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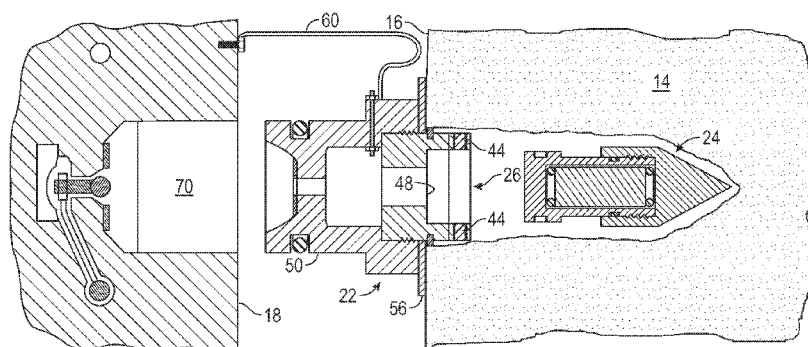


FIG. 5

(57) Abstract: A marker placement device, such as a modified coring gun, is used to place one or more markers into the formation. The marker placement device uses explosive charges to fire one or more marker assemblies into a borehole wall. A marker assembly includes a driver assembly which is adapted to be fired from the placement device and a marker which is releasably secured to the driver with frangible shear members.

SYSTEMS AND METHODS FOR PLACING MARKERS IN A FORMATION

CROSS REFERENCE TO RELATED APPLICATIONS

[0001] This application claims priority to U.S. Provisional Patent Application serial number 61/496,815 filed June 14, 2011.

BACKGROUND OF THE INVENTION

1. Field of the Invention

[0002] The invention relates generally to systems and methods for placing markers within a formation surrounding a wellbore.

2. Description of the Related Art

[0003] Conventional systems for placing markers along a wellbore typically place the markers on the interior surface of the wellbore. The markers that are placed may include radioactive markers.

SUMMARY OF THE INVENTION

[0004] In particular aspects, the present invention provides systems and methods for placing small markers into the formation outside of a wellbore. Preferably, the systems and methods of the invention position each of the markers a short, substantially fixed distance from the wellbore wall. When multiple markers are placed, they are each located a substantially uniform distance from the wellbore into the formation.

[0005] Marker assemblies are described that include a marker and a driver assembly which are secured to one another by frangible shear members. In a described embodiment, the marker includes a magnetic insert within an outer housing. In alternative embodiments, the marker can be an RF (radio frequency) tag. In a described embodiment, the housing of the marker is shaped to facilitate penetration of the borehole wall and surrounding formation. The marker is secured within a driver assembly that is adapted to be fired from and retrieved by a marker placement device. The driver assembly is preferably made up of a driver with an affixed sleeve.

[0006] In a described embodiment, a marker placement device, such as a modified coring gun, is used to place one or more markers into the formation. In described embodiments, the marker placement device uses explosive charges to fire one or more marker

assemblies into a borehole wall. A described marker assembly includes a driver assembly which is adapted to be fired from the placement device and a marker which is releasably secured to the driver assembly with frangible shear members. The marker and driver assembly will penetrate the wellbore wall. The driver assembly will be substantially retained within the wellbore wall. The shear members rupture as the marker assembly impacts the wellbore wall, permitting the marker to separate from the driver assembly and be disposed further outwardly into the formation. The driver assembly is then retrievable from the wellbore wall by a retrieval cable.

[0007] In particular aspects, the invention provides systems and methods for determining and monitoring the extent of compaction or expansion of the earth surrounding a wellbore. During the lifetime of a well, the earth surrounding the wellbore may change due to compaction or expansion. Monitoring of emplaced markers allows measurement of this compaction or expansion.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] For a thorough understanding of the present invention, reference is made to the following detailed description of the preferred embodiments, taken in conjunction with the accompanying drawings, wherein like reference numerals designate like or similar elements throughout the several figures of the drawings and wherein:

[0009] Figure 1 is a side, cross-sectional view of an exemplary wellbore having a tool disposed therein for placement of markers into the formation surrounding the wellbore in accordance with the present invention.

