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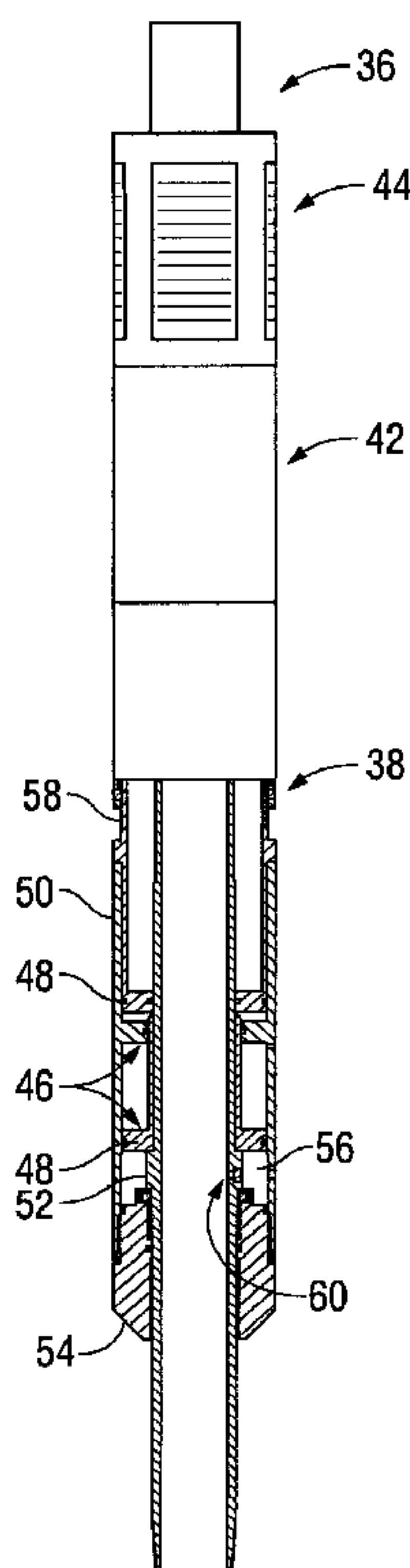
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(54) Title: HYDRAULIC PACKER WITH THERMAL ISOLATION MEMBER



(57) Abrégé/Abstract:

A technique facilitates use of a hydraulically actuated packer in a high temperature, downhole environment. The packer is actuated by directing pressurized fluid to the packer and routing the fluid to an actuation region of the packer to provide the force for setting the packer. A thermal isolation member is positioned in the packer along the pressurized fluid flow path and activates upon exposure to heat. Once the thermal isolation member is fully activated, flow is blocked along the pressurized fluid flow path which prevents return flow of pressurized fluid.



ABSTRACT OF THE DISCLOSURE

A technique facilitates use of a hydraulically actuated packer in a high temperature, downhole environment. The packer is actuated by directing pressurized fluid to the packer and routing the fluid to an actuation region of the packer to provide the force for setting the packer. A thermal isolation member is positioned in the packer along the pressurized fluid flow path and activates upon exposure to heat. Once the thermal isolation member is fully activated, flow is blocked along the pressurized fluid flow path which prevents return flow of pressurized fluid.

52941-28

HYDRAULIC PACKER WITH THERMAL ISOLATION MEMBER

BACKGROUND OF THE INVENTION

Field of the Invention

[0001] In many well-related applications, packers are used to provide pressure isolation in regions of a wellbore. Often, packers are designed to set or anchor against surrounding well casing. The setting of the packer both energizes a packer seal element and engages packer slips with the surrounding casing. Energizing the packer seal element involves using an axial force to compress the seal element and to cause the seal element to extrude outwardly in a radial direction until it contacts the well casing. Similarly, engaging the packer slips with the casing also utilizes axial force to push or pull the slips into a cone which drives the slips outwardly in a radial direction until the slips contact and grip the casing. The axial force may be generated either mechanically or hydraulically.

Description of Related Art

[0002] Mechanical methods of setting a packer rely on tubing manipulation provided from the surface or from a setting tool attached to the packer. Hydraulic methods utilize pressurized fluid delivered down through the tubing string or the surrounding annulus. The pressurized fluid acts on a packer mechanism to create the desired axial force for setting the packer.

[0003] In thermal wells having high temperatures, mechanical packers often have been preferred because hydraulic packers rely on elastomeric seals that can degrade and fail in the high temperature environment. For example, hydraulic packers may utilize o-ring seals to form the piston areas and fluid chambers used to convert hydraulic pressure into axial movement and force for setting the hydraulic packer. The standard materials from which such seals typically are manufactured do not have high service temperature ratings and can fail, causing release of the packer. However, many such well applications are better suited for hydraulic packers rather than mechanical packers. Attempts have been made to employ hydraulic packers in thermal wells by forming seals with exotic

52941-28

elastomers and using high temperature backup rings to prevent seal extrusion. However, such approaches are difficult and costly to implement, while remaining susceptible to seal deterioration from long-term high temperature exposure.

BRIEF SUMMARY OF THE INVENTION

5 **[0004]** In general, the present invention provides a system and methodology for utilizing a hydraulically actuated packer in a high temperature, downhole environment. The packer is actuated by directing pressurized fluid to the packer and routing the fluid to an actuation region of the packer to provide the force for setting the packer. A thermal isolation member is positioned in the packer along the
10 pressurized fluid flow path and activates upon exposure to heat. Once the thermal isolation member is fully activated, flow is blocked along the pressurized fluid flow path which prevents return flow of pressurized fluid.

