **20**, the fluid continues to flow upward in the annulus between the inner equipment string **110** and the outer equipment string **10**.

On completion of the gravel packing operation, the High-Rate Multizone Gravel Pack System can also be configured to reverse flow and remove any excess gravel packing material. Referring to **Fig. 4A-D** and **Fig. 6A-D**, two embodiments of the reverse flow position are shown. The inner equipment string **110** is raised so that the third seal ring **134** engages and seals the high-rate exit ports **18** of the circulation stage **14** which was most recently used for gravel packing operations. Fluid is pumped down hole in the annulus between the casing **4** and the inner equipment string **110**. The upper packer **12** seals the annulus between the casing **4** and the outer equipment string **10**, so that the fluid flows into the annulus between the inner equipment string **110** and the outer equipment string **10**. The fluid is prevented from flowing beyond the third seal ring **134**, and is forced into the inner equipment string **110** through the first outlet ports **122**. The fluid then flows into and through the upper wash pipe **114** to return to the surface.

The above steps can be repeated for each circulation stage **14** which is placed in the well bore **2** by repositioning the inner equipment string **110**, so that each production zone **8** may be gravel packed with a single trip of the inner equipment string **110** into the well bore **2**. When the last production zone **8** is gravel packed and the inner equipment string **110** is lifted out of the well bore **2**, the knock-out isolation valve **26** in the upper-most circulation stage **14** closes, preventing the backwash of fluid from the inner equipment string **110** into the circulation stages **14**.

At all times during these procedures, the memory gauge/landing assembly **124** records the formation pressure and temperature in the lower wash pipe **140** by means of probe **125**. The probe **125** is place in a still location to sense formation pressure without interference from flowing liquid. This memory gauge/landing assembly **124** can be re-trieved and re-inserted into the internal bypass subassembly **118** at any time during the procedures. When the memory gauge/landing assembly **124** is retrieved, the data stored therein can be downloaded to a computer system for analysis of downhole conditions.

Many modifications and variations may be made in the embodiments described herein and depicted in the accompanying drawings without departing from the concept of the present invention. Accordingly, it is understood that the embodiments described and illustrated herein are illustrative only and are not intended as a limitation upon the scope of this invention.

CLAIMS:

1. A method of gravel packing a formation comprising the steps of:

inserting a bypass tool comprising an internal bypass subassembly and an external bypass subassembly into a well bore, wherein said internal bypass subassembly comprises an inner fluid pathway;

pumping gravel-bearing fluid into said inner fluid pathway;

diverting said gravel-bearing fluid from said inner fluid pathway to the exterior of said bypass tool through said external bypass subassembly and toward the formation by deflecting the direction of flow of said gravel-bearing fluid less than four times;

depositing gravel from said gravel-bearing fluid into a formation; and

returning said fluid to the surface.

2. The method of gravel packing a formation of claim 1, wherein said step of diverting said gravel-bearing fluid is accomplished by deflecting the direction of flow of said gravel-bearing fluid no more than two times.

3. The method of gravel packing a formation of claim 1, wherein said external bypass subassembly comprises at least one return channel, and wherein said step of returning said fluid to the surface is accomplished by routing said fluid through said return channel.

4. The method of gravel packing a formation of claim 2, wherein said external bypass subassembly comprises at least one return channel, and wherein said step of returning said fluid to the surface is accomplished by routing said fluid through said

return channel.

5. The method of gravel packing a formation of claim 1, additionally comprising the step of:

moving said internal bypass subassembly relative to said external bypass subassembly subsequent to said depositing step, wherein said movement of said internal bypass subassembly precludes fluid communication between said inner fluid pathway and the exterior of said external bypass subassembly;

providing fluid communication from said inner fluid pathway to the region above said bypass tool and exterior to said internal bypass subassembly;

pumping fluid through a wash pipe into said inner fluid pathway and into the region above said bypass tool and exterior to said internal bypass subassembly and up to the surface; and

removing excess gravel from the well bore.

6. The method of gravel packing a formation of claim 5, additionally comprising the steps of:

altering the position of said internal bypass subassembly within the well bore without removal of said internal bypass subassembly from the well bore; and

gravel packing at least one additional portion of the formation within the well bore.

7. The method of gravel packing a formation of claim 6, additionally comprising the step of:

protecting all sections of the well bore containing previously packed formations from fluid flow resulting from additional formation packing.

8. The method of gravel packing a formation of claim 2, additionally comprising the step of:

moving said internal bypass subassembly relative to said external bypass subassembly subsequent to said depositing step, wherein said movement of said internal bypass subassembly precludes fluid communication between said inner fluid pathway and the exterior of said external bypass subassembly;

providing fluid communication from said inner fluid pathway to the region above said bypass tool and exterior to said internal bypass subassembly;

pumping fluid through a wash pipe into said inner fluid pathway and into the region above said bypass tool and exterior to said internal bypass subassembly and up to the surface; and

removing excess gravel from the well bore.

9. The method of gravel packing a formation of claim 8, additionally comprising the steps of:

altering the position of said internal bypass subassembly within the well bore without removal of said internal bypass subassembly from the well bore; and

gravel packing at least one additional portion of the formation within the well bore.

10. The method of gravel packing a formation of claim 9, additionally com

prising the step of:

protecting all sections of the well bore containing previously packed formations from fluid flow resulting from additional formation packing.

11. The method of gravel packing a formation of claim 1, additionally comprising the steps of:

recording the fluid temperature and/or the formation pressure; and

retrieving the recorded temperature and/or pressure information at the surface.

12. The method of gravel packing a formation of claim 2, additionally comprising the steps of:

recording the fluid temperature and/or the formation pressure; and

retrieving the recorded temperature and/or pressure information at the surface.

13. The method of gravel packing a formation of claim 1, wherein said inner fluid pathway has a cross-sectional area at least forty percent as large as the total cross-sectional area of said internal bypass subassembly.

14. The method of gravel packing a formation of claim 2, wherein said inner fluid pathway has a cross-sectional area at least forty percent as large as the total cross-sectional area of said internal bypass subassembly.

15. The method of gravel packing a formation of claim 4, additionally com

prising the step of:

moving said internal bypass subassembly relative to said external bypass subassembly subsequent to said depositing step, wherein said movement of said internal bypass subassembly precludes fluid communication between said inner fluid pathway and the exterior of said external bypass subassembly;

providing fluid communication from said inner fluid pathway to the region above said bypass tool and exterior to said internal bypass subassembly;

pumping fluid through a wash pipe into said inner fluid pathway and into the region above said bypass tool and exterior to said internal bypass subassembly and up to the surface; and

removing excess gravel from the well bore.

16. The method of gravel packing a formation of claim 15, additionally comprising the steps of:

altering the position of said internal bypass subassembly within the well bore without removal of said internal bypass subassembly from the well bore; and

gravel packing at least one additional portion of the formation within the well bore.

17. The method of gravel packing a formation of claim 16, additionally comprising the step of:

protecting all sections of the well bore containing previously packed formations from fluid flow resulting from additional formation packing.

18. The method of gravel packing a formation of claim 17, additionally comprising the steps of:

recording the fluid temperature and/or the formation pressure; and

retrieving the recorded temperature and/or pressure information at the surface.

19. The method of gravel packing a formation of claim 18, wherein said inner fluid pathway has a cross-sectional area at least forty percent as large as the total cross-sectional area of said internal bypass subassembly.

20. A gravel packing apparatus for directing fluid flow from the surface to deposit gravel therewith into a well bore comprising:

an internal bypass subassembly and an outer equipment string, said internal bypass subassembly comprising an inner fluid pathway and at least one outlet port, said outer equipment string comprising a first external bypass subassembly, and said first external bypass subassembly comprising at least a first exit port;

wherein said internal bypass subassembly and said first external bypass subassembly are alignable to provide fluid communication from said inner fluid pathway through said outlet port and said first exit port to the exterior of said first external bypass subassembly; and

said first exit port is capable of deflecting fluid from said inner fluid pathway to the exterior of said first external bypass subassembly through fewer than four deflections.

21. The apparatus of claim 20, wherein said first exit port deflects the fluid

flow no more than twice.

22. The apparatus of claim 20, wherein said first external bypass subassembly additionally comprises at least a first return channel providing a fluid pathway for returning fluid moving back toward the surface after depositing the gravel.

23. The apparatus of claim 21, wherein said first external bypass subassembly additionally comprises at least a first return channel providing a fluid pathway for returning fluid moving back toward the surface after depositing the gravel.

24. The apparatus of claim 20, wherein said internal bypass subassembly additionally comprises:

a plurality of seals mounted on said internal bypass subassembly selectively positionable against the interior of said first external bypass subassembly, to selectively allow or prevent fluid flow through said first exit port.

25. The apparatus of claim 21, wherein said internal bypass subassembly additionally comprises:

a plurality of seals mounted on said internal bypass subassembly selectively positionable against the interior of said first external bypass subassembly, to selectively allow or prevent fluid flow through said first exit port.

26. The apparatus of claim 20 wherein said internal bypass subassembly additionally comprises a memory gauge/landing module capable of recording the formation pressure and/or the fluid temperature.

27. The apparatus of claim 26 wherein said memory gauge/landing module is retrievable to the surface without removing said internal bypass subassembly from the well bore.

28. The apparatus of claim 21 wherein said internal bypass subassembly additionally comprises a memory gauge/landing module capable of recording the formation pressure and/or the fluid temperature.

29. The apparatus of claim 28 wherein said memory gauge/landing module is retrievable to the surface without removing said internal bypass subassembly from the well bore.

30. The apparatus of claim 20 wherein said inner fluid pathway has a cross-sectional area of at least at least forty percent as large as the total cross-sectional area of said first internal bypass subassembly.

31. The apparatus of claim 21 wherein said inner fluid pathway has a cross-sectional area of at least at least forty percent as large as the total cross-sectional area of said first internal bypass subassembly.

32. The apparatus of claim 20 wherein said outer equipment string further comprises at least a second external bypass subassembly, wherein said second external bypass subassembly comprises at least a second exit port, and wherein said internal bypass subassembly may be aligned with said second external bypass subassembly to provide fluid communication from said inner fluid pathway through said outlet port and

said second exit port to the exterior of said second external bypass subassembly, and wherein said second exit port is capable of deflecting fluid from said inner fluid pathway to the exterior of said second external bypass subassembly through fewer than four deflections; and

at least one isolation packer mounted to said outer equipment string, wherein said isolation packer prevents fluid flow external to said outer equipment string from adjacent said second external bypass subassembly to and adjacent said first external bypass subassembly.

33. The apparatus of claim 32, wherein said second exit port deflects the fluid flow no more than twice.

34. The apparatus of claim 32, wherein said second external bypass subassembly additionally comprises at least a second return channel providing a fluid pathway for fluid returning toward the surface.

35. The apparatus of claim 33, wherein said second external bypass subassembly additionally comprises at least a second return channel providing a fluid pathway for fluid returning toward the surface.

36. The apparatus of claim 25, wherein said internal bypass subassembly additionally comprises:

a plurality of seals mounted on said internal bypass subassembly selectively positionable against the interior of said second external bypass subassembly, to selectively allow or prevent fluid flow through said second exit port.

37. The apparatus of claim 36 wherein said internal bypass subassembly additionally comprises a memory gauge/landing module capable of recording the formation pressure and/or the fluid temperature.

38. The apparatus of claim 37 wherein said memory gauge/landing module is retrievable to the surface without removing said internal bypass subassembly from the well bore.

39. The apparatus of claim 38 wherein said inner fluid pathway has a cross-sectional area of at least at least forty percent as large as the total cross-sectional area of said second internal bypass subassembly.

40. The apparatus of claim 23, wherein said internal bypass subassembly additionally comprises:

a plurality of seals mounted on said internal bypass subassembly selectively positionable against the interior of said first external bypass subassembly, to selectively allow or prevent fluid flow through said first exit port.

41. The apparatus of claim 40 wherein said internal bypass subassembly additionally comprises a memory gauge/landing module capable of recording the formation pressure and/or the fluid temperature.