[0010] Figure 2 is a side, cross-sectional view of an exemplary marker assembly constructed in accordance with the present invention.

[0011] Figure 3 is a side, cross-sectional view of an exemplary marker assembly retained within a marker placement tool.

[0012] Figure 4 is a side, cross-sectional view of an exemplary marker assembly entering a surrounding wellbore wall.

[0013] Figure 5 is a side, cross-sectional view of an exemplary marker penetrating further into the formation surrounding the wellbore wall.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0014] Figure 1 depicts an exemplary wellbore 10 which has been drilled within the earth 12. The wellbore 10 passes through a hydrocarbon-bearing formation 14. The wellbore 10 presents an interior wellbore wall 16.

[0015] A marker placement tool 18 is disposed within the wellbore 10 on a wireline running string 20 and carries marker assemblies 22 having markers 24 that are to be disposed within the formation 14 at selected intervals or locations along the length of the wellbore 10. In preferred embodiments, the marker placement tool 18 comprises a coring gun of the type that uses explosive charges to fire coring samplers into a borehole wall and is equipped with retrieval cables for removing the samplers. In a currently preferred embodiment, the marker placement tool 18 is a Model 1812 Baker Atlas core gun which is available commercially from Baker Hughes Incorporated of Houston, Texas.

[0016] Figures 2 and 3 illustrate an exemplary marker assembly 22 constructed in accordance with the present invention. The marker assembly 22 includes a marker 24, sleeve 26, and a driver 50. The marker 24 and sleeve 26 are releasably secured to each other. The exemplary marker 24 includes a magnetic insert 28 that is retained within an outer housing 30. It is noted that, in alternative embodiments, the marker 24 can be an RF (radio frequency) marker of a type known in the art. The outer housing 30 preferably includes a housing cap 32 and a housing body 34 which are affixed together by a threaded connection 36. An O-ring seal 38 is preferably included in the connection 36 to ensure fluid tightness. In the depicted embodiment, the cap 32 is pointed to facilitate penetration of the wellbore wall 16 and formation 14. The outer housing 30 defines an interior chamber 40 which preferably completely contains the magnetic insert 28. Preferably, the outer housing 30 is formed of non-magnetic material, such as Nitronic 50 which is hardened to RC50+. In a particular embodiment, the magnetic insert 28 is a cylindrical magnet having a .5 inch diameter and which is 1 inch in length. Cushions 42 are preferably located within the chamber 40 at each axial end of the magnetic insert 28 and help protect the magnetic insert 28 against potential breakage as the marker assembly 22 is fired into the wellbore wall 16. In the depicted embodiment, the cushions 42 comprise elastomeric o-rings of a type known in the art.

[0017] The marker 24 is releasably secured to the sleeve 26 by one or more frangible shear members. Figure 2 illustrates shear screws 44 which are formed of a frangible or rupturable material, such as nylon polymer. It is currently preferred to use a soft rupturable

material, such as nylon, which enables the shear screws 44 to absorb some of the impact as the marker assembly 22 impacts the wellbore wall 16 before breaking away. In addition, because a soft rupturable material, such as nylon, will absorb some degree of shock before breaking, the use of this material will prevent them from breaking prematurely when marker assemblies above or below are fired using the same marker placement tool 18. The marker 24 is seated within a central bore 46 is formed within the sleeve 26. An upwardly-facing shoulder 48 is formed within the bore 46.

[0018] The sleeve 26 of the marker assembly 22 is secured to an enlarged cylindrical driver 50, which is preferably a modified driver of the type available commercially from Baker Hughes Incorporated of Houston, Texas. The sleeve 26 and affixed driver 50 collectively form a driver assembly. The sleeve 26 preferably acts as an adapter that permits the marker assembly 22 to be fired from a conventional core gun of the type used to obtain sidewall core samples. The driver 50 is preferably shaped and sized to be fired from a conventional sidewall coring gun of a type known in the art. The driver 50 preferably defines a recess 52 within which the sleeve 26 is securely seated. In the depicted embodiment, the sleeve 26 is threadedly affixed to the base 50 at a threaded connection 54. In the depicted embodiment, a Belleville washer 56 is secured about the circumference of the sleeve 26 by annular clip 58. A retrieval cable 60 is preferably affixed to the driver 50 at one end. The other end of the retrieval cable 60 is secured to the marker placement tool 18 (see, Figures 4 and 5).