 An aspect of the invention relates to a system comprising: a packer expandable by application of hydraulic pressure downhole, the packer comprising: a
15 mandrel having an internal flow passage and a radial port extending through a wall of the mandrel to the internal flow passage; a cylinder positioned around the mandrel to create a cavity exposed to the radial port; a piston system slidably mounted in the cylinder and exposed to the cavity; an expandable member operatively engaged with the piston system; and a thermal isolation member positioned at the radial port to
20 automatically block flow through the radial port when the thermal isolation member is exposed to sufficient heat.

 Another aspect of the invention relates to a method, comprising: constructing a hydraulically actuated packer with an actuation piston exposed to an actuating fluid via an inlet passage; and positioning a thermal isolation member at the
25 inlet passage to automatically block flow through the inlet passage by expanding when exposed to sufficient heat.

52941-28

Still another aspect of the invention relates to a system for use in a well, comprising a well completion comprising a packer, the packer having a fluid passage for receiving a fluid under pressure to actuate the packer, the packer further comprising a thermal isolation member deployed along the fluid passage, the thermal isolation member reacting to heat in a manner that blocks return flow along the fluid passage.

A further aspect of the invention relates to a method, comprising: moving a hydraulic packer downhole into a wellbore; setting the packer by directing a high pressure fluid into a packer actuation region; and blocking return flow of fluid from the packer actuation region with a thermally activated isolation member.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] Certain embodiments of the invention will hereafter be described with reference to the accompanying drawings, wherein like reference numerals denote like elements, and:

15 **[0006]** Figure 1 is a view of a well system deployed in a wellbore with a hydraulic packer, according to an embodiment of the present invention;

[0007] Figure 2 is an illustration of one example of the hydraulic packer illustrated in Figure 1, according to an embodiment of the present invention;

[0008] Figure 3 is an enlarged view of a portion of the hydraulic packer
20 illustrated in Figure 2, according to an embodiment of the present invention;

[0009] Figure 4 is a cross-sectional view of a thermal isolation device positioned in a packer flow passage, according to an embodiment of the present invention;

[0010] Figure 5 is a cross-sectional illustration similar to that of Figure 4 but showing the thermal isolation device in an activated state, according to an embodiment of the present invention; and

[0011] Figure 6 is a cross-sectional illustration of another example of the thermal isolation device, according to an alternate embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0012] In the following description, numerous details are set forth to provide an understanding of the present invention. However, it will be understood by those of ordinary skill in the art that the present invention may be practiced without these details and that numerous variations or modifications from the described embodiments may be possible.

[0013] The present invention relates to a system and methodology for isolating regions of a wellbore. For example, one or more packers may be deployed downhole and set to provide pressure isolation of specific wellbore regions with respect to adjacent wellbore regions. As described in greater detail below, the system and methodology facilitate the use of hydraulic packers, even when using standard elastomeric seals, in thermal wells that subject the hydraulic packer to high temperatures. The hydraulic packer may even be used in wells in which the temperatures at the packer are above 450°F. Many standard elastomers used in the creation of seals reach a flow phase at such temperatures.

[0014] In the present system and methodology, a thermal isolation device is located in the hydraulic packer to prevent formation of a leak path that would allow unsetting of the packer. The thermal isolation device blocks development of such a leak

path even if the hydraulic seals deteriorate in the high temperature well environment. In some embodiments, the thermal isolation device automatically reacts to heat in a manner that blocks return flow of actuation fluid in the packer. For example, the thermal isolation device may comprise a member or plug that expands or otherwise changes form in the presence of sufficient heat. The thermal isolation device can be used in cooperation with an actuation fluid passage to block flow through the passage under high heat conditions.

[0015] Referring generally to Figure 1, one example of a well system 20 is illustrated according to an embodiment of the present invention. In the embodiment illustrated, well system 20 comprises well equipment 22 deployed downhole in a well 24 defined by a wellbore 26. The wellbore 26 extends downwardly from a wellhead 28 at a surface location 30, and the well equipment 22 may be deployed within a surrounding tubing 32, such as a well casing.

[0016] Well equipment 22 may comprise a well completion or other equipment deployed downhole by a suitable conveyance 34, such as a flexible conveyance or tubing, e.g. coiled tubing. The well equipment 22 comprises a hydraulic packer 36 used to isolate regions of the wellbore 26. It should be noted, however, that well equipment 22 may comprise a variety of components and include one or more hydraulic packers 36. For purposes of description, the illustrated hydraulic packer 36 is representative of the one or more hydraulic packers that can be used to isolate regions of wellbore 26.

[0017] The hydraulic packer 36 may be constructed in a variety of shapes, sizes and forms that use various components and component configurations. By way of example, hydraulic packer 36 comprises an actuation system 38 used to selectively expand one or more expandable members 40. Expandable members 40 may comprise an expandable packer seal element 42 that is selectively expanded against the surrounding tubing 32 to form a seal sufficient to isolate the wellbore region above hydraulic packer 36 from the wellbore region below hydraulic packer 36. The expandable members 40 also may comprise retention mechanisms 44, e.g. slips, which may be selectively

expanded to engage the surrounding wall and secure the hydraulic packer 36 at a desired location along wellbore 26.

[0018] Referring generally to Figure 2, one embodiment of hydraulic packer 36 is illustrated. In this embodiment, actuation system 38 comprises a piston system 46 having one or more pistons 48 that may be moved by application of sufficient hydraulic pressure. As illustrated, the actuation system 38 further comprises a cylinder 50 and a mandrel 52 disposed within the cylinder 50. An end structure 54 is connected between the cylinder 50 and mandrel 52 to enable the cylinder 50 and the mandrel 52 to cooperate and create an actuation region 56 that receives actuating fluid under pressure to move piston 48. In this embodiment, piston(s) 48 ultimately is connected with packer seal element 42 and retention mechanisms 44 via linkage 58 to provide the axial movement used to actuate packer seal element 42 and/or retention mechanisms 44.