42. The apparatus of claim 41 wherein said memory gauge/landing module is retrievable to the surface without removing said internal bypass subassembly from the

well bore.

43. The apparatus of claim 42 wherein said inner fluid pathway has a cross-sectional area of at least at least forty percent as large as the total cross-sectional area of said first internal bypass subassembly.

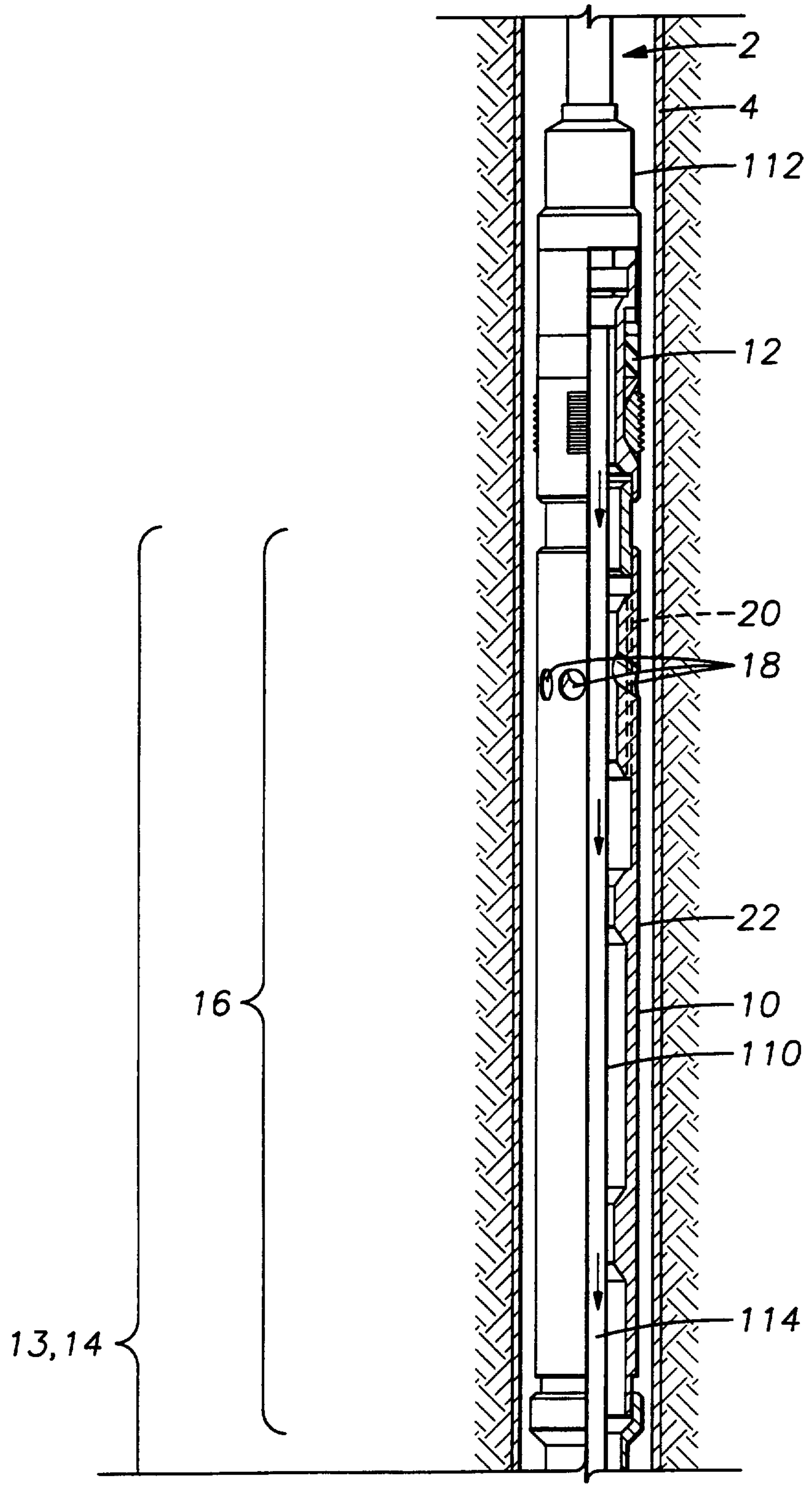

FIG. 1A

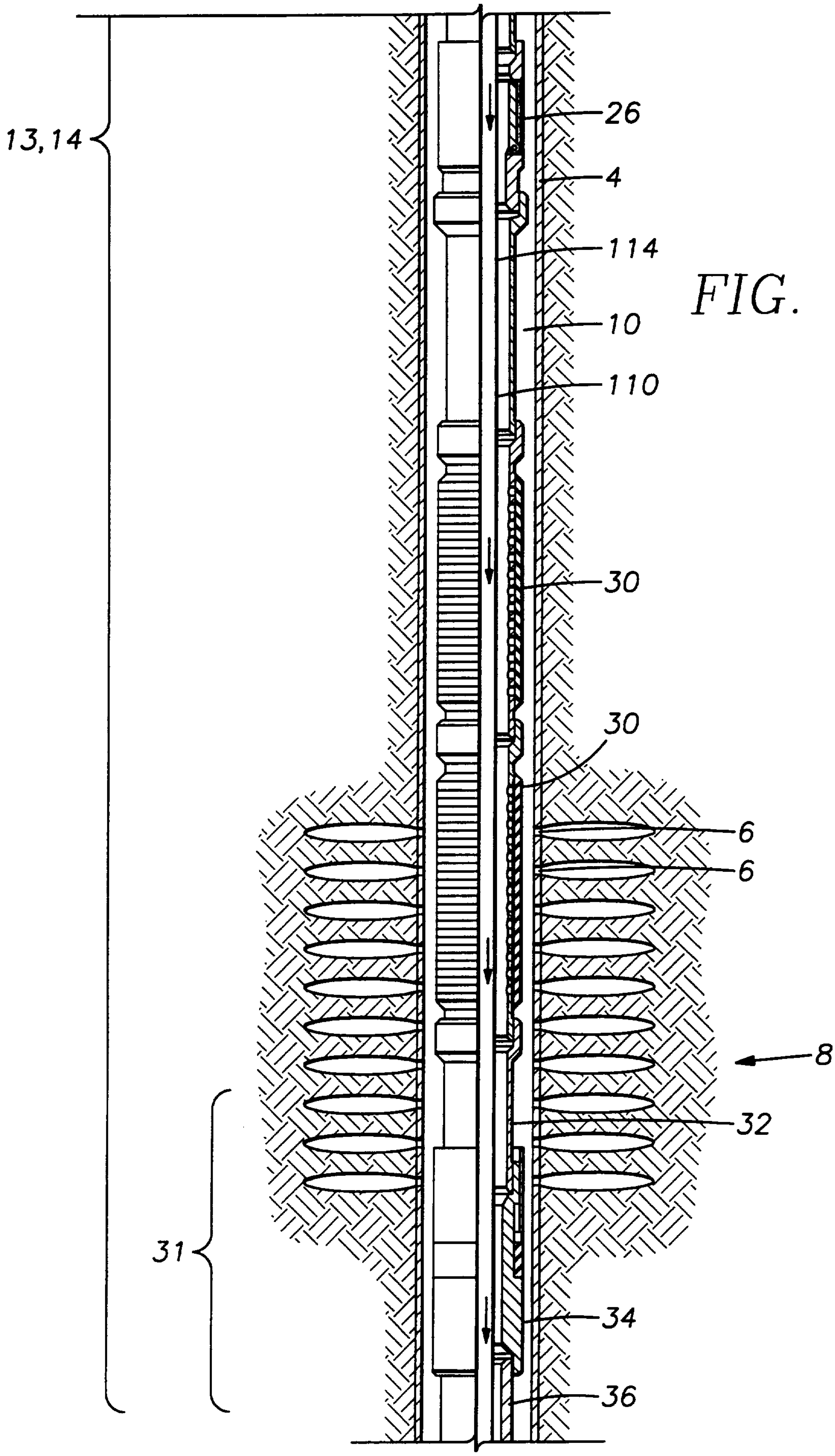

FIG. 1B

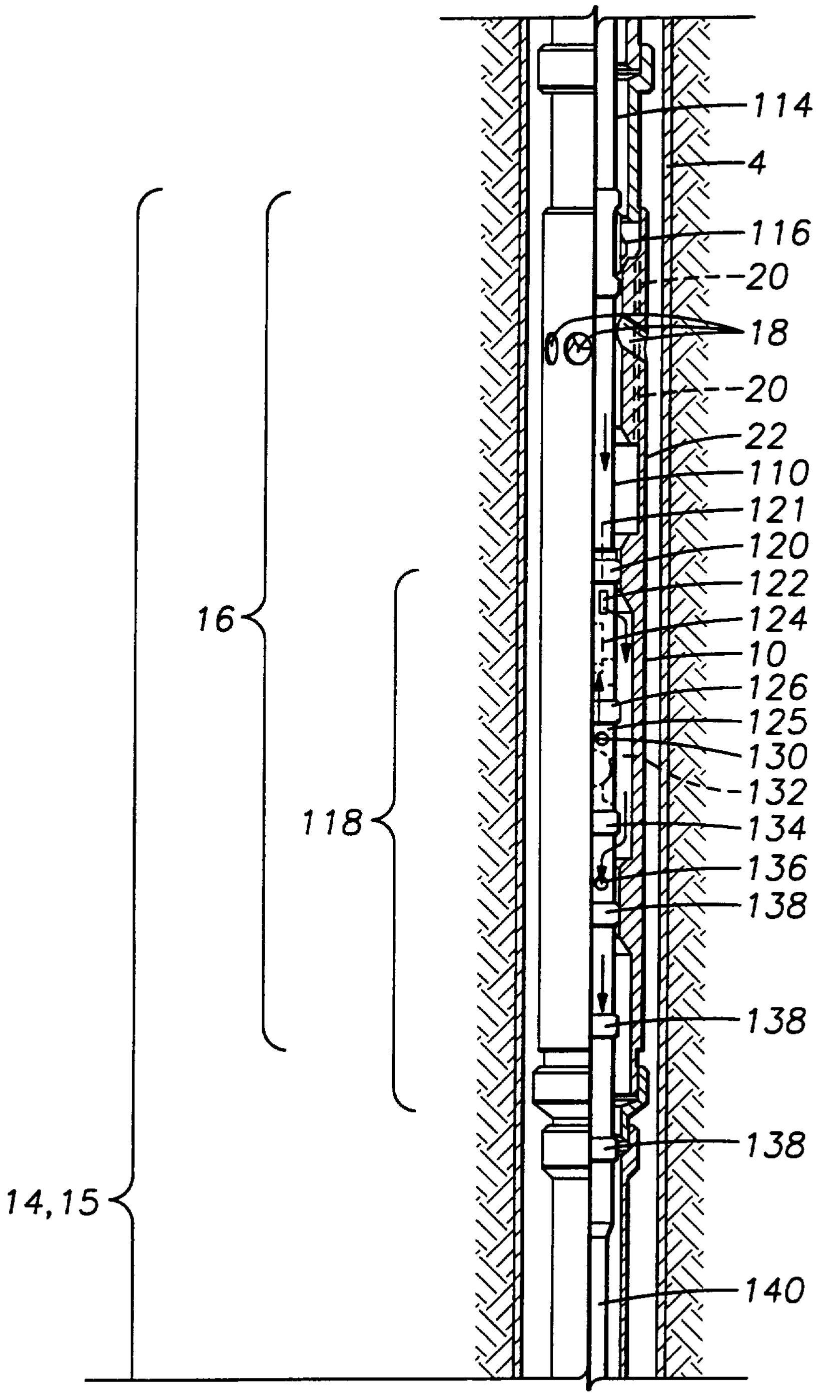
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FIG. 1C

