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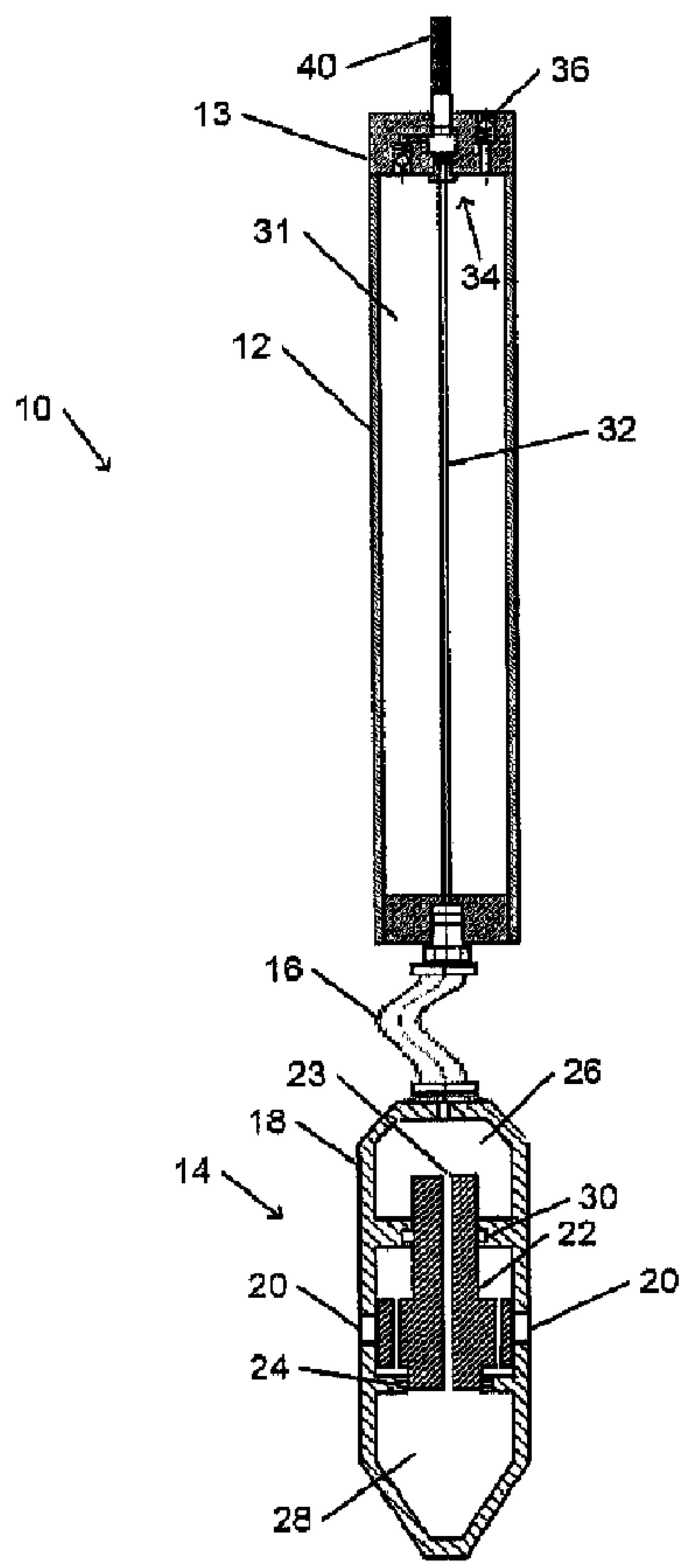

(57) Abrégé/Abstract:
A self-contained gas impulse apparatus includes a gas impulse unit for generating a plurality of gas blasts when supplied with pressurized gas. A gas supply unit is connected by a gas conduit to the gas impulse unit. The gas supply unit is configured to be

(57) Abrégé(suite)/Abstract(continued):
remotely activated to supply pressurized gas via the conduit to the gas impulse unit. The self-contained gas impulse apparatus is transportable by a cable to and from a remote location for operation at the remote location.

ABSTRACT

A self-contained gas impulse apparatus includes a gas impulse unit for generating a plurality of gas blasts when supplied with pressurized gas. A gas supply unit is connected by a gas conduit to the gas impulse unit. The gas supply unit is configured to be remotely activated to supply pressurized gas via the conduit to the gas impulse unit. The self-contained gas impulse apparatus is transportable by a cable to and from a remote location for operation at the remote location.