[0019] Referring also to Figure 3, the actuating fluid is delivered to actuation region 56 which may comprise a cavity adjacent piston 48. The actuating fluid is delivered to actuation region 56 through a flow passage 60 that may include a flow port 62. A thermal isolation device 64 is deployed along flow passage 60 and is designed to enable flow of actuating fluid along flow passage 60 during setting of hydraulic packer 36. However, when exposed to sufficient heat due to, for example, the temperature of the environment in which hydraulic packer 36 is deployed, thermal isolation device 64 actuates to block flow along flow passage 60. The blockage prevents return flow that could otherwise allow an undesirable release/unsetting of hydraulic packer 36.

[0020] In the embodiment illustrated in Figures 2 and 3, piston 48 is designed to move axially relative to cylinder 50 and mandrel 52. The pressurized actuating fluid acts on piston 48 and is converted into axial movement and force. Cylinder 50 and mandrel 52 function to contain the pressurized actuating fluid and piston 48. In some embodiments, piston 48, cylinder 50, and mandrel 52 are three individual components. In other embodiments, the piston and cylinder may be combined into one component while the mandrel remains a separate component. Alternatively, the piston and the

mandrel may be combined into one component while the cylinder remains a separate component. Regardless of the specific configuration, the combination of piston, cylinder, and mandrel utilizes sealing elements to create a pressure integral seal between the relatively moving components. In many applications, the sealing elements are constructed as o-rings, however other types of seals may be used.

[0021] Referring again to the embodiment of Figure 3, pressurized actuating fluid is delivered to the actuation region 56 to move piston 48, and any fluid on the backside of piston 48 can be discharged to the surrounding annulus via a discharge port 65. In the embodiment illustrated, actuating fluid is delivered along a flow path through an interior 66 of mandrel 52 and radially outwardly through flow port 62 formed through a wall of mandrel 52. The actuating fluid flows past thermal isolation device 64 to actuation region 56. In alternate embodiments, however, the actuating fluid can be directed along a surrounding annulus and to actuation region 56 by locating the inlet flow port through a wall of cylinder 50, as indicated by port 68. In other embodiments, the actuating fluid can be directed to actuation region 56 via a dedicated control line. In any of these embodiments, the thermal isolation device 64 is positioned at an appropriate location along the actuating fluid flow path.

[0022] Once the pressurized actuating fluid reaches actuation region 56, the fluid acts on piston 48 and causes it to move in an axial direction a sufficient distance to set hydraulic packer 36. The actuating pressure is maintained by a plurality of seal elements, such as seals 70 located between piston system 46 and cylinder 50. Seals 70 or additional seals 72 can also be used to form a pressure seal between the piston system 46 and mandrel 52. Other seals 74 can be positioned at additional locations to again form a pressure seal between elements of piston system 46 and cylinder 50. In the specific embodiment illustrated, additional seals 76 may be used to form appropriate pressure seals between end structure 54 and the adjacent sections of cylinder 50 and mandrel 52. The number and type of seals may vary according to the design and configuration of hydraulic packer 36, but generally the seals containing the pressurized actuating fluid may be formed of elastomers that have a defined temperature range in which such

materials function properly. Once the ambient temperature exceeds this temperature range, the structural integrity of the seals can begin to deteriorate which may lead to leakage and failure of pressure integrity at high temperatures. Without thermal isolation device 64, such deterioration could create a leak path or return path along flow passage 60 so as to release actuating fluid which could further result in release/unsetting of hydraulic packer 36.

[0023] Thermal isolation device 64 can be used to seal off flow passage 60 and to prevent unwanted release of actuating fluid. In some embodiments, thermal isolation device 64 is used to permanently block any communication through flow port 62 which prevents unwanted release of hydraulic packer 36. For example, in many downhole applications, once hydraulic packer 36 is set, the function of the elastomeric seals is no longer necessary other than to prevent release of actuating fluid. However, thermal isolation device 64 removes the threat of seal deterioration in high temperature environments by automatically blocking the flow path that would otherwise potentially allow release of the actuating fluid. Accordingly, the presence of thermal isolation device 64 enables deterioration and failure of several seal elements without affecting the functionality of hydraulic packer 36 in these applications. Consequently, less expensive elastomers can be used to form various seal elements.

[0024] Referring generally to Figure 4, one example of thermal isolation device 64 is illustrated. In this embodiment, thermal isolation device 64 comprises a plug 78 deployed in flow port 62. Before being exposed to sufficient heat to fully activate thermal isolation device 64, a fluid gap 80 exists between plug 78 and the wall of flow port 62. The fluid gap 80 enables transfer of activating fluid to actuation region 56 during setting of hydraulic packer 36. Plug 78 may be retained along the flow passage, e.g. retained in flow port 62, by a variety of mechanisms. For example, plug 78 may be inserted into an expanded portion 82 of flow port 62 and held within the expanded portion 82 by a plug retainer 84 such as the illustrated snap ring 86.

[0025] Once the temperature around hydraulic packer 36 within wellbore 26 reaches a high level and plug 78 is exposed to sufficient heat, plug 78 activates, which eliminates the fluid gap 80 and blocks flow along flow port 62, as illustrated in Figure 5. By way of example, plug 78 may expand when exposed to sufficient heat and create an interference 88 with the surrounding port wall surface 90. If flow port 62 is routed through mandrel 52, the plug 78 creates interference 88 with the surrounding material of mandrel 52. Upon sealing off flow port 62, the potential leak path created by seal element failure is no longer a concern with respect to detrimentally affecting the function of hydraulic packer 36.