[0019] Figure 3 also illustrates various components of an exemplary detonation mechanism of the marker placement tool 18. Hot line electrical cable 62 extends through the tool 18 and is interconnected with lateral conductor 64 which leads to contact pin 66. Explosive charge 68 resides within recess 70 within the body of the tool 18.

[0020] In operation, the marker placement tool 18 is disposed within the wellbore 10 until one or more markers 24 are located adjacent a location in the wellbore 10 wherein it is desired to place a marker 24. The marker placement tool 18 is then actuated to detonate explosive charges 68 to launch one or more of the marker assemblies 22 toward the wellbore wall 16 and surrounding formation 14. The amount of explosive or relative effectiveness of the explosive used may be varied to compensate for formation strength or other formation properties.

[0021] Figures 4 and 5 illustrate a single marker assembly 22 being fired from the marker placement tool 18. As the marker assembly 22 impacts the wall 16 (Figure 4), the

shear members 44 rupture as the marker 24 is urged into contact with the shoulder 48 in bore 46. The ability of the marker 24 to move axially downwardly within the bore 46 to the shoulder 48 assists the shear members 44 in fully breaking away and freeing the marker 24 from the sleeve 26 and the driver 50.

[0022] Figure 5 depicts a further point in time after the marker assembly 22 has been fired from the marker placement tool 18. The driver 50 and sleeve 26 have become lodged within the wellbore wall 16. Belleville washer 56 flattens out against the formation 14 and helps to prevent the driver 50 and sleeve 26 from lodging into the formation 14. The marker 24, now separated from the driver 50 and sleeve 26, passes beyond the wall 16 and into the formation 14, as depicted in Figure 5. It is noted that the marker 24 will be disposed a substantially fixed distance from the wellbore wall 16. Firing of other marker assemblies 22 will result in other markers 24 being positioned a relatively equal distance into the formation 14.

[0023] After the desired marker 24 or markers 24 have been placed into the formation 14, the running string 22 is withdrawn from the wellbore 10. The retrieval cables 60 cause the drivers 50 and sleeves 26 to be retrieved while the markers 24 are left in place within the formation 14. The presence of the markers 24 can thereafter be detected by casing collar locators, acoustic imagers, magnetometers, radio frequency devices or other equipment known in the art. Movement of a marker 24 upwardly or downwardly with respect to neighboring markers 24 will indicate compaction or expansion of the formation 14.

[0024] Those of skill in the art will recognize that numerous modifications and changes may be made to the exemplary designs and embodiments described herein. The invention is limited only by the claims that follow and any equivalents thereof.

CLAIMS

What is claimed is:

1. A marker assembly to be fired from a marker placement tool to place a marker in a formation surrounding a wellbore, the marker assembly comprising:
 - a marker to be disposed within the formation;
 - a driver assembly that is shaped and sized to be fired from a marker placement tool;and
the driver assembly being releasably secured to the marker.
2. The marker assembly of claim 1 wherein the marker further comprises:
 - an outer housing defining an interior chamber;
 - a magnetic insert retained within the chamber.
3. The marker assembly of claim 1 wherein the marker further comprises an RF marker.
4. The marker assembly of claim 1 further comprising a cushion within the chamber to protect the magnetic insert from breakage.
5. The marker assembly of claim 1 wherein the driver assembly is releasably secured to the marker by a frangible shear member.
6. The marker assembly of claim 5 wherein the frangible shear member comprises a shear screw formed of polymer.
7. The marker assembly of claim 2 wherein the housing is non-magnetic.
8. The marker assembly of claim 1 further comprising a retrieval cable affixed to the driver assembly for retrieving the driver assembly.
9. A system for placing markers within a formation surrounding a wellbore, the system comprising:
 - a marker placement tool for firing a marker assembly into the formation;
 - a marker assembly comprising:
 - a marker to be disposed within the formation;
 - a driver assembly that is shaped and sized to be fired from a marker placement tool;and
the driver assembly being releasably secured to the marker.
10. The system of claim 9 wherein the marker placement tool comprises a sidewall coring gun.