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SELF-CONTAINED GAS IMPULSE CREATION

FIELD OF THE INVENTION

[0001] The present invention relates to remote creation of gas impulses by a self-contained apparatus.

BACKGROUND OF THE INVENTION

[0002] During the course of its lifetime, the production capacity of an oil, gas, or water well may deteriorate for any of several reasons. Well capacity may be restored by using a stimulation process.

[0003] Propellant stimulation is one method employed for oil well stimulation. In propellant stimulation, tubing or a wireline that delivers a gas-generating propellant is lowered to a perforation zone of the well or an open borehole. The propellant is then ignited to produce a single high-pressure gas wave. Adjustment of pulse pressure and energy in accordance with specific well conditions may be problematic, since the charge is typically of a standard manufactured size. Poor pressure control could result in damage to the well. The typically requirement of hundreds or thousands of feet of tamping fluid above the propellant gun may make propellant stimulation difficult to use under some well conditions. In addition, propellant stimulation may not be very efficient. Some of the propellant energy is wasted in the formation of secondary waves that travel along the well casing and which could damage hardware in the well.

[0004] Use of gas impulse devices or air guns is well known in well rehabilitation. Gas impulse devices operate by repeated sudden discharge of pressurized gas, such as air or nitrogen, from a pressurization chamber into the surrounding environment. The rapid discharge of pressurized gas produces a gas blast. After each blast cycle, the pressurized chamber is blocked off from the environment by a piston unit. The chamber is pressurized during operation by delivery of high-pressure gas from the surface.

[0005] In US Patent No. 6,250,388, Carmi et al. describe a gas impulse device for water or oil well rehabilitation and stimulation. The device creates sudden blasts of high-pressure compressed gas. During operation of the device, the device continuously receives pressurized gas, such as compressed air, nitrogen or carbon dioxide, from a pressurized gas source that is located at the surface. The creation of gas blasts may be controlled by self-firing of the gas impulse device, or the gas impulse device may be remotely controlled by electrical activation.

[0006] In US Patent No. 5,297,631, Gipson describes an electrically activated air gun that may be applied to cleaning of an oil well. The air gun is deployed by means of a coil tubing conduit that is connected at its distal end to the air gun. The conduit houses a high-pressure compressed gas supply line and an electrical power transmission line that connect to the gun.

[0007] Supplying highly pressurized compressed gas in deep wells may be problematic. In shallow (e.g., less than 500 m deep) wells, a flexible hose may be used to supply gas to a gas impulse device or air gun. Using such a hose in deeper wells (deeper than 500m, e.g. 2 kilometers deep) may be limited by such factors as the size of the hose reel, or by the possibility of a flexible hose becoming stuck or breaking in the well. Furthermore, it may be difficult to precisely control the depth of the device under such circumstances, since a hose may uncontrollably elongate under its own weight with increasing depth. Use of coil tubing that contains both internal gas and electrical lines may present logistic difficulties or may be expensive. Depth of operation may be further limited by pressure loss when supplying compressed gas to the device from a distant source at the surface. Reduced pressure of the compressed gas may result in decreased energy in a gas blast.

[0008] When the source of high pressure gas for use in a well remains at the surface, a high pressure gas conduit is required, e.g., in the form of tubing or coil tubing. Running the tubing to the required depth and bringing the tubing back to the surface may be time consuming, e.g., requiring several work shifts of personnel, as well as requiring an expensive drilling or workover rig. If the tubing is not kept clean, debris falling via the tube may clog passages in the air gun, interfering with operation of the air gun. Coil tubing, although capable of being run to the required depth in less time, is itself expensive.

The extremely large amount of gas that is required in order to fill the tubing prior to air gun activation requires a high-capacity nitrogen truck, further increasing expenses.

Thus, there is a need for a cost-effective yet highly effective method for oil, gas and water well stimulation.

SUMMARY OF THE INVENTION

[0009] There is thus provided, in accordance with some embodiments of the present invention, a self-contained gas impulse apparatus including: a gas impulse unit for generating a plurality of gas blasts when supplied with pressurized gas; and a gas supply unit connected by a gas conduit to the gas impulse unit, the gas supply unit being configured to be remotely activated to supply pressurized gas via the conduit to the gas impulse unit, wherein the self-contained gas impulse apparatus is transportable by a cable to and from a remote location for operation at the remote location.

[0010] Furthermore, in accordance with some embodiments of the present invention, the apparatus is connected to the cable.

[0011] Furthermore, in accordance with some embodiments of the present invention, the cable includes a wireline or a slickline.