[0026] The materials, construction, configuration, and location of thermal isolation device 64 may vary depending on the design of hydraulic packer 36 and the environment in which it is employed. In the specific example illustrated, the material, form, and number of plugs 78 and plug retainers 84 can be adjusted. In Figure 6, for example, another embodiment of plug retainer 84 is illustrated. In this embodiment, plug retainer 84 comprises a threaded member 92, such as an externally threaded nut, having an internal port 94 to accommodate the flow of actuating fluid when setting hydraulic packer 36.

[0027] The plug 78 or other member used for blocking flow along flow passage 60, e.g. through flow port 62, may be formed from a material 96 that reacts to heat in a desired manner. In many applications, the material 96 is selected based on its thermal expansion coefficient. In other words, the material is selected to expand more than the material 98 that surrounds the plug 78 or other actuation member. By way of specific example, the material 96 may be selected to expand and create interference 88 at a temperature below the upper temperature limit of the elastomer seal elements.

[0028] The actual materials 96, 98 that are selected for a given hydraulic packer 36 may vary depending on the specific application. In one example, the surrounding material 98 is an alloy steel having a thermal expansion coefficient range from 8.6×10^{-6} inches/inch/°F to 6.3×10^{-6} inches/inch/°F. In this example, plug 78 may be formed from

a suitable material, such as aluminum, having a thermal expansion coefficient ranging from 13.7×10^{-6} inches/inch/°F to 11.7×10^{-6} inches/inch/°F. The aluminum material expands significantly more than the surrounding alloy steel material.

[0029] In other applications, material 96 may comprise a shape memory alloy. The shape memory alloy can be used to construct plug 78 or other flow isolation member in a manner such that its outer diameter is greater than the diameter of the flow port 62 at a predetermined high temperature. The larger diameter created by material 96 causes the desired interference 88 and seals off the flow port 62, thus preventing unwanted communication of activating fluid. In various applications, the use of shape memory alloy allows the thermal isolation plug 78 or other thermal isolation member to retain its expanded geometry even after the ambient temperature has decreased significantly. Additionally, shape memory alloys can be designed so that the thermal expansion is more reliable and predictable, which facilitates its use in a variety of thermal isolation devices employed in various components and at various locations along flow passage 60.

[0030] The design of hydraulic packer 36 with thermal isolation device 64 enables use of hydraulic packers in a wider variety of environments and applications. The size, type, and configuration of hydraulic packer 36 can vary according to the specific application and environment. For example, the type of piston system or other actuation system, the routing of activating fluid, the type and location of the thermal expansion device, and the type, arrangement and size of various other components can be adjusted to accommodate environmental conditions and operational parameters. Additionally, the overall well system may utilize individual or multiple hydraulic packers to provide the desired pressure isolation zones. Furthermore, the size and configuration of the thermal isolation devices, as well as the materials used to construct the thermal isolation devices, can be selected and adjusted according to the specific well applications.

[0031] Accordingly, although only a few embodiments of the present invention have been described in detail above, those of ordinary skill in the art will readily appreciate that many modifications are possible without materially departing from the

teachings of this invention. Such modifications are intended to be included within the scope of this invention as defined in the claims.

CLAIMS

What is claimed is:

1. A system, comprising:
 - a packer expandable by application of hydraulic pressure downhole, the packer comprising:
 - a mandrel having an internal flow passage and a radial port extending through a wall of the mandrel to the internal flow passage;
 - a cylinder positioned around the mandrel to create a cavity exposed to the radial port;
 - a piston system slidably mounted in the cylinder and exposed to the cavity;
 - an expandable member operatively engaged with the piston system; and
 - a thermal isolation member positioned at the radial port to automatically block flow through the radial port when the thermal isolation member is exposed to sufficient heat.
2. The system as recited in claim 1, wherein the piston system comprises at least one piston having an elastomeric seal positioned to form a seal with an internal surface of the cylinder.
3. The system as recited in claim 1, wherein the expandable member comprises a packer seal element.
4. The system as recited in claim 1, wherein the expandable member comprises a plurality of packer slips.
5. The system as recited in claim 1, wherein the thermal isolation member is retained in the radial port with a snap ring.

6. The system as recited in claim 1, wherein the thermal isolation member is retained in the radial port with a ported, threaded member.
7. The system as recited in claim 1, wherein the thermal isolation member comprises a material having a greater thermal expansion coefficient than a surrounding mandrel material.
8. The system as recited in claim 1, wherein the thermal isolation member comprises an aluminum material.
9. The system as recited in claim 1, wherein the thermal isolation member comprises a shape memory alloy.
10. A method, comprising:
 - constructing a hydraulically actuated packer with an actuation piston exposed to an actuating fluid via an inlet passage; and
 - positioning a thermal isolation member at the inlet passage to automatically block flow through the inlet passage by expanding when exposed to sufficient heat.
11. The method as recited in claim 10, further comprising:
 - delivering the hydraulically actuated packer downhole into a wellbore; and
 - actuating the hydraulically actuated packer by delivering the actuating fluid through the inlet passage.
12. The method as recited in claim 10, wherein constructing the hydraulically actuated packer comprises constructing the hydraulically actuated packer with a packer seal element expandable via the actuation piston.

13. The method as recited in claim 10, wherein constructing the hydraulically actuated packer comprises constructing the actuation piston with a plurality of packer slips expandable via the actuation piston.
14. The method as recited in claim 10, wherein positioning the thermal isolation member comprises positioning the thermal isolation member in the inlet passage between an interior and an exterior of a packer mandrel.
15. The method as recited in claim 10, wherein positioning the thermal isolation member comprises positioning a shape memory alloy thermal isolation member.
16. The method as recited in claim 10, wherein positioning the thermal isolation member comprises positioning a metal thermal isolation member having a greater thermal expansion coefficient than the surrounding material through which the inlet passage is formed.
17. A system for use in a well, comprising a well completion comprising a packer, the packer having a fluid passage for receiving a fluid under pressure to actuate the packer, the packer further comprising a thermal isolation member deployed along the fluid passage, the thermal isolation member reacting to heat in a manner that blocks return flow along the fluid passage.
18. The system as recited in claim 17, wherein the packer comprises an actuating piston which can be moved by the fluid under pressure to set the packer at a desired location in a wellbore.
19. The system as recited in claim 18, wherein once the thermal isolation member blocks return flow along the fluid passage, the piston is not able to move.
20. The system as recited in claim 17, wherein the thermal isolation member expands to block the fluid passage upon exposure to sufficient heat.