11. The system of claim 9 wherein the marker further comprises:
an outer housing defining an interior chamber;
a magnetic insert retained within the chamber.
12. The system of claim 11 further comprising a cushion within the chamber to protect the magnetic insert from breakage.
13. The system of claim 9 wherein the driver assembly is releasably secured to the marker by a frangible shear member.
14. The system of claim 13 wherein the frangible shear member comprises a shear screw formed of polymer.
15. The system of claim 11 wherein the housing is non-magnetic.
16. The system of claim 9 further comprising a retrieval cable extending between the driver assembly and the marker placement tool for retrieval of the driver assembly.
17. A method of placing markers within a formation surrounding a wellbore having a wellbore wall, the method comprising the steps of:
 - a) disposing a marker placement tool within a wellbore;
 - b) firing a marker assembly from the marker placement tool into the wellbore wall, the marker assembly having a marker to be disposed within the formation and a driver assembly that is shaped and sized to be fired from the marker placement tool;
 - c) lodging the driver assembly in the wellbore wall; and
 - d) separating the marker from the driver assembly, allowing the marker to penetrate into the formation beyond the wellbore wall.
18. The method of claim 17 wherein the step of separating the marker from the driver assembly further comprises shearing a frangible shear member.
19. The method of claim 17 further comprising the step of retrieving the driver assembly from the wellbore wall.
20. The method of claim 19 wherein the driver assembly is retrieved from the wellbore wall by a retrieval cable that interconnects the driver assembly with the marker placement tool.

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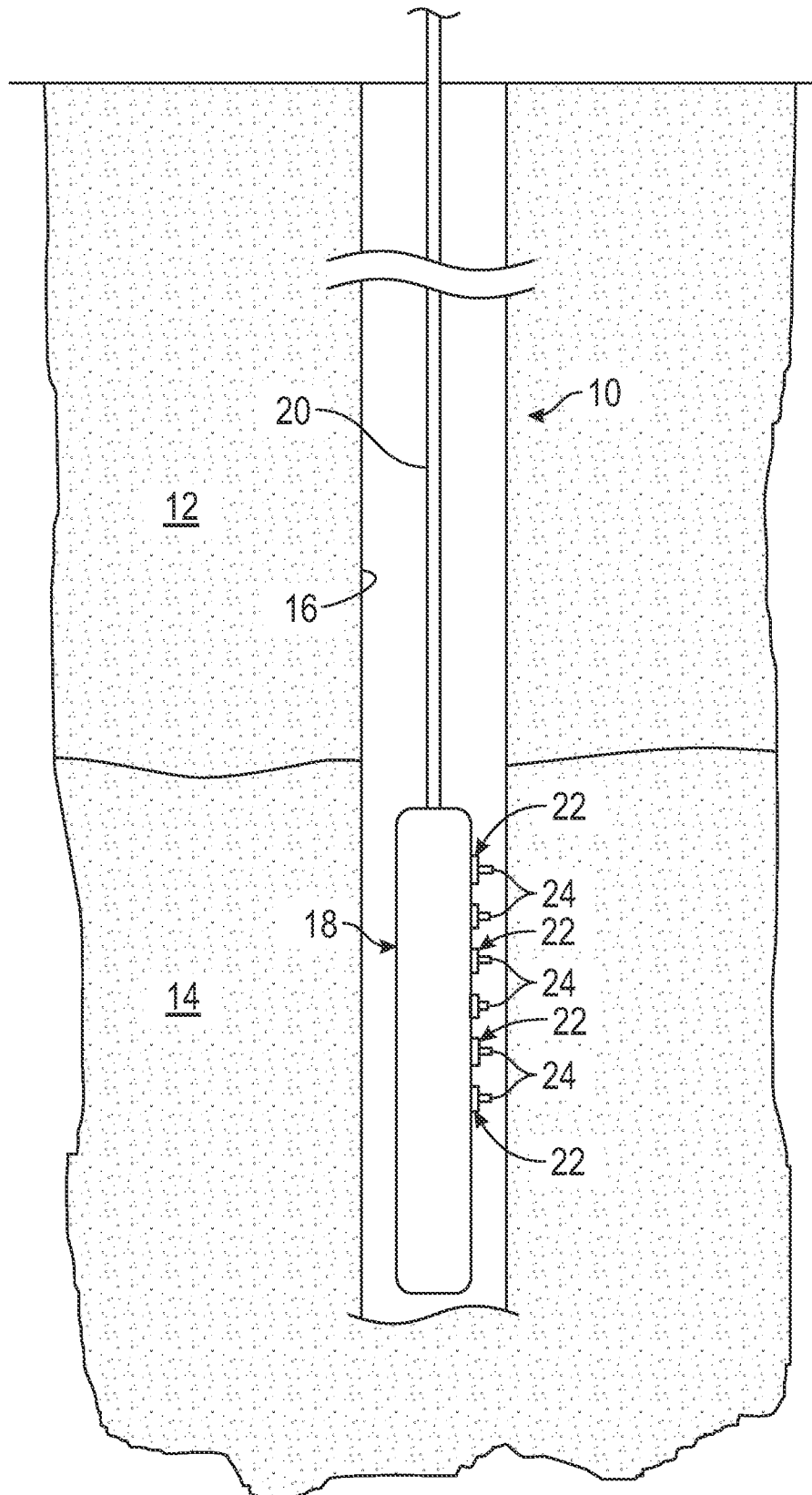