[0012] Furthermore, in accordance with some embodiments of the present invention, the gas supply unit includes a compressed gas storage unit that is fillable with a compressed gas.

[0013] Furthermore, in accordance with some embodiments of the present invention, the compressed gas storage unit includes a barrier to initially prevent flow of the compressed gas from the compressed gas storage unit to the gas impulse unit and an activation device for opening the barrier.

[0014] Furthermore, in accordance with some embodiments of the present invention, the activation device includes a squib.

[0015] Furthermore, in accordance with some embodiments of the present invention, the barrier includes a piston or a sealing disk.

[0016] Furthermore, in accordance with some embodiments of the present invention, the gas supply unit includes a gas generator unit that is fillable with a gas generation material.

[0017] Furthermore, in accordance with some embodiments of the present invention, the gas generator unit is activable by initiation of a gas-generating reaction in the gas generation material.

[0018] Furthermore, in accordance with some embodiments of the present invention, gas generation material includes a solid propellant.

[0019] Furthermore, in accordance with some embodiments of the present invention, the apparatus includes an igniter for initiating the reaction.

[0020] Furthermore, in accordance with some embodiments of the present invention, the gas generation material includes a liquefied gas.

[0021] Furthermore, in accordance with some embodiments of the present invention, the gas supply unit is configured to hang below the gas impulse unit when being transported to or from the remote location.

[0022] Furthermore, in accordance with some embodiments of the present invention, the apparatus is configured to be lowered to the remote location at a depth of at least 50 meters within a well.

[0023] Furthermore, in accordance with some embodiments of the present invention, the gas supply unit is configured to be remotely activated via an electrically conducting wire.

[0024] There is further provided, in accordance with some embodiments of the present invention, a method for generating gas impulses at a remote location, the method including: providing a self-contained gas impulse apparatus that includes a gas impulse unit and a gas supply unit that is connected to the gas impulse unit by a gas conduit; using a cable to transport the apparatus to the remote location; and activating the gas supply unit to supply pressurized gas to the gas impulse unit such that the gas impulse unit generates a plurality of gas blasts.

[0025] Furthermore, in accordance with some embodiments of the present invention, using a cable to transport the apparatus includes lowering the apparatus into a well to a depth of at least 50 meters.

[0026] Furthermore, in accordance with some embodiments of the present invention, remotely activating the gas supply unit includes transmitting an activation signal to the apparatus.

[0027] Furthermore, in accordance with some embodiments of the present invention, remotely activating the gas supply unit includes setting a delay mechanism.

[0028] Furthermore, in accordance with some embodiments of the present invention, remotely activating the gas supply unit includes opening a barrier that initially prevents flow of the pressurized gas from the gas supply unit to the gas impulse unit, or initiating a process that generates the pressurized gas within the gas supply unit.

BRIEF DESCRIPTION OF THE DRAWINGS

[0029] In order to better understand the present invention, and appreciate its practical applications, the following Figures are provided and referenced hereafter. Like components are denoted by like reference numerals.

[0030] Fig. 1A shows an axial sectional view of self-contained gas impulse apparatus, with a gas supply unit and gas impulse unit, in accordance with an embodiment of the present invention.

[0031] Fig. 1B illustrates operation of the self-contained gas impulse apparatus shown in Fig. 1A.

[0032] Fig. 2 shows details of an end cap of the gas supply unit shown in Fig. 1A.

[0033] Fig. 3A shows an end cap with a micro gas generator and a piston activation system of the gas supply unit, shown in Fig. 1A in accordance with embodiments of the present invention.

[0034] Fig. 3B illustrates the micro gas generator and piston activation system shown in Fig. 3A after activation.

[0035] Fig. 4 shows a self-contained gas impulse apparatus with a gas generator unit, in accordance with an embodiment of the present invention.

[0036] Fig. 5 schematically illustrates a method for generating gas impulses at a remote location, in accordance with an embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

[0037] In the following detailed description, numerous specific details are set forth in order to provide a thorough understanding of the invention. However, it will be understood by those of ordinary skill in the art that the invention may be practiced without these specific details. In other instances, well-known methods, procedures, components, modules, units and/or circuits have not been described in detail so as not to obscure the invention.

[0038] In accordance with embodiments of the present invention, a self-contained gas impulse apparatus includes a high-pressure gas impulse unit and a connected gas supply unit. The gas supply unit may include, for example, a compressed gas storage unit or a gas generator unit. The gas impulse unit and gas supply unit may be permanently attached to one another (e.g., enclosed or encased in a single housing, or welded, bolted or otherwise permanently attached to one another), or may be separable from one another (e.g., configured to be assembled on site).