21. The system as recited in claim 17, wherein the thermal isolation member is formed from a shape memory alloy.
22. A method, comprising:
 - moving a hydraulic packer downhole into a wellbore;
 - setting the packer by directing a high pressure fluid into a packer actuation region; and
 - blocking return flow of fluid from the packer actuation region with a thermally activated isolation member.
23. The method as recited in claim 22, wherein blocking return flow of fluid comprises blocking return flow with the thermally activated isolation member formed of a material that expands upon exposure to sufficient heat.
24. The method as recited in claim 22, wherein blocking return flow of fluid comprises blocking return flow with the thermally activated isolation member formed as a plug deployed in a fluid port.

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1/3

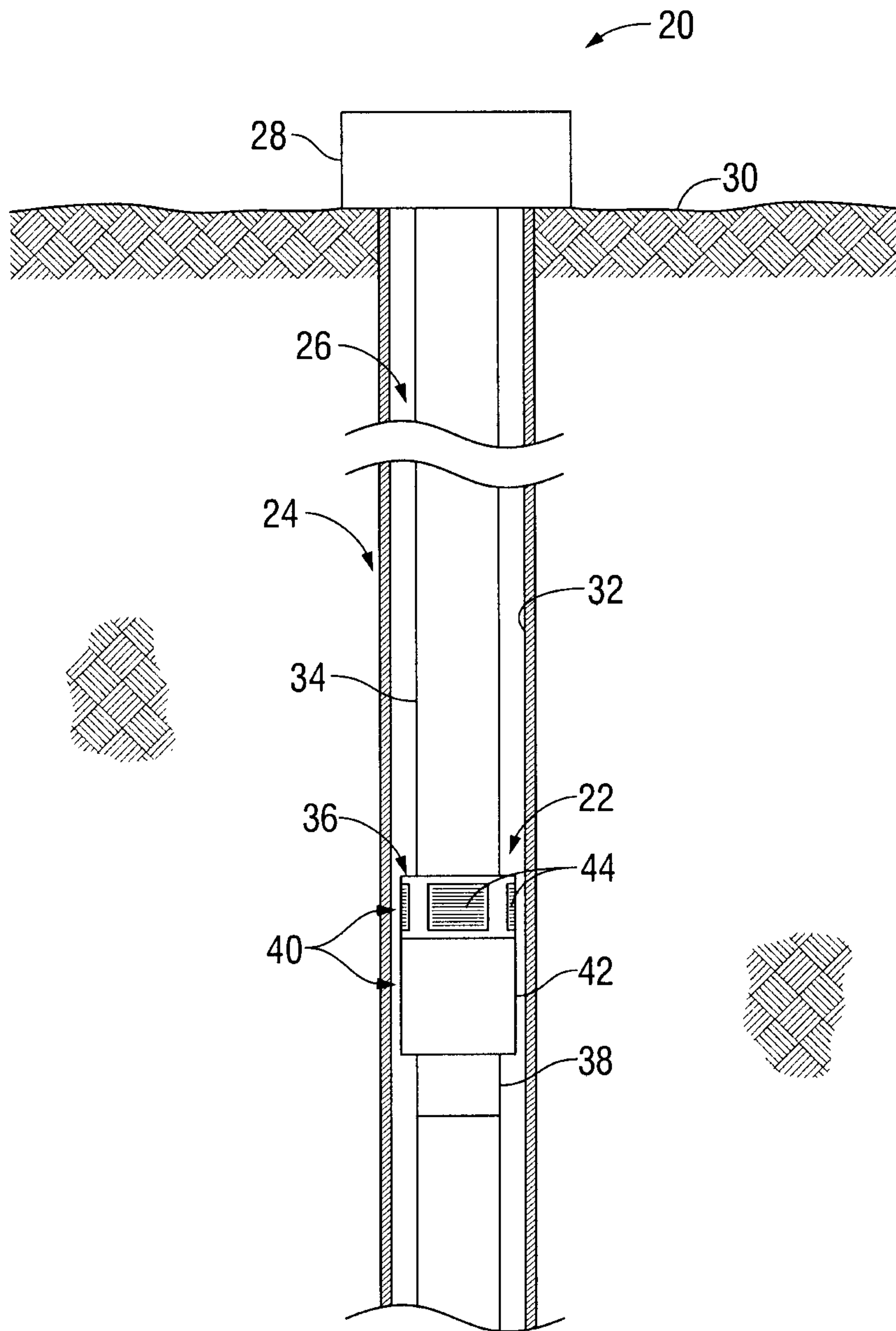


FIG. 1

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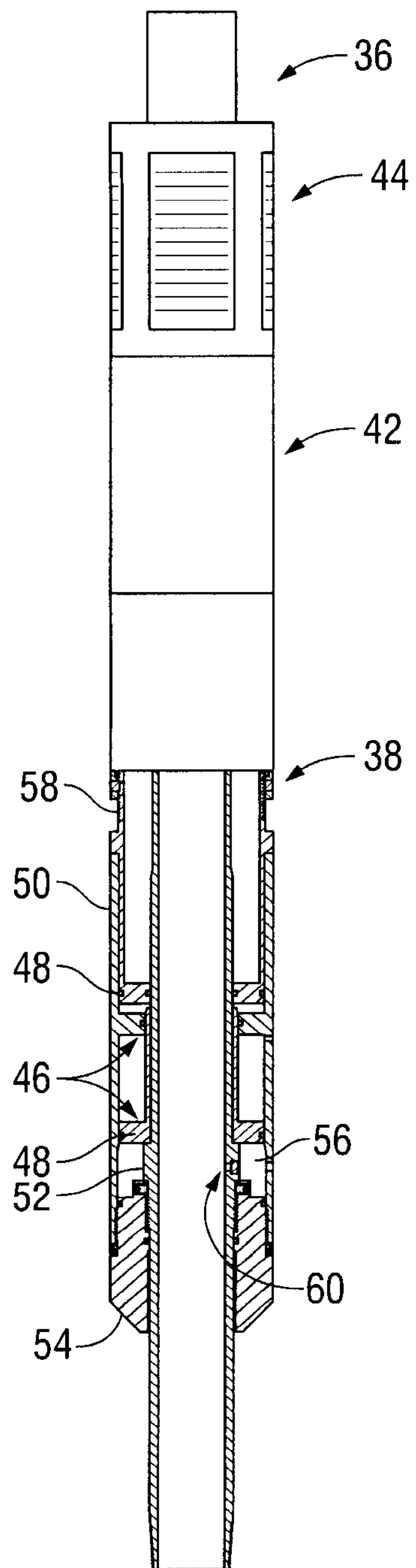