FIG. 1

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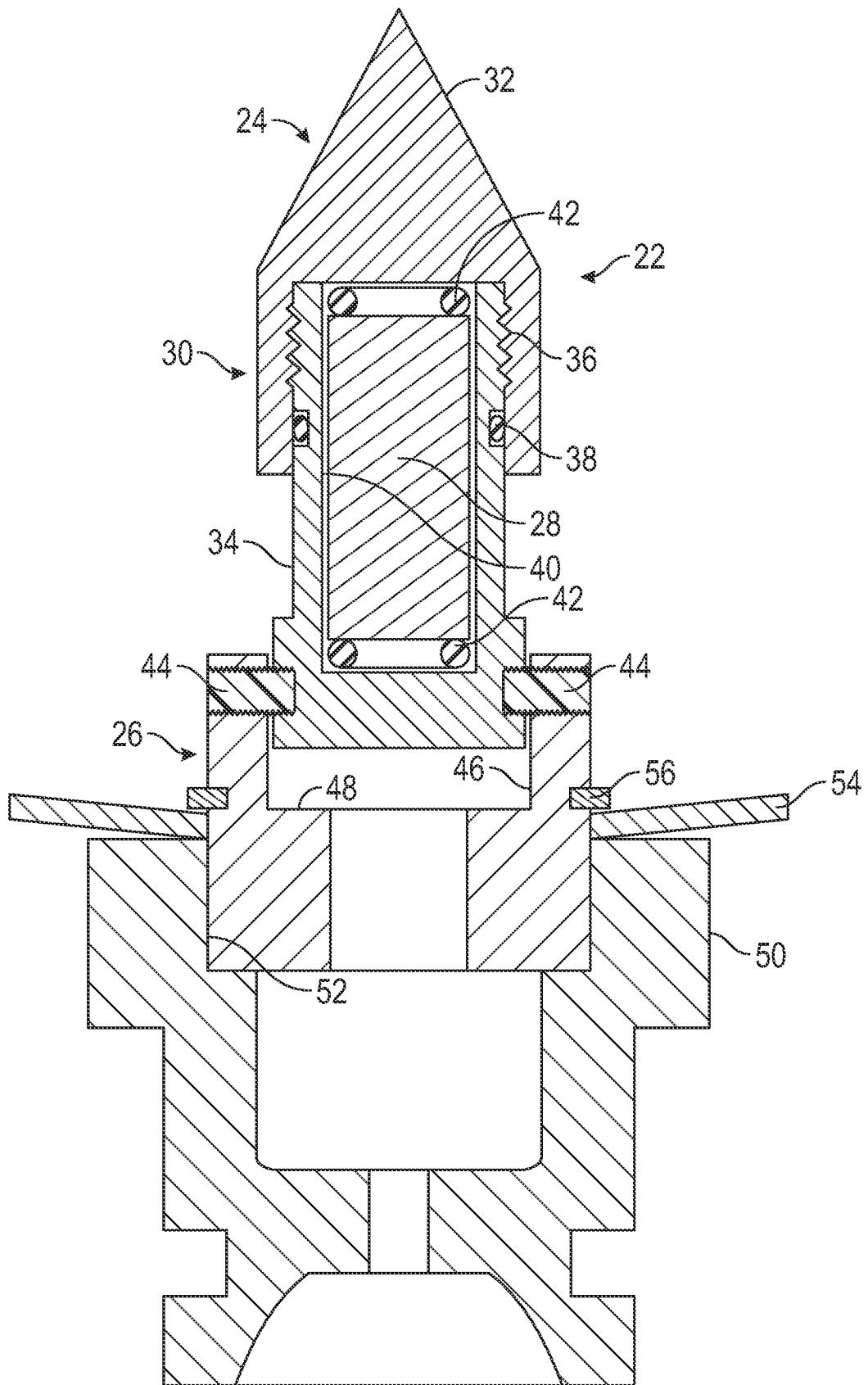