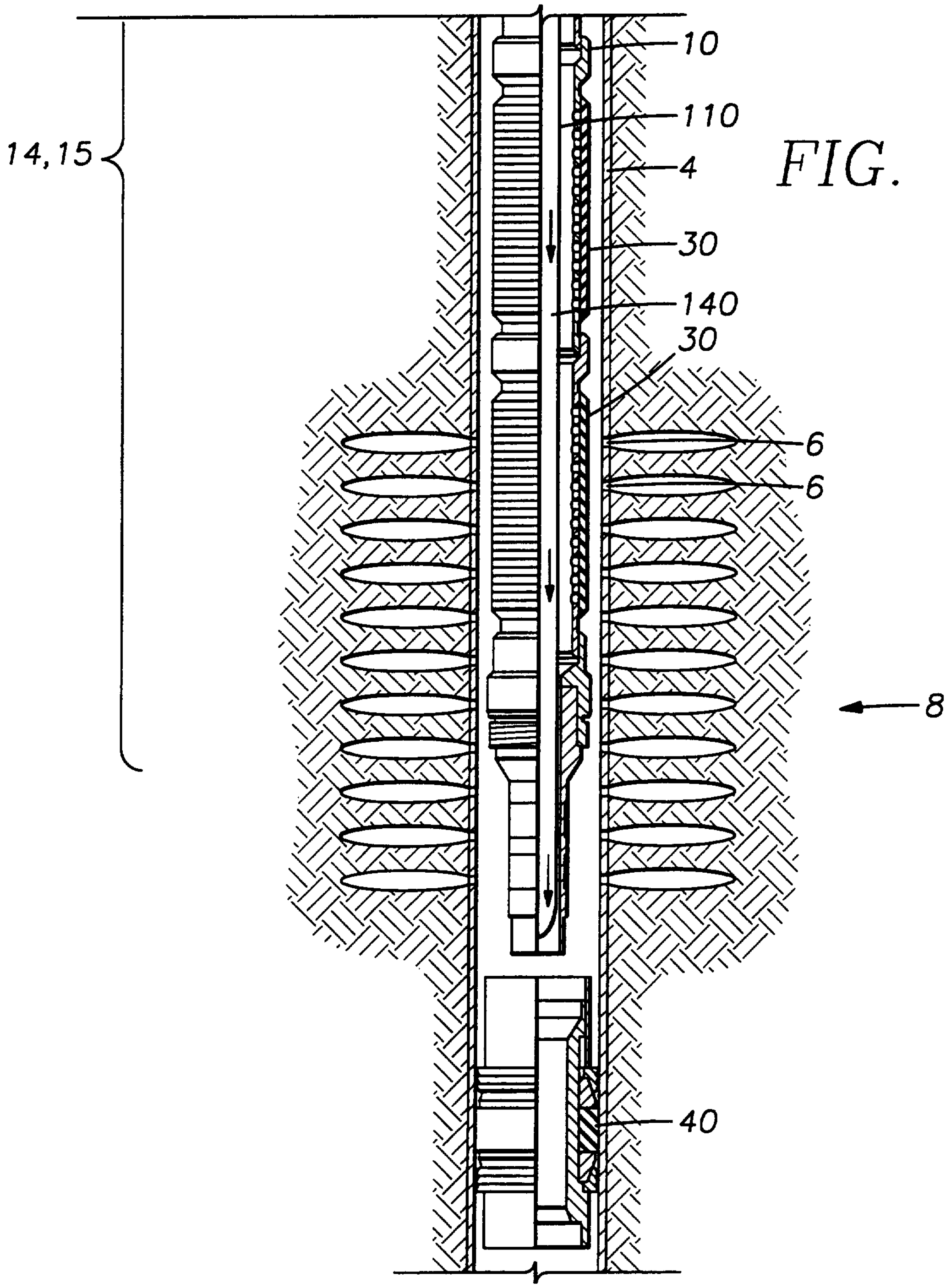

FIG. 1D

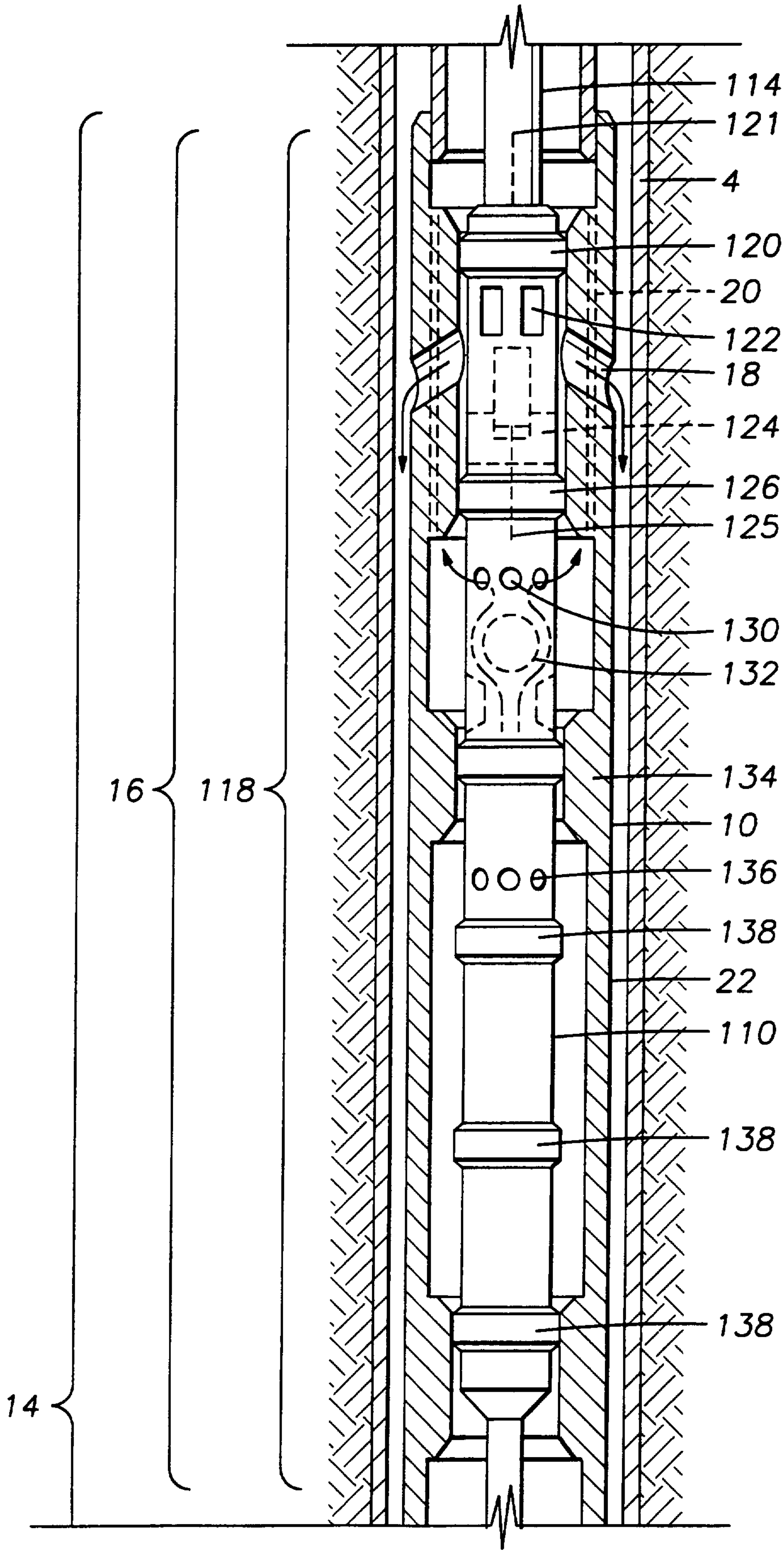
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FIG. 2A