FIG. 2

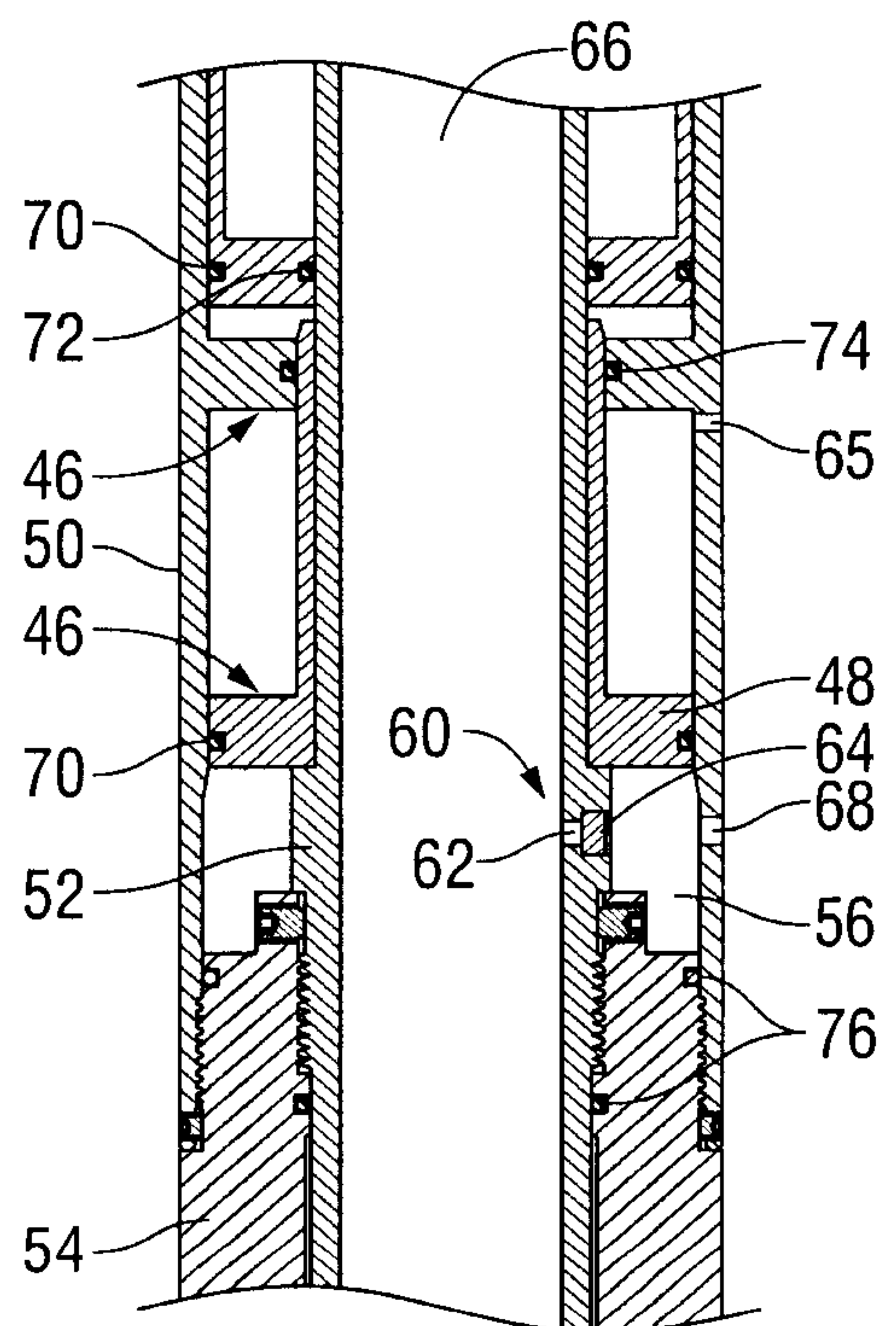


FIG. 3

3/3