[0039] The gas supply unit is configured to be delivered together with the gas impulse unit to the remote location. The gas supply unit serves to provide compressed or pressurized gas for operation of the gas impulse unit. The gas supply unit is connected to the gas supply unit by a conduit (e.g., flexible or inflexible, to be understood as including a hole or passageway between a permanently attached gas supply unit and gas impulse unit) that is suitable for providing gas to the gas impulse unit at a rate that is suitable for operation of the gas impulse unit. The self-contained gas impulse apparatus is self-contained in that the gas impulse unit of the apparatus may operate without any delivery of compressed gas from an external source during operation. The gas supply unit is remotely activable to provide compressed or pressurized gas to the gas impulse unit. As used herein, a gas supply unit is considered to be remotely activable when the gas supply unit is configurable to provide gas only after the self-contained gas impulse apparatus is delivered to a remote location. A remotely activable activation device of the gas supply unit may be remotely activated by an operator via a transmitted signal (e.g., via an electrical or other wired or cabled connection, or via a wireless connection), or by setting a delay mechanism that activates the activation device after a predetermined period of time or under predetermined conditions (e.g. depth, pressure, temperature, or ambient fluid chemistry). The activation device may include, for example, a squib (micro gas generator) or valve (e.g., solenoid operated) for releasing gas in a compressed gas storage unit, or an appropriate initiator (e.g., igniter, catalyst, or heater) for initiating or driving a gas-producing process (e.g., chemical reaction or phase change) in a gas generator unit.

[0040] Thus, the self-contained gas impulse apparatus may be delivered to any depth of an oil well or other well (e.g., to a depth of the well that is greater than 50 meters, 500 meters, 1000 meters, 2000 meters, or more), or to another remote location. No gas flow connection is required between the self-contained gas impulse apparatus and an external gas storage facility. Use of a self-contained gas impulse apparatus in accordance with embodiments of the present invention in an oil well or other deep well may overcome known limitations of other devices. For example, the self-contained gas impulse apparatus may produce multiple high-pressure impulses (firings), the pressure is not limited by an external connection, and no high-pressure conduit or tamping fluid is required. A self-contained gas impulse apparatus may be transported, e.g., into or out of a deep well, using an appropriate cable (e.g. wireline or slickline). Use of cable to transport the self-contained gas impulse apparatus may be advantageous over transport using tubing of devices in which gas storage is not self-contained. Use of cable may enable quicker (or less expensive) transportation of the self-contained gas impulse apparatus into and out of a well than would be possible for a device in which gas storage is not self-contained.

[0041] The pressure provided to a gas impulse unit of a self-contained gas impulse apparatus in accordance with embodiments of the present invention may be as high as 1300 bars, or as low as 50 bars, or, more particularly, in a range of 200 bars to 700 bars.

[0042] In accordance with embodiments of the present invention, a method for creation of gas impulses at a remote location includes delivering a self-contained gas impulse apparatus to the location. At the time that the self-contained gas impulse apparatus is delivered, no gas flows from the gas supply unit to the gas impulse unit. For example, a barrier in the form of a sealing disk, diaphragm, plug, or closed valve may prevent the flow of gas from a compressed gas supply unit to the gas impulse unit. As another example, a gas-generating process (e.g., reaction) in a gas generation unit may not yet have been initiated.

[0043] When the gas supply unit and gas impulse unit are separable from one another, the gas supply unit may be attached to the gas impulse unit by a short conduit prior to delivery of the self-contained gas impulse apparatus to the remote location. A gas supply unit in the form of a compressed gas storage unit may be filled with compressed gas up to a predetermined pressure prior to delivery. For example, when the self-contained gas impulse apparatus is to be lowered into a well, the filling of the compressed gas storage unit may take place at the surface, e.g., in the vicinity of the well. The compressed gas storage unit may be filled with a compressed gas by a high-pressure gas bottle, or by a gas compressor and/or booster pump for pressurizing supplied gas (or ambient gas). A gas supply unit in the form of a gas generator unit may be filled with a gas generation material (e.g., a solid propellant that may be combusted to create pressurized gas, or a liquefied gas such as liquid nitrogen that may be heated to release pressurized gas) in which an appropriate gas-generating process (e.g., chemical or combustive reaction, or phase change from liquid to gas) may be initiated.