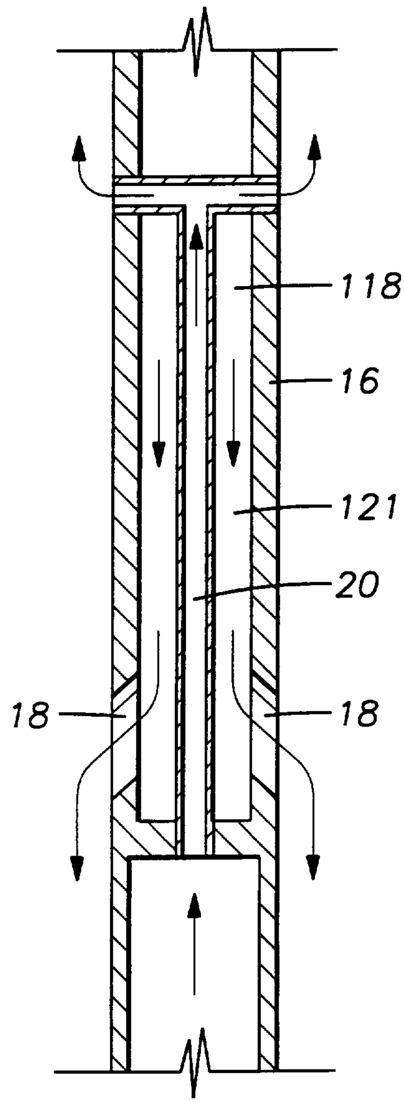

FIG. 2B

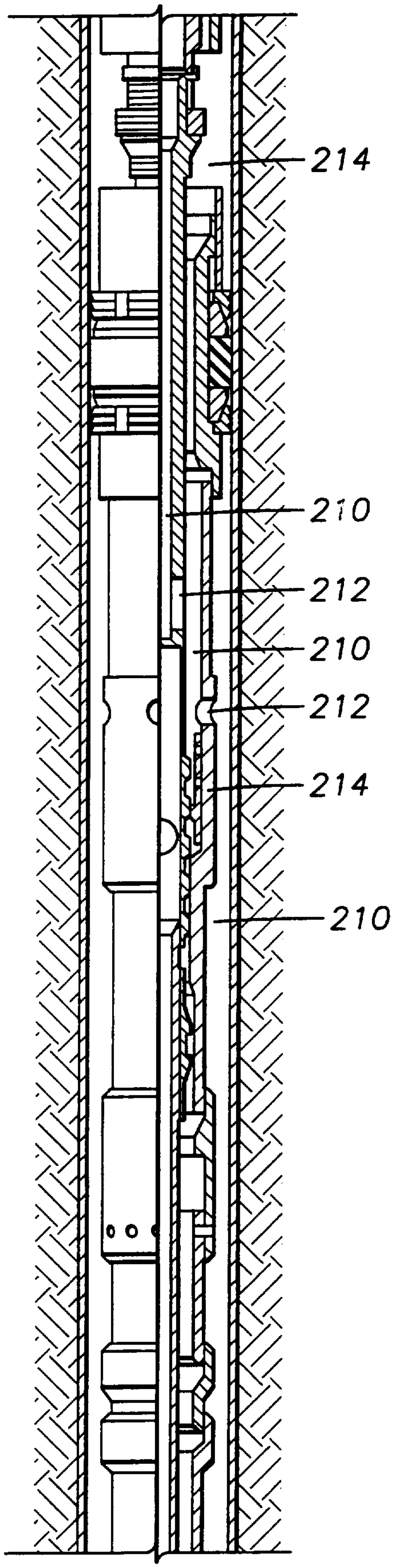

FIG. 2C

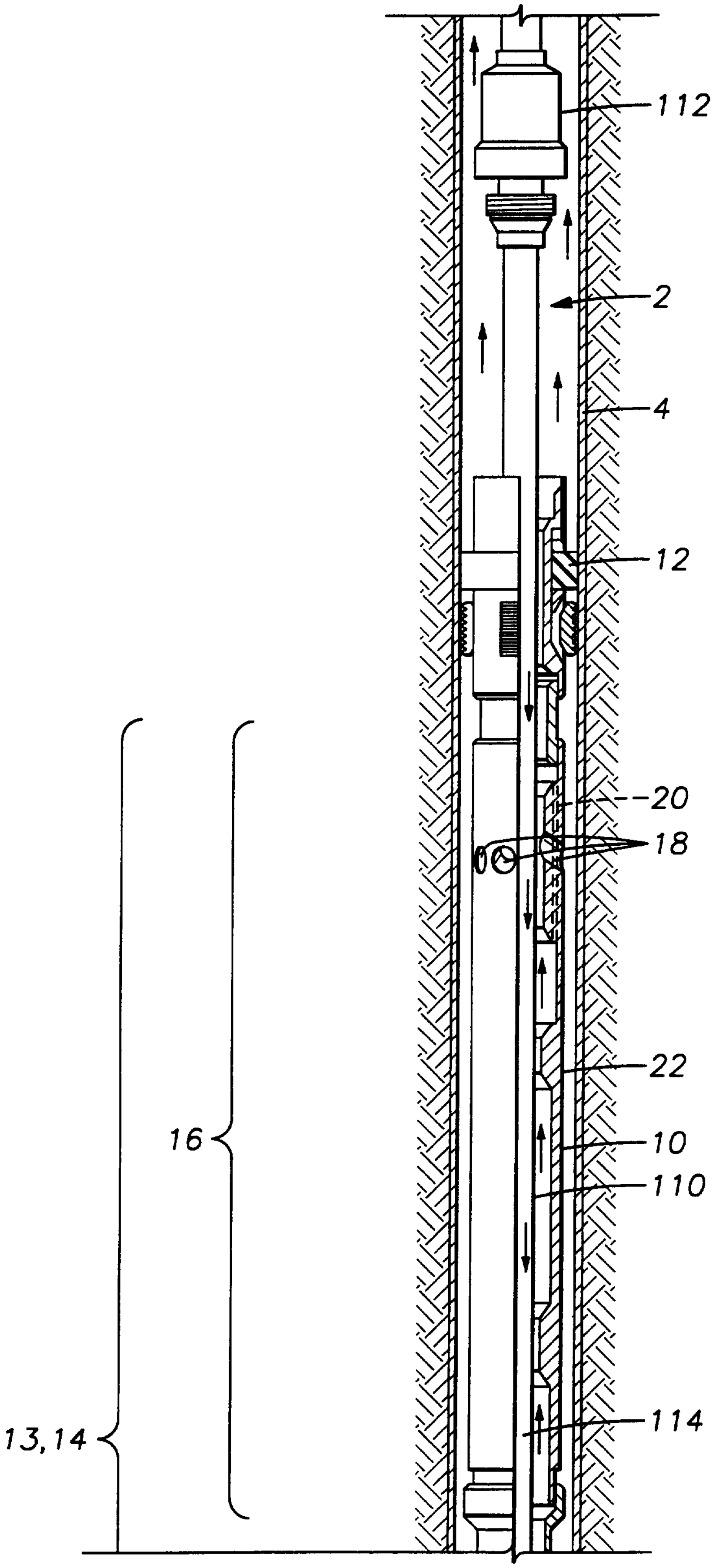

FIG. 3A

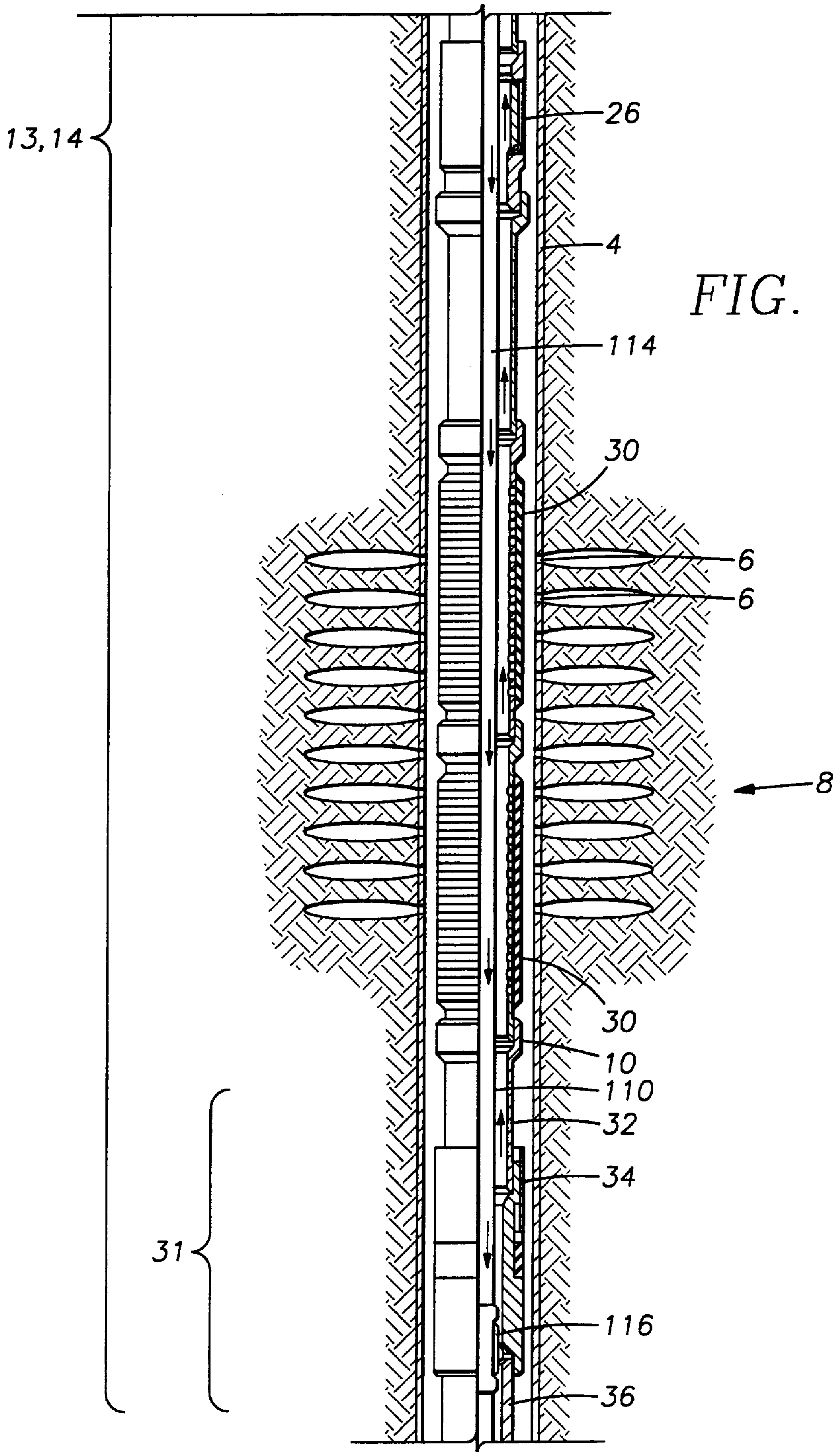

FIG. 3B

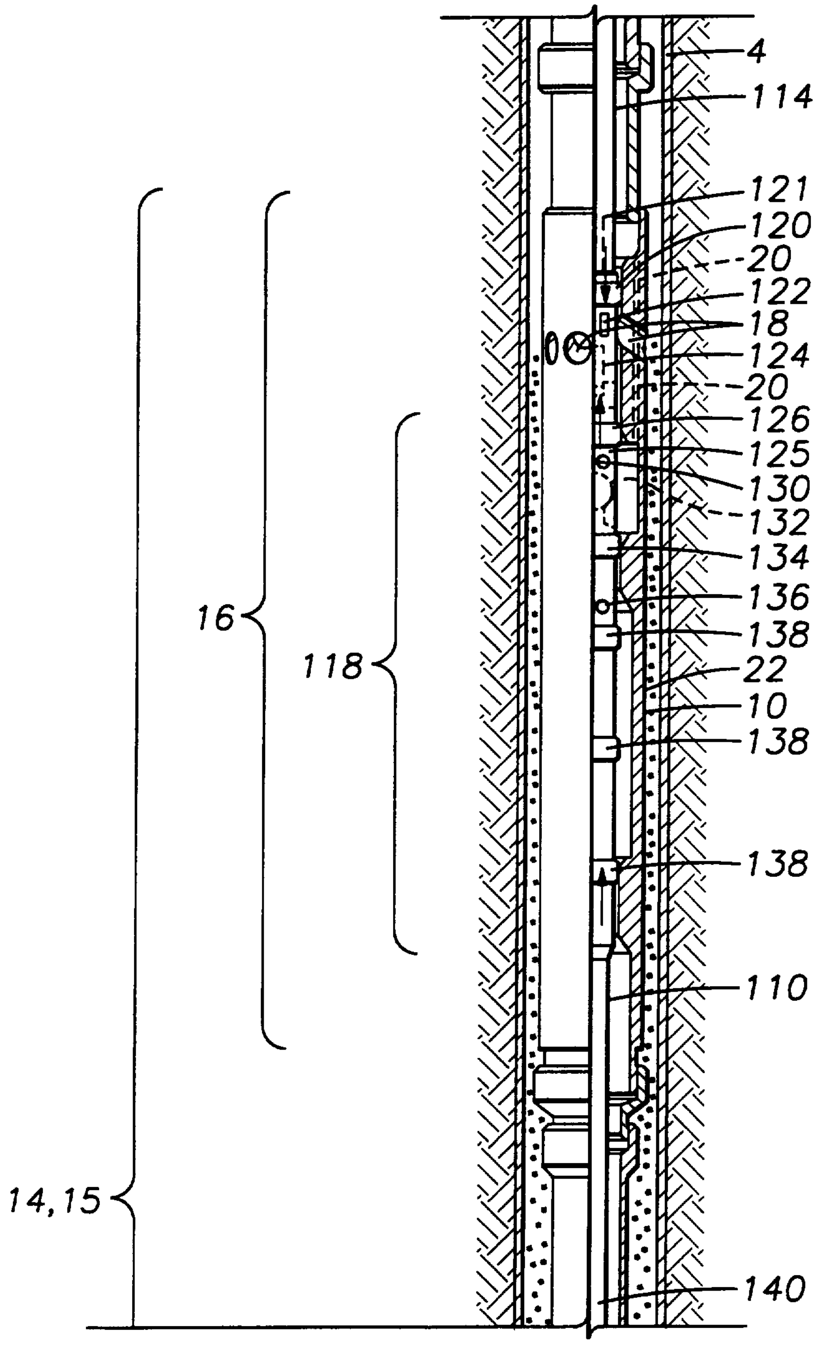
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FIG. 3C