FIG. 2

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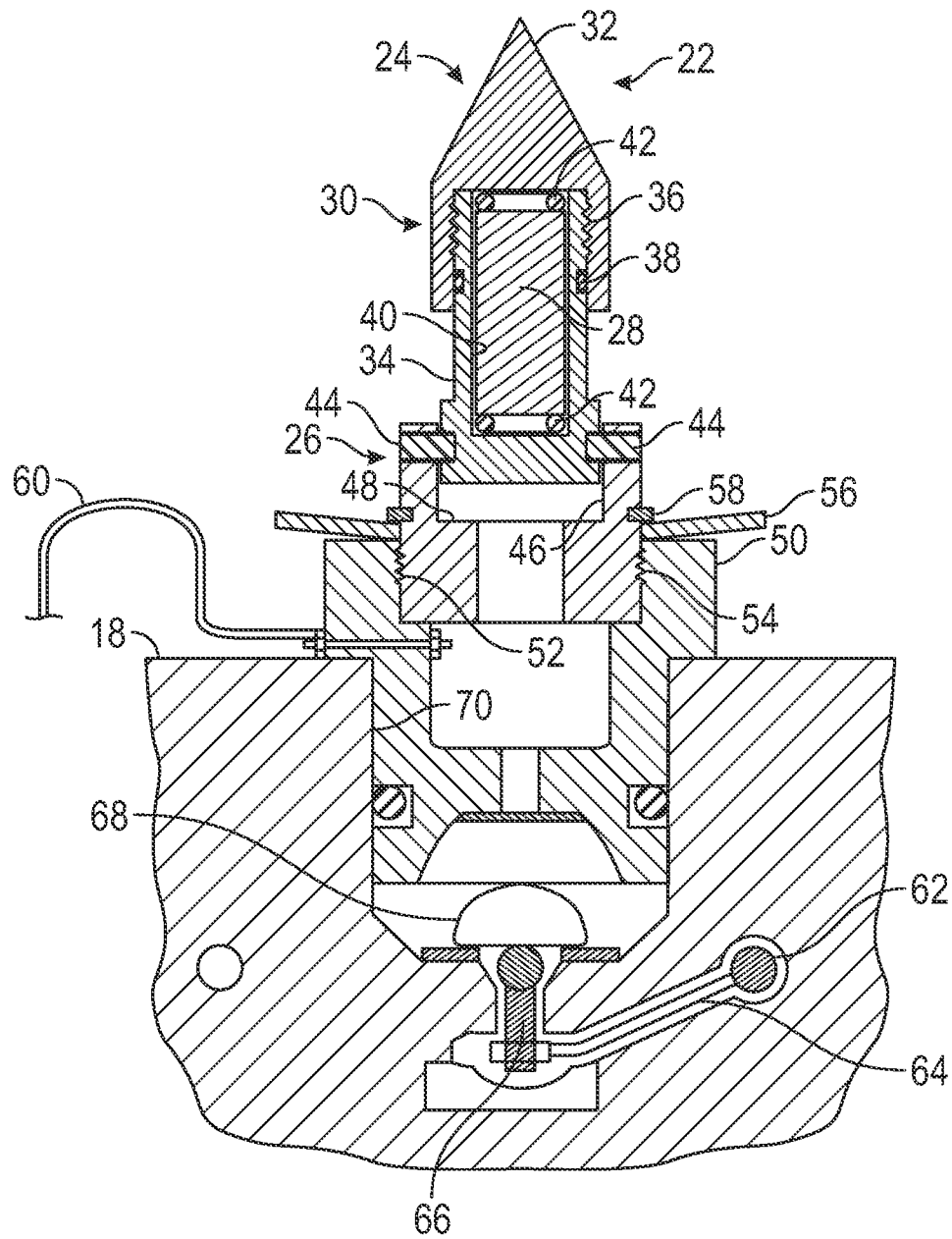