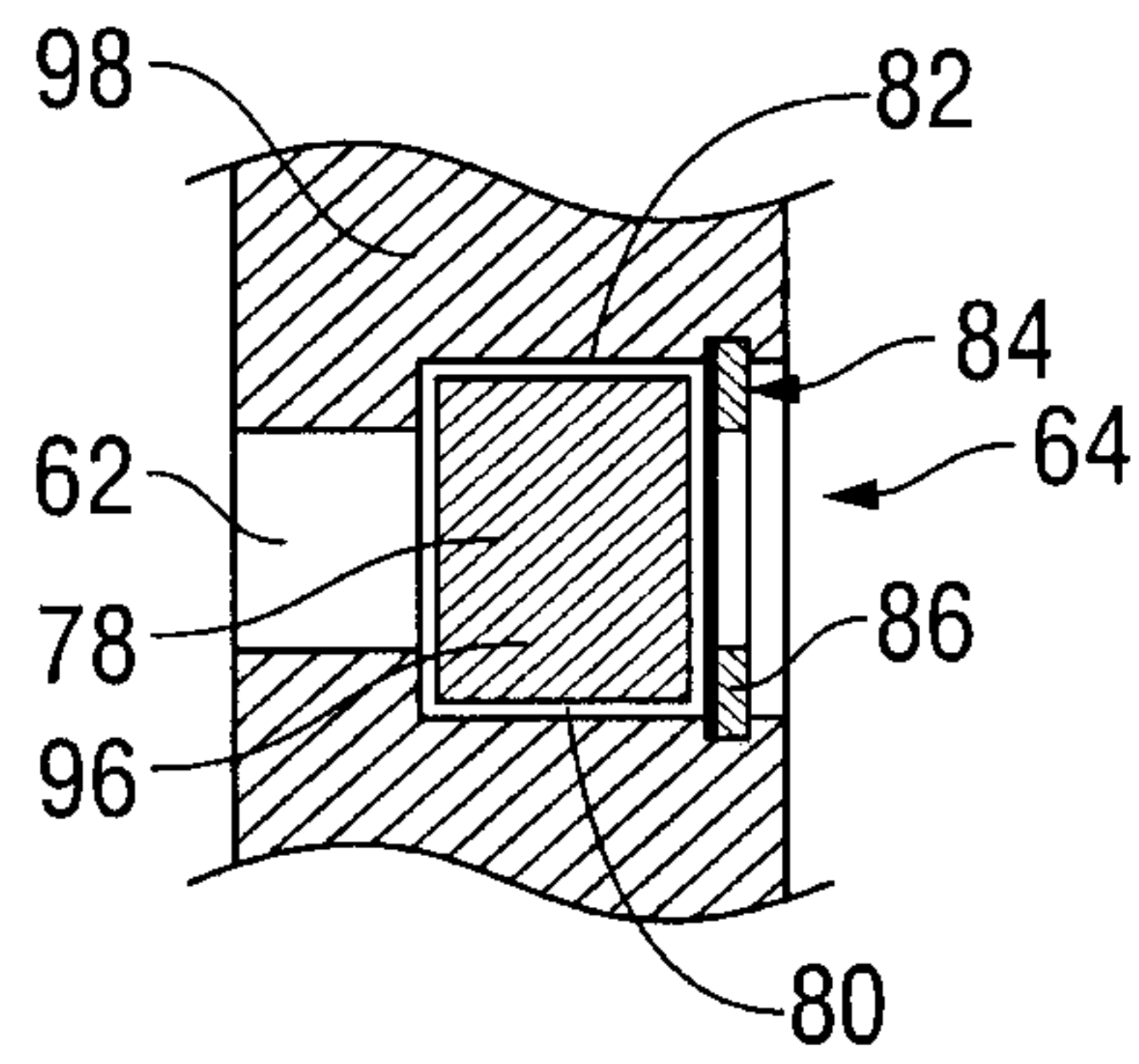


FIG. 4

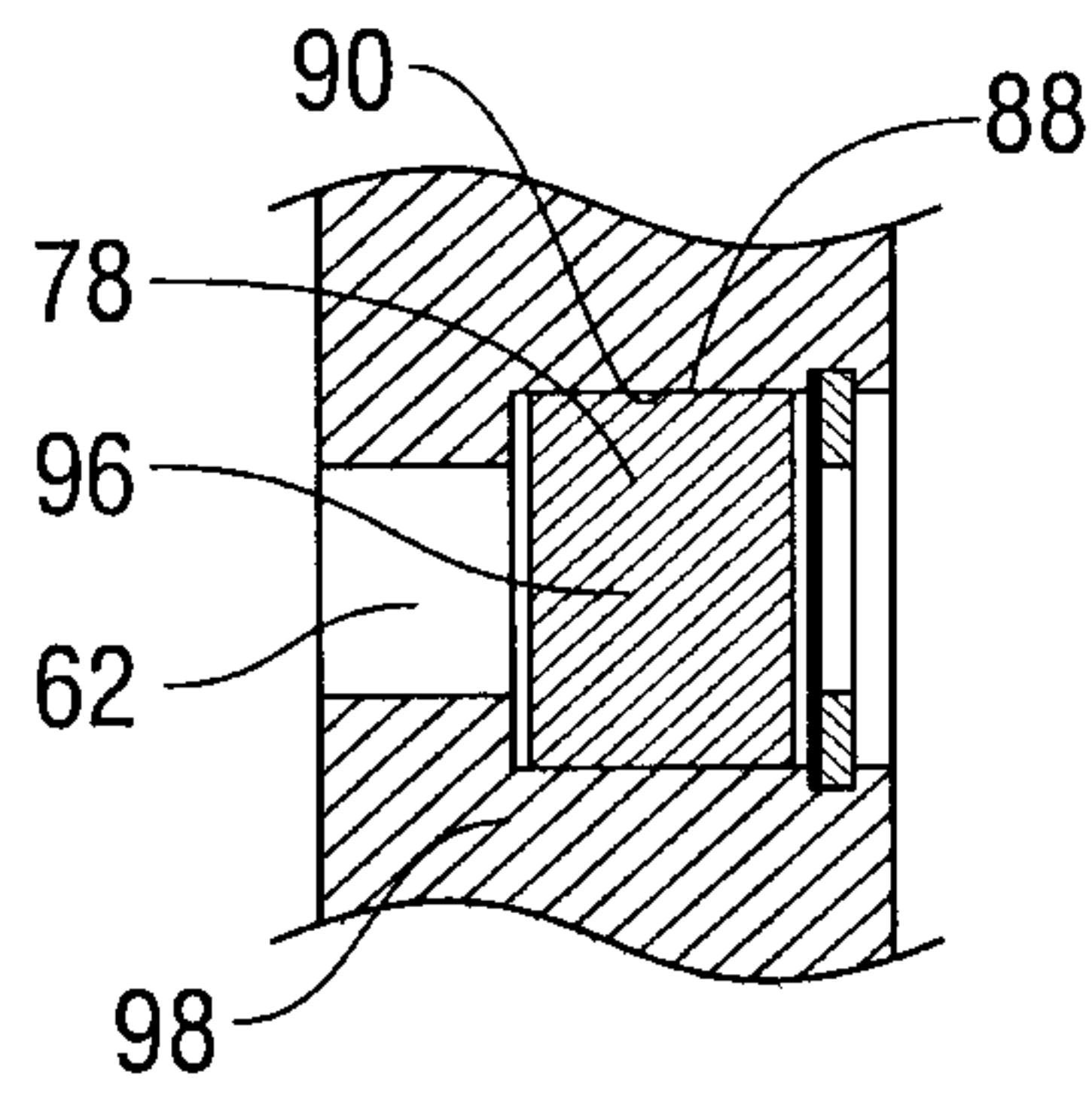