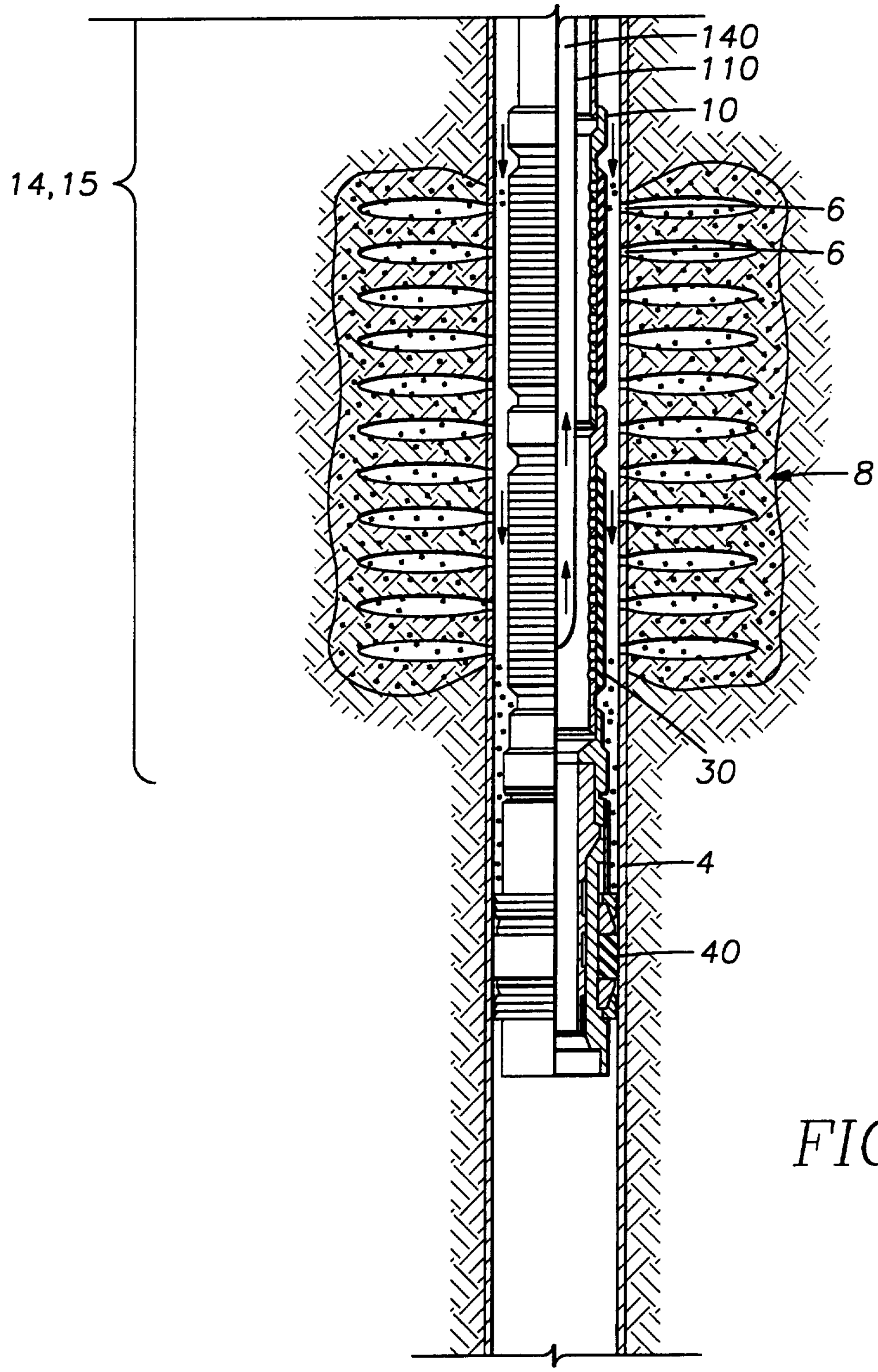

FIG. 3D

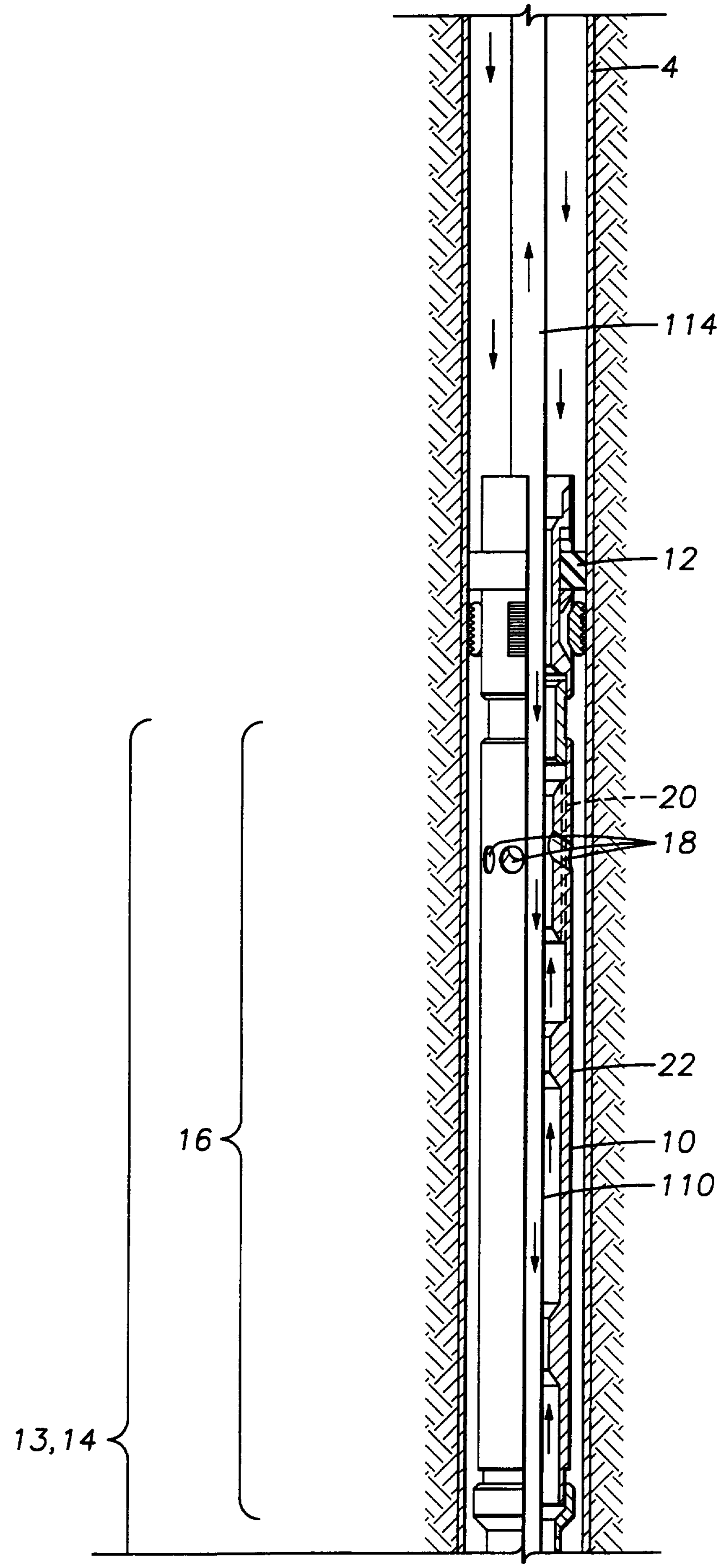

FIG. 4A

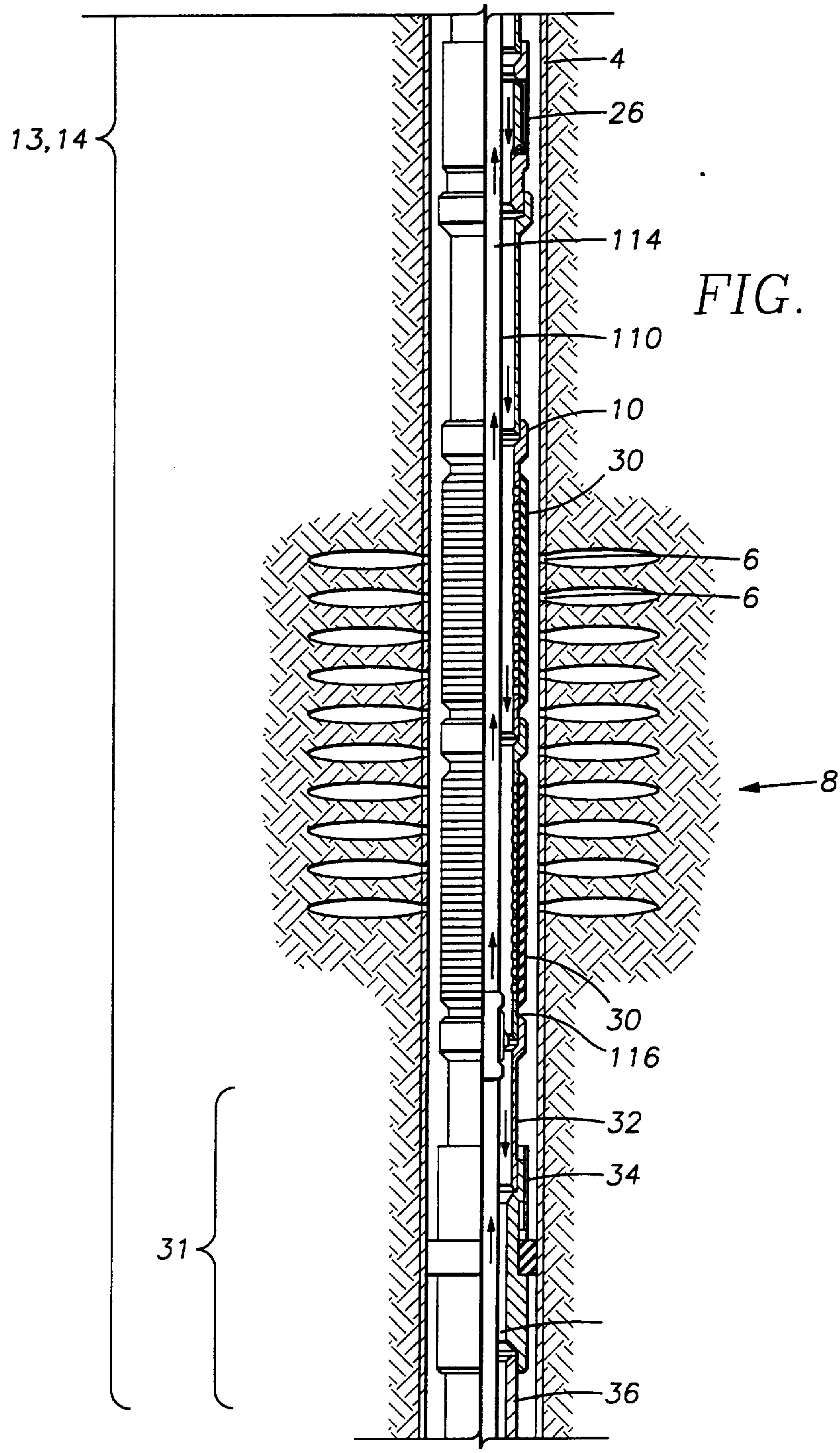

FIG. 4B

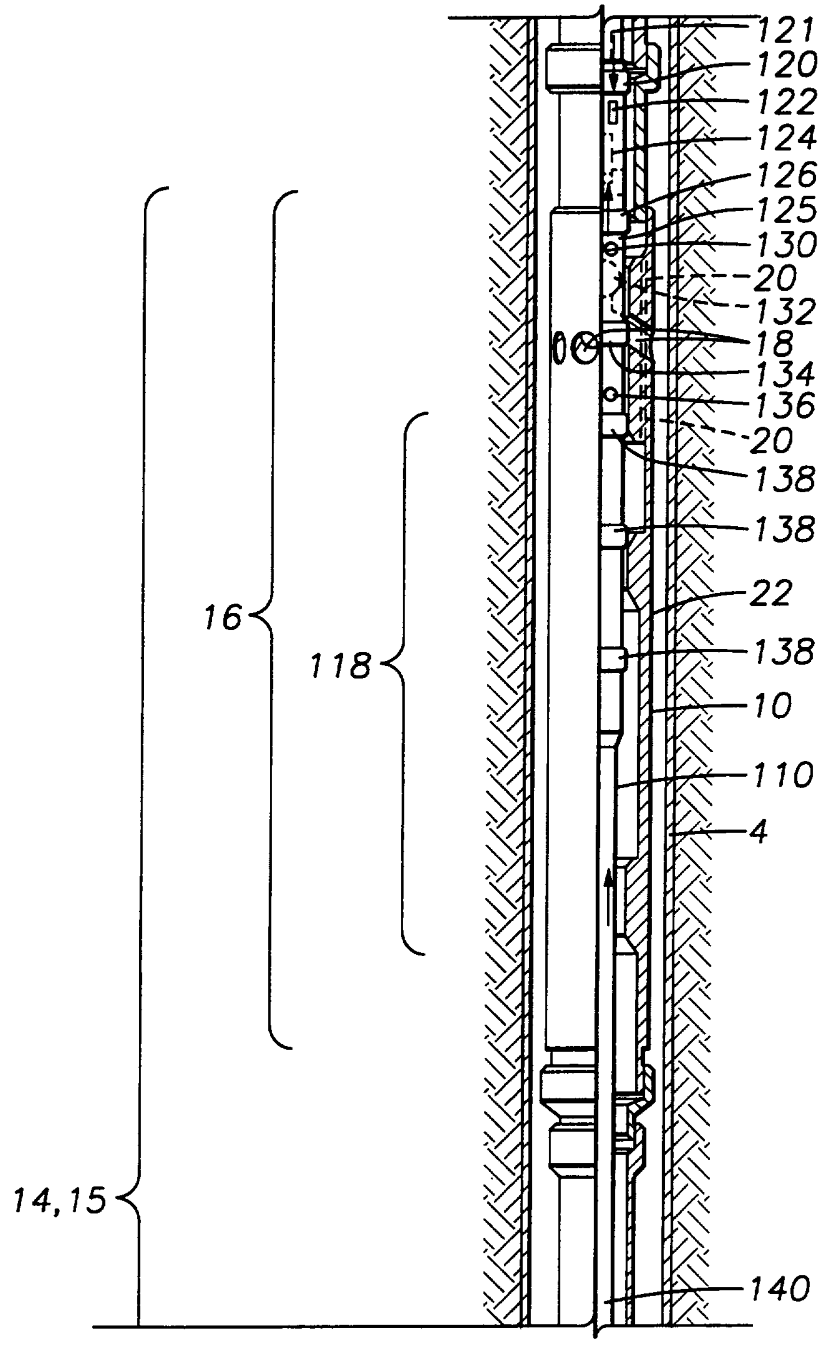
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FIG. 4C