FIG. 3

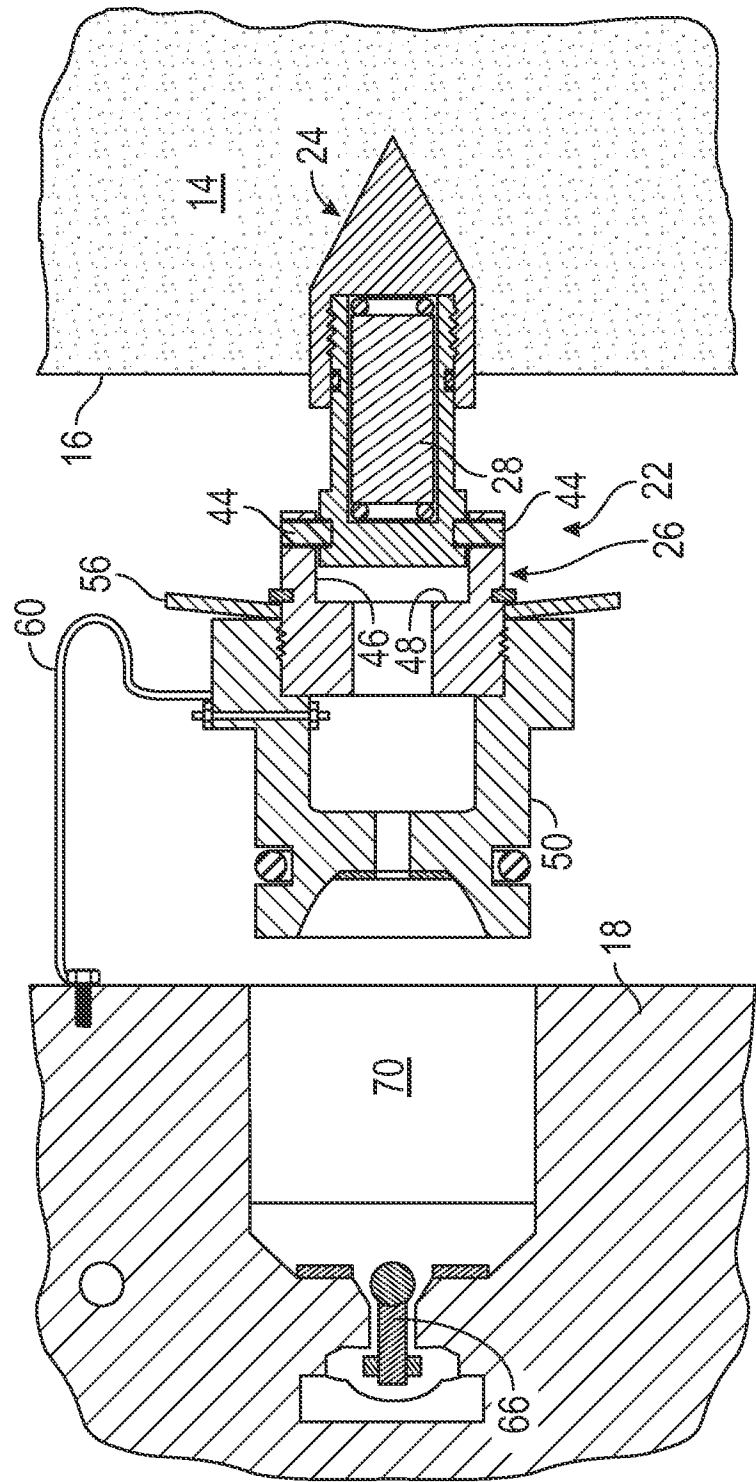