[0044] If the gas supply unit is to be activated by a delay mechanism (e.g., timer or sensor-triggered device), the delay mechanism may be preset to a desired value (e.g., time or environment-related quantity such as pressure or temperature).

[0045] The self-contained gas impulse apparatus may then be delivered to the remote location. For example, when the self-contained gas impulse apparatus is to be lowered into a well, the self-contained gas impulse apparatus may be attached to an appropriate cable, e.g., a wireline, logging cable, or another line (e.g., optical fiber or wave guide) that may be capable of conducting an electrical signal, or other (e.g., optical or electromagnetic) signal. The self-contained gas impulse apparatus is then lowered into the well to a desired depth, e.g., to a perforation interval, borehole-formation face, or production zone.

[0046] The self-contained gas impulse apparatus may be activated so as to generate a series of gas blasts. For example, an activating electrical (or optical, electromagnetic or other transmissible) signal may be transmitted to the self-contained gas impulse apparatus. The electrical signal may be generated by a signal generation unit that is accessible to an operator of the self-contained gas impulse apparatus. For example, the electrical signal may activate a squib (micro gas generator), solenoid, or other activation device that opens a component that had previously prevented flow of gas from a gas supply unit in the form of a compressed gas storage unit to the gas impulse unit. As another example, the electrical signal may trigger a process (e.g., combustive or other chemical reaction, or heating of a liquefied gas) that creates pressurized gas in a gas supply unit in the form of a gas generator unit.

[0047] Alternatively to a transmitted signal, the activation device may be activated by a local delay device. For example, a timer, pressure switch, temperature sensor, or similar device may be preset to operate the activation device at a predetermined time or under predetermined conditions that indicate arrival of the self-contained gas impulse apparatus at the remote location, e.g., to the desired depth.

[0048] When activated, a flow of pressurized gas from the gas supply unit to the gas impulse unit causes the gas impulse unit to operate. Operation of the gas impulse unit creates high-pressure gas impulses as long as a sufficient supply of gas is continued at a sufficient rate. In accordance with some embodiments of the present invention, the self-contained gas impulse apparatus may be gradually propelled along a well screen, perforation interval, production zone, or other region of the remote location as gas impulses are repeatedly created. For example, the generated gas impulses or blasts may be aimed so as to apply a propulsion force to the gas impulse device and to the self-contained gas impulse apparatus.

[0049] A self-contained gas impulse apparatus in accordance with embodiments of the present invention may be operated to provide gas impulses for various tasks that are associated with well stimulation. Such tasks include, for example, perforation cleaning, removing debris, creating near-wellbore fracturing, repairing formation damage, enhancing acid treatment or regular hydraulic fracturing, improving gravel pack placement, inducing sand flow into wells for cold heavy production with sand, exact injecting of chemicals or other materials, rehabilitating wells, or other stimulation procedures.

[0050] Fig. 1A shows an axial sectional view of self-contained gas impulse apparatus, in accordance with an embodiment of the present invention. Self-contained gas impulse apparatus 10 includes compressed gas storage unit 12. Compressed gas storage unit 12 is connected to gas impulse unit 14 via gas conduit 16. Compressed gas storage unit 12 and gas impulse unit 14 are shown in Fig. 1A as separate structures connected by an external gas conduit 16. In accordance with some embodiments of the present invention, the compressed gas storage unit, the gas impulse unit, and the gas conduit may be incorporated into a single structure.

[0051] As shown, gas impulse unit 14 is in the form of an air gun with housing 18. Gas blasts may be discharged via one or more gas discharge ports 20. Fig. 1B illustrates operation of the self-contained gas impulse apparatus shown in Fig. 1A. In the illustrated mechanism, piston 22 has a bore 23 and is configured to move back and forth within housing 18. First seal arrangement 24 and second seal arrangement 30 prevent gas flow between inlet chamber 26 and pressurization chamber 28 except via bore 23. When pressurized gas flows into inlet chamber 26 via gas conduit 16, piston 22 is alternatively forced toward pressurization chamber 28 and toward inlet chamber 26. When piston 22 is nearest to inlet chamber 26, the initial greater gas pressure in inlet chamber 26 forces piston 22 toward pressurization chamber 28. When piston 22 is nearest to pressurization chamber 28, escape of gas via gas discharge ports 20 is prevented and gas pressure increases within pressurization chamber 28. In time, e.g., after a few seconds, the gas pressure in pressurization chamber 28 increases to a pressure that approaches the gas pressure in inlet chamber 26. Gas impulse unit 14 is configured such that the surface area of the end of piston 22 that faces pressurization chamber 28 is greater than the surface area of piston 22 that faces inlet chamber 26. Therefore, the force resulting from pressure buildup in pressurization chamber 28 forces piston 22 back toward inlet chamber 26. Piston 22 is shaped such that after being pushed slightly toward inlet chamber 26, the surface area that is presented to pressurization chamber 28 suddenly increases. Thus, piston 22 is pushed rapidly toward inlet chamber 26. Gas discharge ports 20 are then suddenly uncovered such that gas may escape from pressurization chamber 28 vial gas discharge ports 20. The result is a sudden release of a gas blast through gas discharge ports 20, as indicated by gas flow 21.