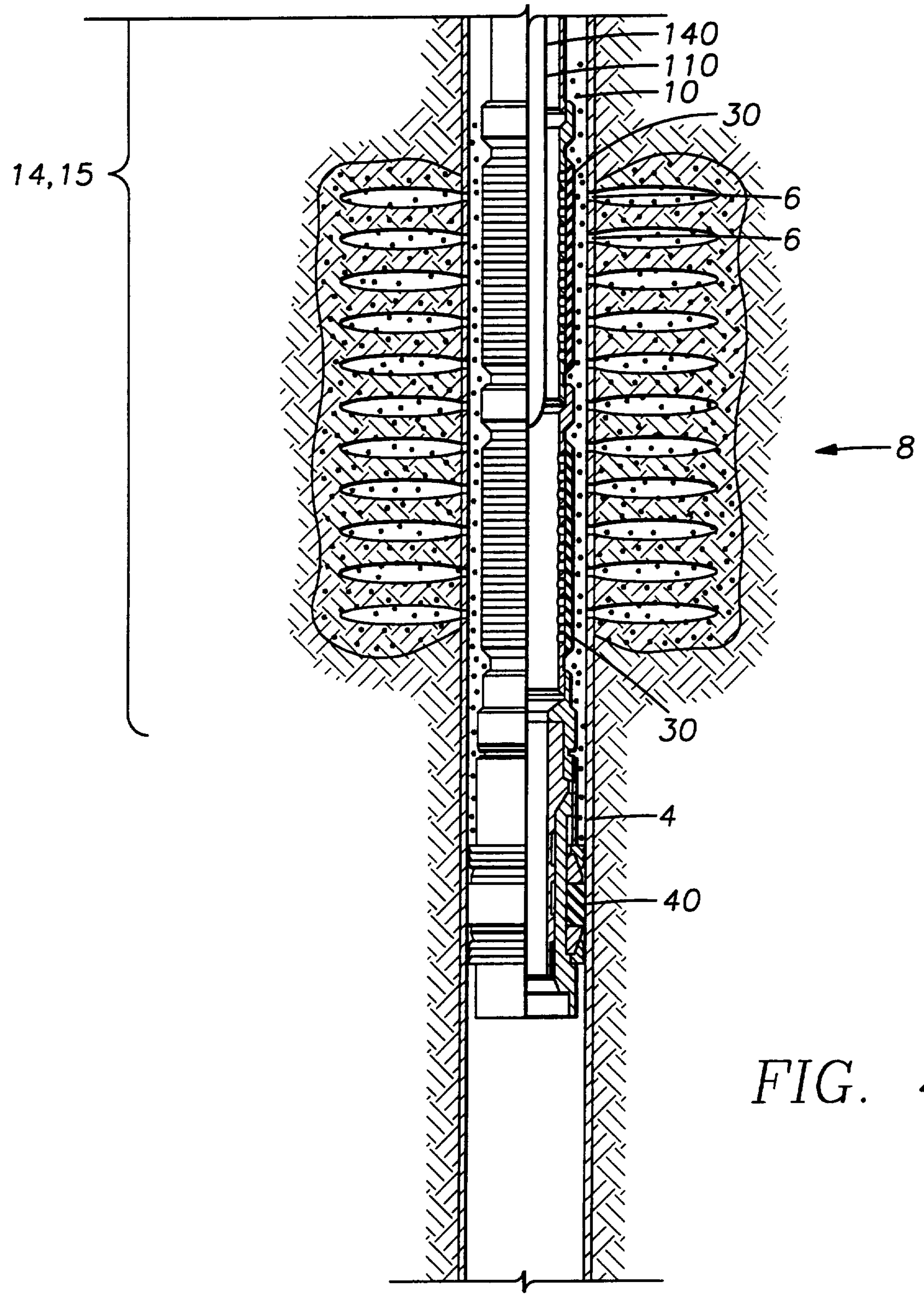

FIG. 4D

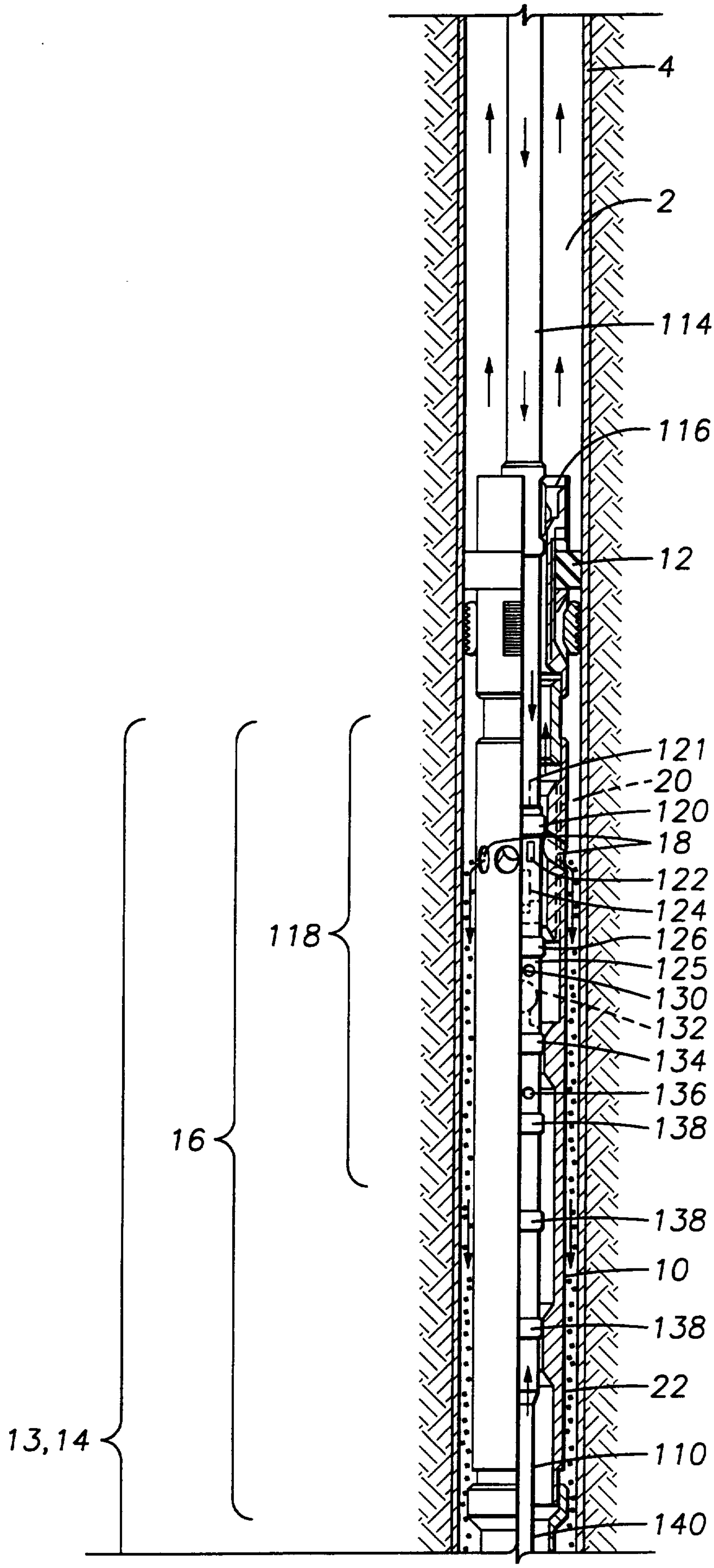
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FIG. 5A