FIG. 5

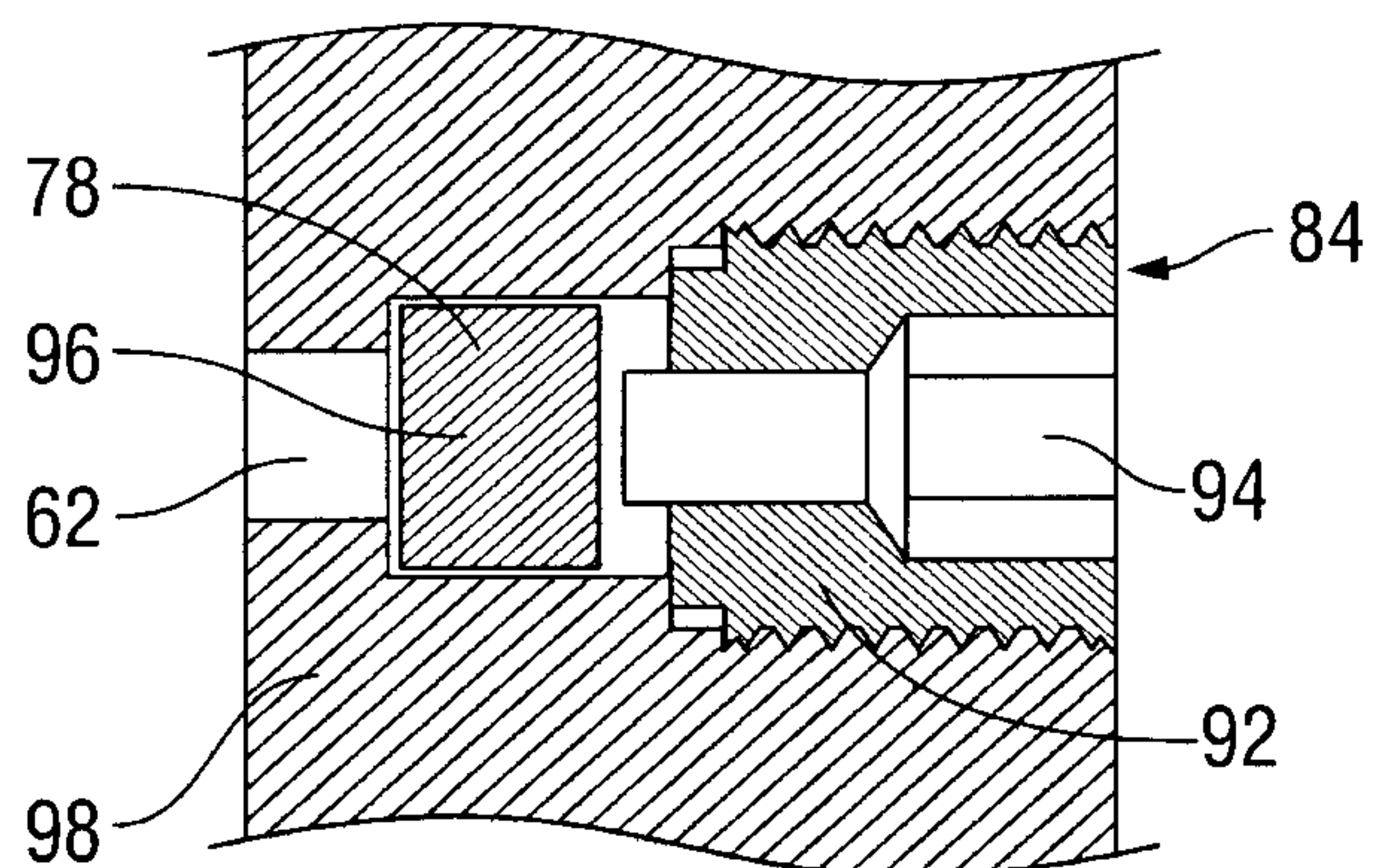


FIG. 6