[0052] Once the gas pressure in pressurization chamber 28 is released, then continuously incoming gas into inlet chamber 26 again pushes piston 22 away from inlet chamber 26. Piston 22 is forced back toward pressurization chamber 28, closing gas discharge ports 20. The cycle may continue as long as there is sufficient gas pressure in compressed gas storage unit 12.

[0053] It should be understood that internal structure and mechanisms of gas impulse unit 14 is shown for illustrative purposes only. Other type of gas impulse units or devices may be utilized as a gas impulse unit for a self-contained gas impulse apparatus. In particular, an alternative gas impulse unit may include another form of a piston, a different arrangement of chambers, or mechanism that does not require a piston or chamber.

[0054] Gas conduit 16 for enabling flow of gas to gas impulse unit 14 from compressed gas storage unit 12 may be flexible or rigid. Gas conduit 16 may be sufficiently strong to support gas impulse unit 14 below compressed gas storage unit 12. Alternatively, an additional cable or connector may support the weight of gas impulse unit 14 below compressed gas storage unit 12.

[0055] Compressed gas storage unit 12 may be shaped in the form of an elongated cylinder to tube. Such an elongated shape may be suitable for lowering into a well or other similarly narrow spaces. Other shapes may be used for applications in regions that are not long and narrow. Compressed gas storage unit 12 is constructed so as to contain a pressurized gas. For example, for a typical application, gas pressure in compressed gas storage unit 12 may be in a range from 50 bar to 1300 bar, or, more specifically, from 200 bar to 700 bar. Compressed gas storage unit 12 is configured to hold the compressed gas until a triggering event enables flow of gas from compressed gas storage unit 12 to gas conduit 16.

[0056] In the configuration shown for compressed gas storage unit 12, compressed gas is held in gas storage chamber 31. End cap 13 includes filling port 36 and activation assembly 34. Compressed gas may be introduced into compressed gas storage unit 12 via filling port 36, e.g., at a filling station or facility outside of a well. Filling port 36 may be provided with a check valve, or other one-way valve or arrangement. The check valve enables gas to flow inward through filling port 36 to gas storage chamber 31. The check valve prevents outward flow of gas from gas storage chamber 31 through filling port 36 to the outside atmosphere. Activation assembly 34 initially prevents flow of gas from gas storage chamber 31. Activation of activation assembly 34 enables gas to flow from gas storage chamber 31 to gas conduit 16 via central tube 32.

[0057] As shown, compressed gas storage unit 12 hangs from cable 40 (e.g., in the form of a wireline or slickline). Gas conduit 16 and gas impulse unit 14 hang below compressed gas storage unit 12. Other arrangements are possible. For example, compressed gas storage unit 12 may be suspended below gas impulse unit 14.

[0058] Fig. 2 shows details of an end cap of the gas supply unit shown in Fig. 1A. Activation assembly 34, as shown, includes a barrier in the form of sealing disk 44 that may be burst, or otherwise removed or opened, by a high pressure gas that is generated by a squib or pyrotechnic device, or other gas generation device, represented here as micro gas generator 38. Opening sealing disk 44 enables flow of gas from gas storage chamber 31 to central tube 32.

[0059] Other activation assemblies are possible. For example, an activation assembly may include a solenoid-operated valve, a motor-operated valve, a piston, or other mechanism that may be operated remotely or by a timer to enable a previously blocked flow of gas from gas storage chamber 31 to central tube 32.

[0060] Storage chamber 31 may be filled via filling port 36. When being filled, a gas from a pressurized gas supply facility is forced in through filling port 36, such that check valve 48 is opened and gas flows into storage chamber 31 via passage 50. Gas in storage chamber 31 is initially blocked by sealing disk 44 from flowing through check valve 42 and space 46 into central tube 32. Check valve 42 may be opened by a pressure excess in storage chamber 31 to enable gas pressure in space 46 to initially equalize with gas pressure in storage chamber 31.