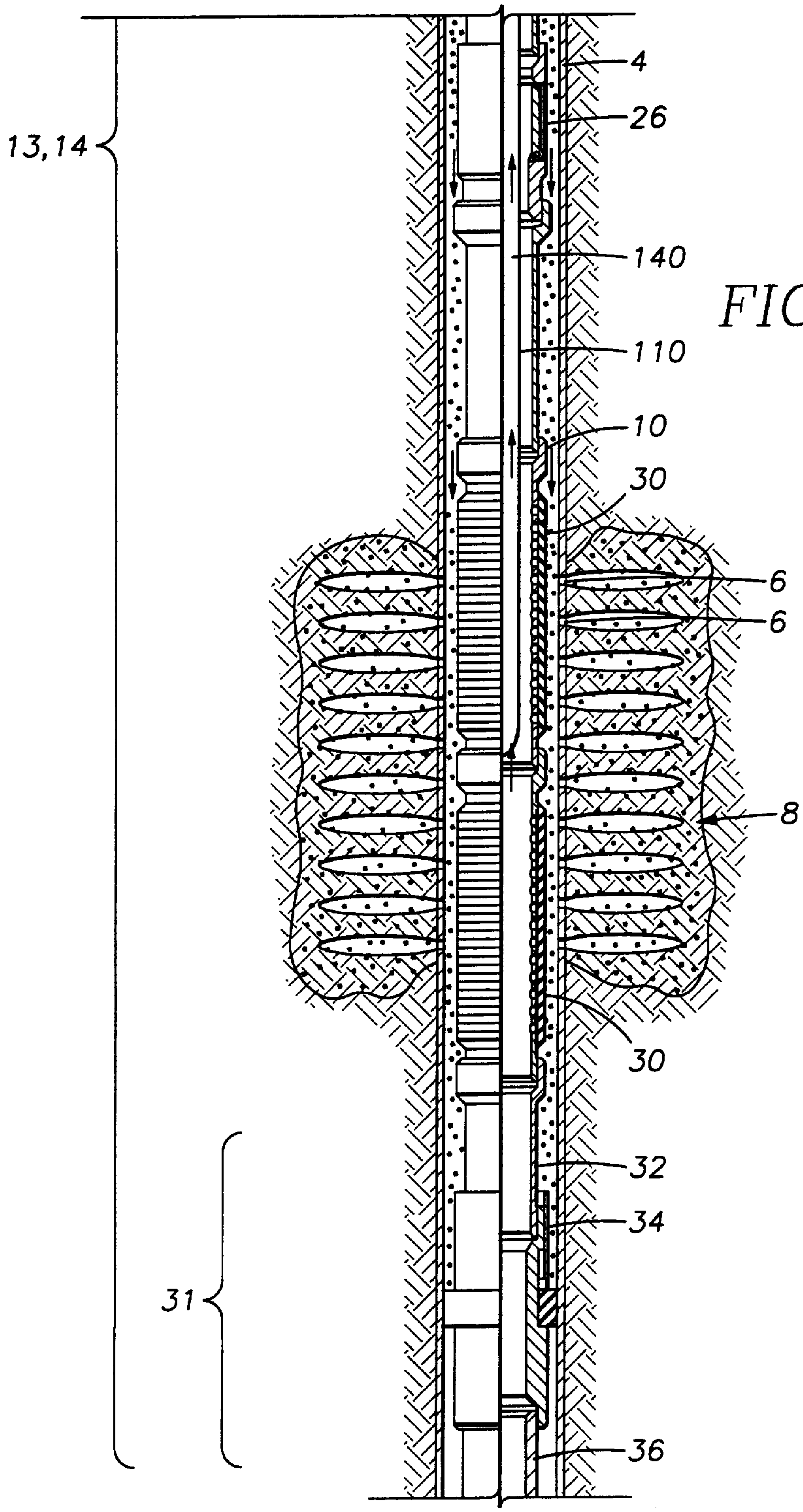

FIG. 5B

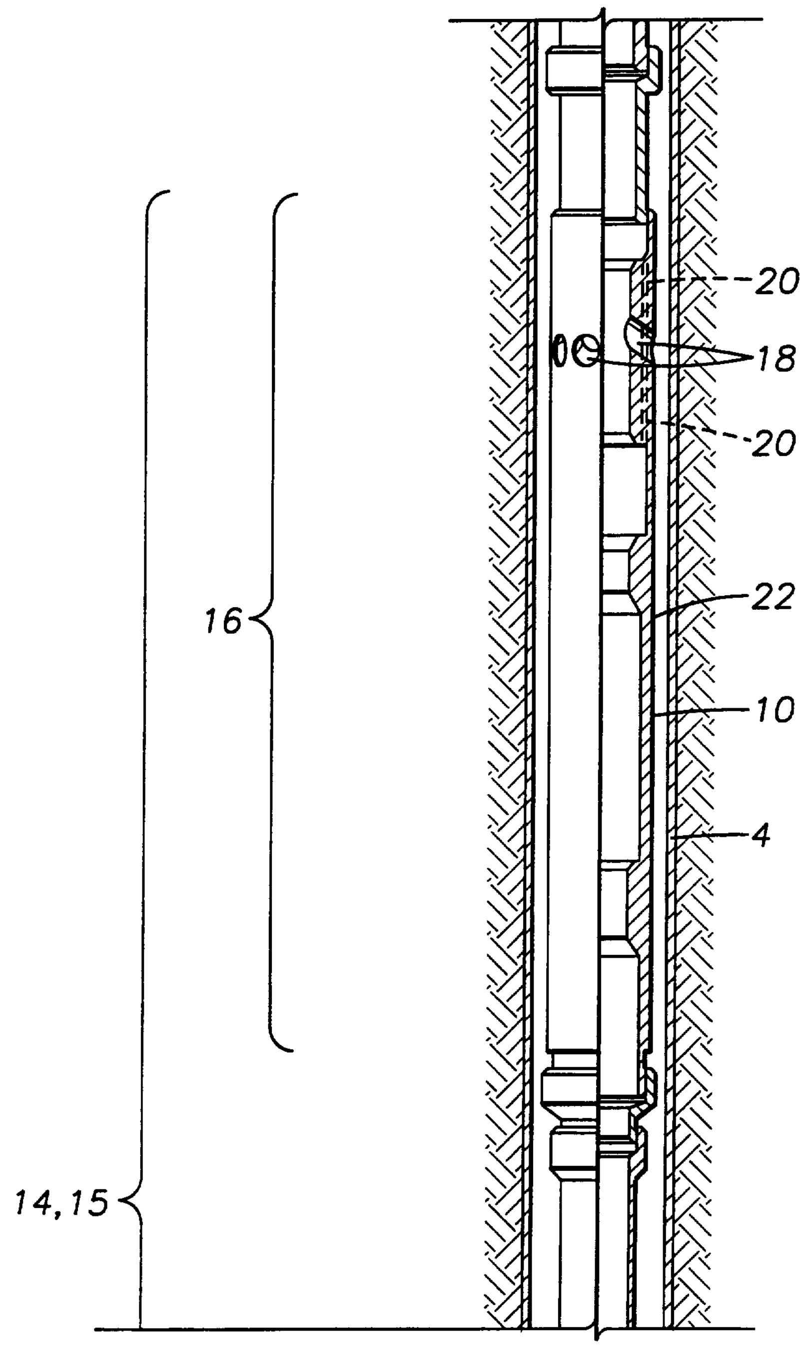

FIG. 5C

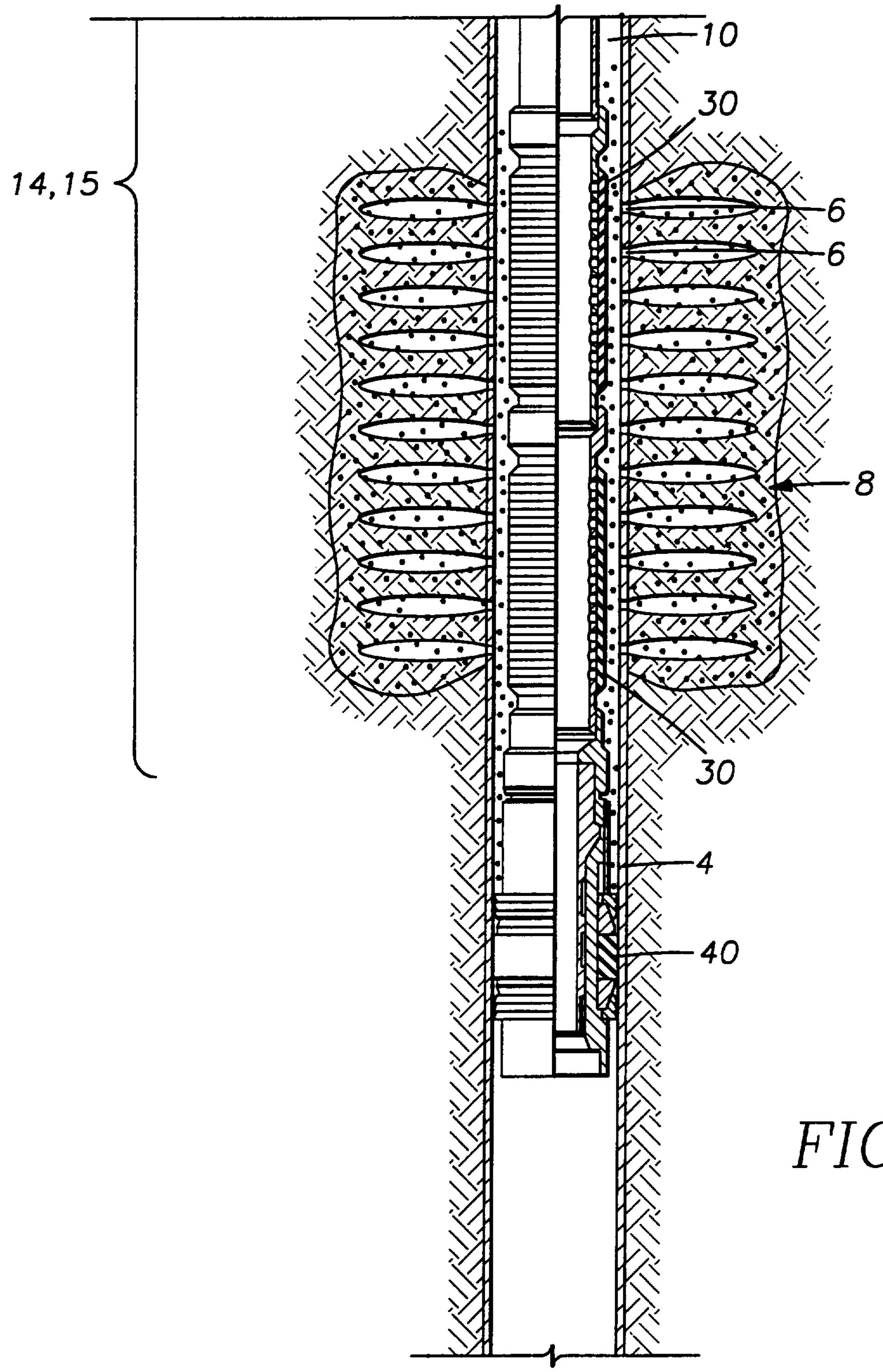

FIG. 5D

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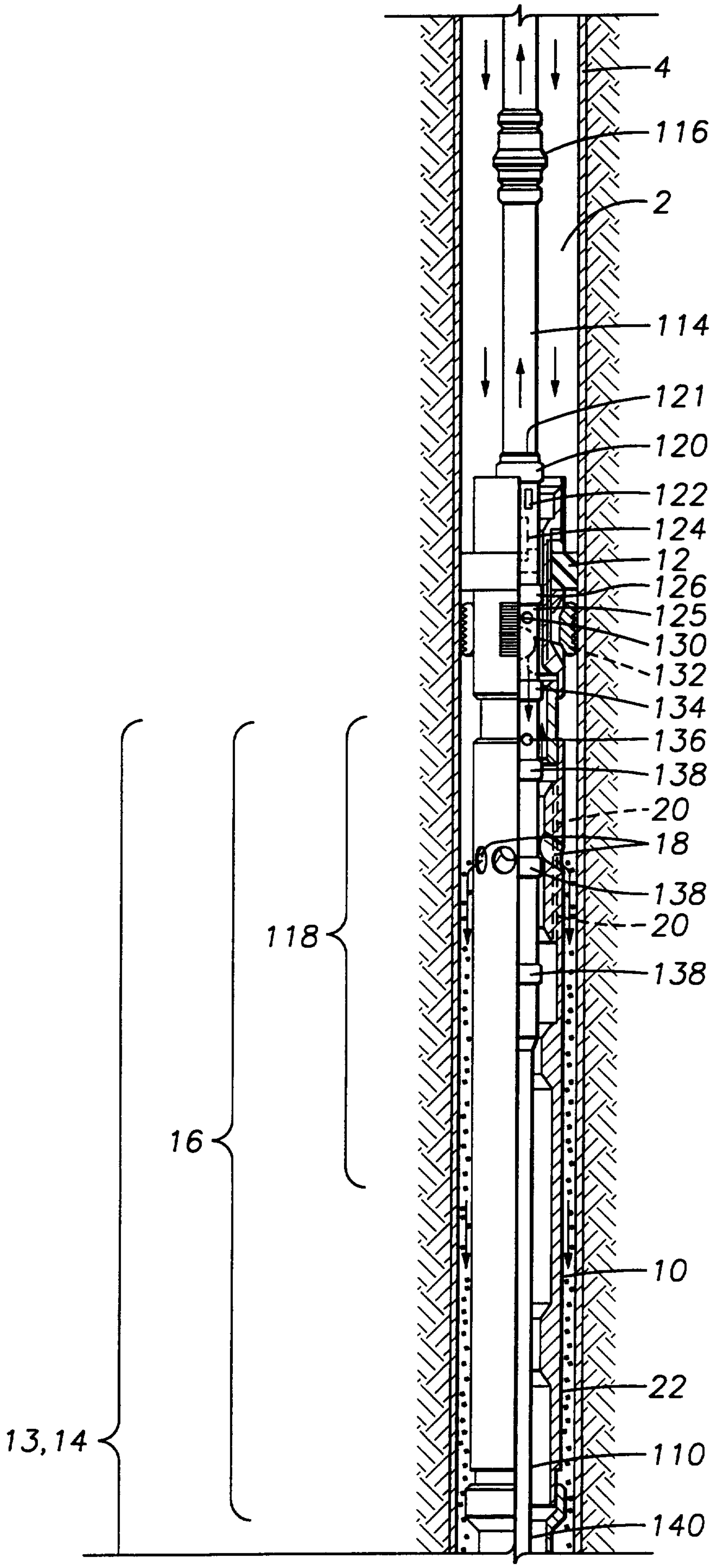
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FIG. 6A