FIG. 4

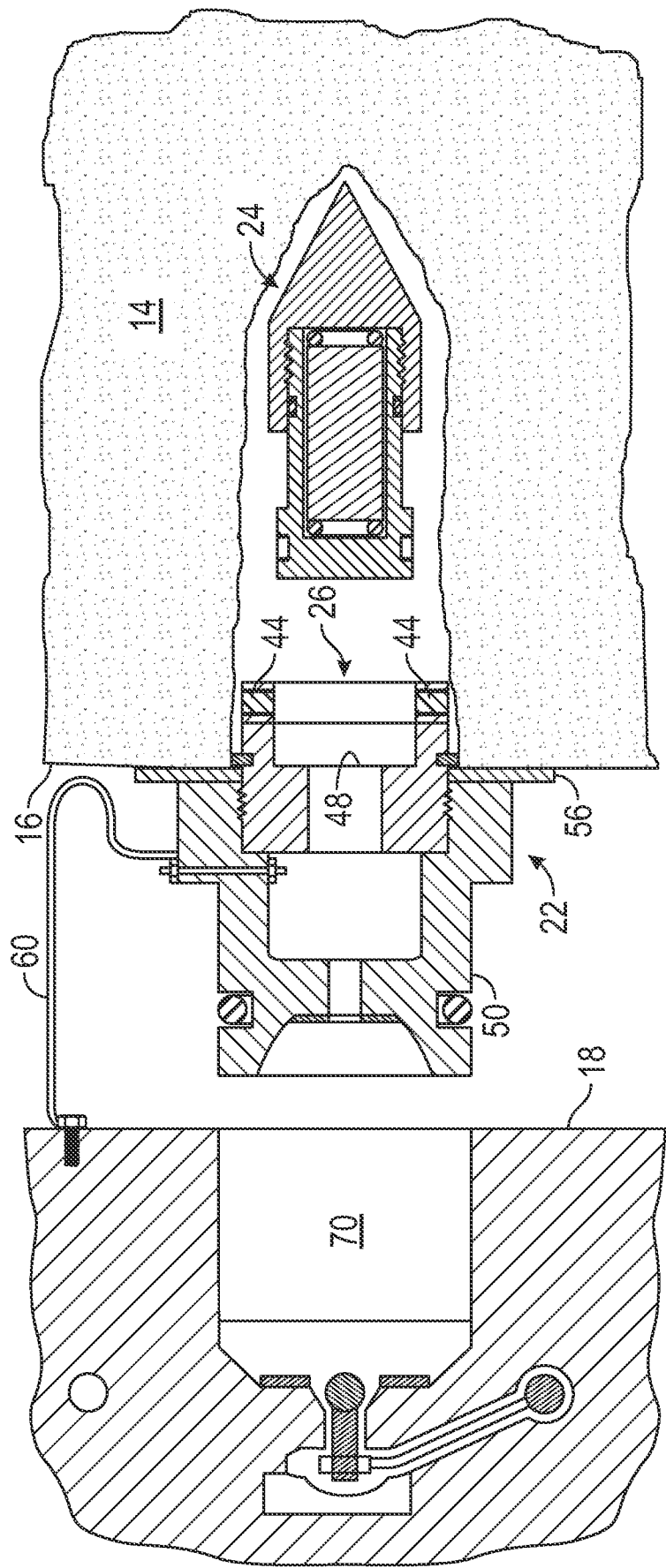


FIG. 5