[0061] Micro gas generator 38 may be activated by an electrical or other signal, e.g., that is transmitted by an electrical cable component of cable 40 (e.g., in the form of a wireline), that is transmitted wirelessly (e.g., by an optical or electromagnetic beam), or that is generated by a timer or other delay device (e.g., a pressure-sensitive or depth-detecting device) that is associated with micro gas generator 38. (When micro gas generator 38 is not activated by a signal that is conducted or guided by a wire or conduit, cable 40 may be in the form of a slickline.) Activation of micro gas generator 38 creates an explosive or other reaction that suddenly releases pressurized gas so as to increase gas pressure in space 46. During activation, check valve 42 prevents loss of pressure by preventing flow of the suddenly released gas from flowing directly into storage chamber 31. The increased pressure forces sealing disk 44 to open. For example, sealing disk 44 may burst or break. When sealing disk 44 is forced open, gas may flow from storage chamber 31, via space 46, and into central tube 32.

[0062] When gas in storage chamber 31 is exhausted, self-contained gas impulse apparatus 10 (Fig. 1A) no longer operates. Self-contained gas impulse apparatus 10 may then be retrieved from the remote location (e.g., withdrawn out of a well). End cap 13 of compressed gas storage unit 12 may be replaced, or may be restored by replacement of some components of end cap 13. Replaced components typically include micro gas generator 38 and sealing disk 44. After replacement or restoration of end cap 13, storage chamber 31 of compressed gas storage unit 12 may be refilled with compressed gas. After refilling, self-contained gas impulse apparatus 10 may be delivered to the same or another remote location and operated again.

[0063] The volume of compressed gas storage unit 12 may be made adjustable. For example, compressed gas storage unit 12 may be assembled from sections that may be assembled lengthwise. Selection of the number and sizes of the sections to be assembled may determine the length, and thus the volume, of compressed gas storage unit 12. A typical compressed gas storage unit 12 may have a volume in a range of about 15 liters to 30 liters. A typical pressurization chamber 28 of a gas impulse unit 14 has a volume in the range of about 0.5 liters to 2 liters. A compressed gas storage unit 12 of a self-contained gas impulse apparatus 10 that is configured for use in a well may have a typical diameter in the range of about 2 inches to 4 inches.

[0064] An alternative activation assembly may include a micro gas generator and a barrier in the form of a piston. Fig. 3A shows an end cap with a micro gas generator and a piston activation system of the gas supply unit, shown in Fig. 1A in accordance with embodiments of the present invention.

[0065] Piston end cap 70 includes filling port 36 and an activation system that includes micro gas generator 38 and piston 54. Piston 54 is configured to move back and forth within sleeve 60. Passageway 52 may prevent gas from being trapped at one end of piston 54. (Trapped gas could result in uneven pressure at opposite ends of piston 54 and could impede motion of piston 54 within sleeve 60.) However, passageway 52 may be sufficiently narrow such that a sudden increase of gas pressure (e.g., by an explosion) could impel piston 54 to slide within sleeve 60. Piston 54 may include two or more components, e.g., each component made of different materials. For example, a plug component may be initially placed adjacent to micro gas generator 38.

[0066] In the initial state that is illustrated in Fig. 3A, compressed gas in storage chamber 31 is prevented from flowing through gas tube 58 and into central tube 32 by piston 54 and sealing rings 56 (e.g. in the form of O-rings).

[0067] Micro gas generator 38 may be activated (e.g., may be pyrotechnically exploded) so as to apply a sudden pressure to piston 54. Fig. 3B shows the micro gas generator and piston activation system shown in Fig. 3A after activation.

[0068] For example, an electrical signal that is transmitted via an electrically conducting component of cable 40 (or otherwise transmitted or generated) may ignite micro gas generator 38 to create explosion 38'. Explosion 38' generates a sufficient quantity of expanding gas to push piston 54 toward widening 64 of sleeve 60, as shown in Fig. 3B. The movement of piston 54 brings indentation 62 of piston so as to extend from gas tube 58 to widening 64. Thus, a passageway to permit gas flow is opened from storage chamber 31, via gas tube 58, indentation 62, and widening 64, to central tube 32. Thus, gas may be supplied from compressed gas storage unit 12 to gas impulse unit 14 (Fig. 1A).