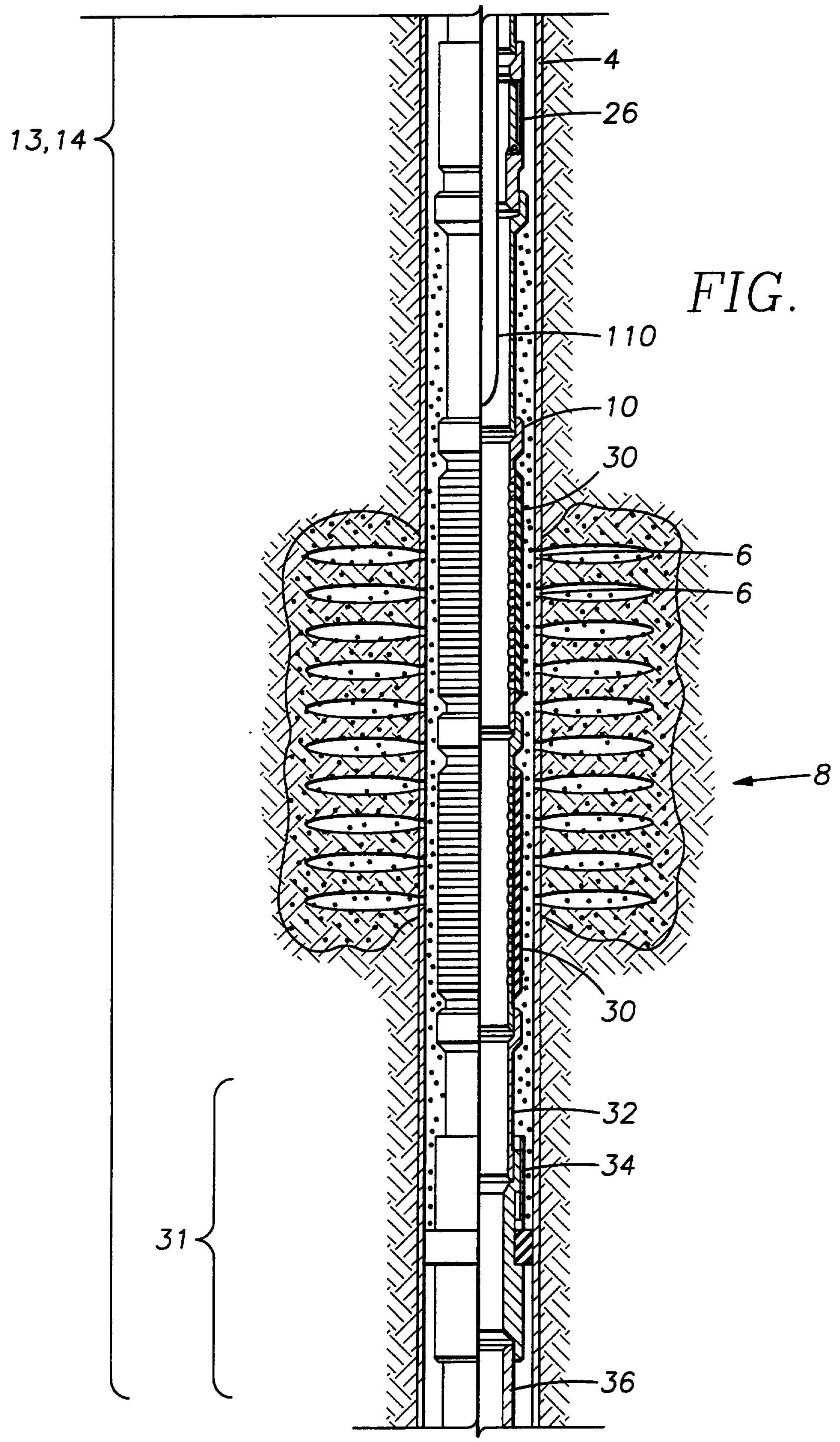

FIG. 6B

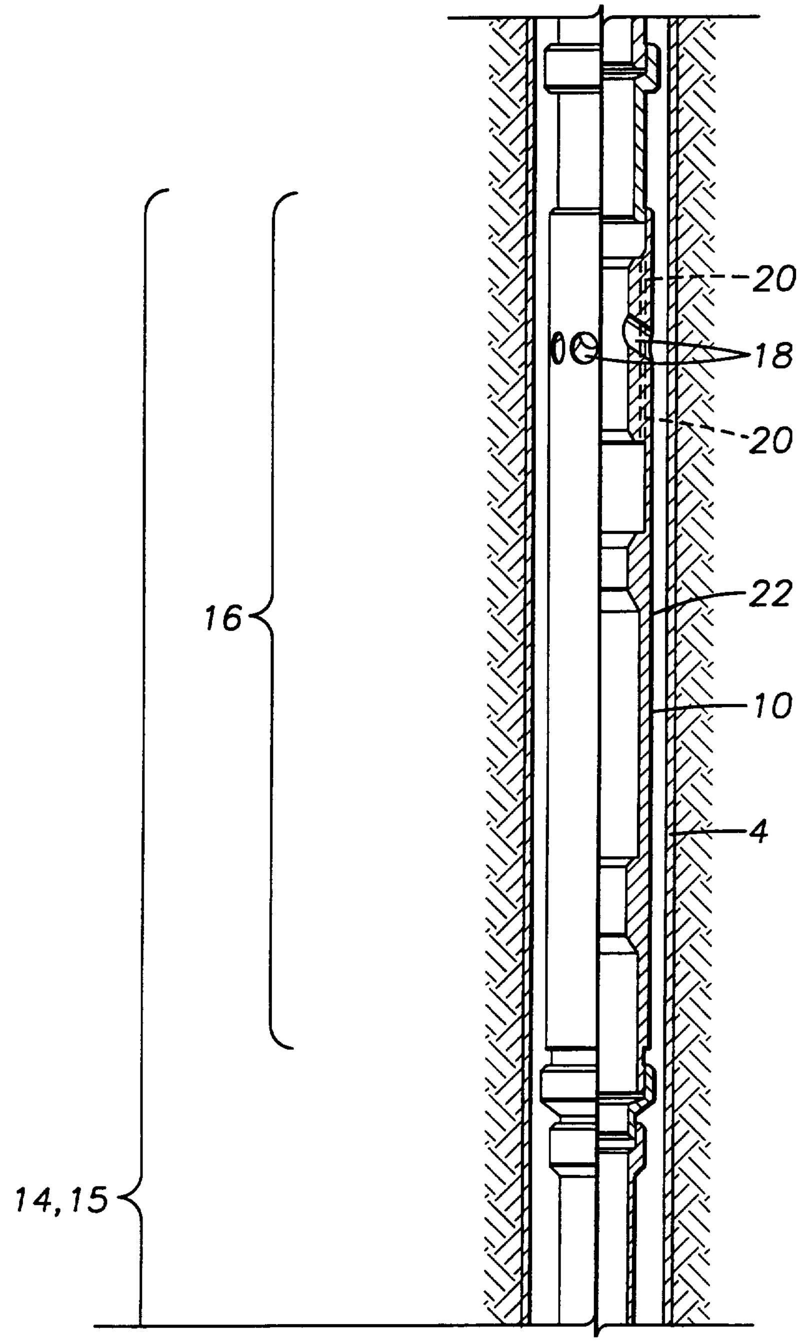

FIG. 6C

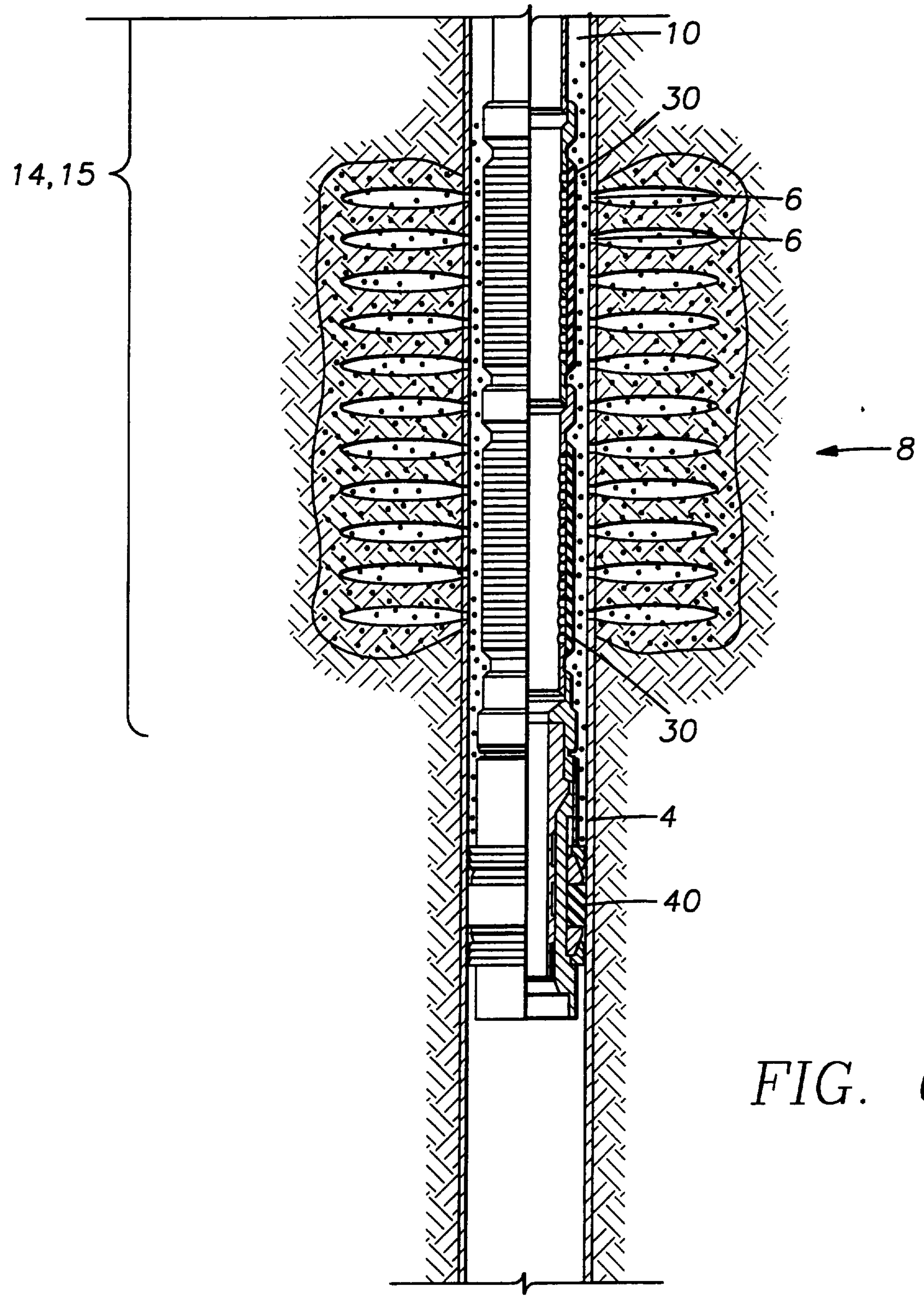

FIG. 6D

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 96/03285

A. CLASSIFICATION OF SUBJECT MATTER
IPC 6 E21B43/04 E21B47/12 E21B23/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 6 E21B

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

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

WPI, Tulsa, Full-text english EP, WO, US, GB

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US,A,4 049 055 (BROWN) 20 September 1977 see column 14, line 24 - line 55; figures 7A,7B ---	1-5,8, 15,20-23
X	US,A,4 570 714 (TURNER ET AL.) 18 February 1986 see column 10, line 59 - column 11, line 5; figures 1A,2A ---	1-4, 20-23
X	US,A,3 627 046 (MILLER ET AL.) 14 December 1971 see column 7, line 15 - line 47; figure 4 ---	1,2
A	US,A,4 945 991 (JONES) 7 August 1990 see column 4, line 37 - line 55; figure 2 --- -/--	1,2

[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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Date of the actual completion of the international search	Date of mailing of the international search report
14 June 1996	21.06.96

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Rampelmann, K

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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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A	US,A,4 783 995 (MICHEL ET AL.) 15 November 1988 see column 3, line 14 - line 38 see column 4, line 2 - line 8 ---	12,18, 26-29, 37,38, 41,42
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Inte   nal Application No
PCT/US 96/03285

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