[0069] Alternatively to a compressed gas storage unit, a self-contained gas impulse apparatus in accordance with embodiments of the present invention may include gas supply unit in the form of a gas generator unit.

[0070] Fig. 4 shows a self-contained gas impulse apparatus with a gas generator unit, in accordance with an embodiment of the present invention.

[0071] Self-contained gas impulse apparatus 80 includes gas generator unit 82 for providing gas to gas impulse unit 14 via gas conduit 16. Gas generator unit 82 is initially filled with gas generation material 84. For example, gas generation material 84 may include a solid propellant material. Retaining disk 88, or a similar plug or other structure, may initially hold gas generation material 84 inside gas generator unit 82.

[0072] A gas-generating reaction (e.g., combustion) may be initiated in gas generation material 84 by operation of activator 86 (e.g., in the form of an igniter). For example, an activator 86 in the form of an igniter may be operated to electronically or mechanically generate a spark to initiate a combustion reaction in gas generation material 84. As another example, activator 86 may be operated to release a catalyst that initiates a gas-generating reaction in gas generation material 84. Activator 86 may be remotely operated via an electrically, electromagnetically, or otherwise transmitted signal. The signal may be transmitted to activator 86 via an electrical cable component of cable 40 (e.g., that is in the form of a wireline), by another signal transmitting cable or conduit, or may be generated by a timer or other delay device that is associated with activator 86 (where cable 40 may be in the form of a slickline).

[0073] Initiation of the gas-generating reaction causes generation of pressurized gas. Generation of the gas may open a barrier, e.g., may cause a retaining disk 88 to burst, rupture, or break free, enabling the generated disk to flow through gas conduit 16 into gas impulse unit 14. Flow of pressurized gas into gas impulse unit 14 operates gas impulse unit 14 so as to create a series of gas blasts.

[0074] Alternatively, a gas generator unit 82 may include a gas generation material 84 in the form of a liquefied gas, such as liquid nitrogen. Activator 86 may include a heater that causes a phase change in which the liquefied gas becomes a pressurized gas (e.g., gaseous nitrogen).

[0075] Fig. 5 schematically illustrates a method for generating gas impulses at a remote location, in accordance with an embodiment of the present invention.

[0076] A method for gas impulse generation at a remote location, in accordance with embodiments of the present invention, includes preparing a gas supply unit 12 of a self-contained gas impulse apparatus 10 to supply gas. For example, a compressed gas storage unit may be filled with compressed gas, or a gas generation unit may be filled with a gas generation material. An activation device or component, such as a squib (micro gas generator), heater, or igniter, as well as appropriate caps or disks for preventing loss of compressed gas or gas generation material prior to activation, may be separately replaced or installed, or an entire cap assembly may be replaced or installed. When a delay device is used to activate the gas supply unit, the delay device may be preset with a value or setting that activates gas supply unit only after the self-contained gas impulse apparatus has been delivered to the remote location. For example, a timer may be set to a time when it is estimated that the self-contained gas impulse apparatus will have arrived at the remote location. An environmentally-related or geographically-related setting of the delay device may be set to a setting that is indicative of arrival at the remote location.

[0077] Gas supply unit 12 and gas impulse unit 14 of self-contained gas impulse apparatus 10 may be assembled (if they are separate or detachable units) and attached to a cable 40 (e.g., wireline or slickline). Self-contained gas impulse apparatus 10 may then be delivered to a remote location. For example, cable 40 may be extended to lower self-contained gas impulse apparatus 10' into well 90.

[0078] Self-contained gas impulse apparatus 10 may reach the remote location at which it is to be operated, as schematically represented by self-contained gas impulse apparatus 10' at layer 92 in well 90. An activation mechanism may be operated, e.g., automatically or by operation of a control to generate an activation signal. For example, an appropriate squib (micro gas generator), heater, or igniter may be remotely activated. Operation of the activation mechanism causes gas to be supplied by gas supply unit 12 to gas impulse unit 14. Supply of gas to gas impulse unit 14 causes to gas impulse unit 14 to operate, releasing one or more gas blasts, as represented by arrows 94.

CLAIMS

1. A self-contained gas impulse apparatus comprising:

a gas impulse unit for generating a plurality of gas blasts when supplied with pressurized gas; and

a gas supply unit connected by a gas conduit to the gas impulse unit, the gas supply unit being configured to be remotely activated to supply pressurized gas via the conduit to the gas impulse unit,

wherein the self-contained gas impulse apparatus is transportable by a cable to and from a remote location for operation at the remote location.

2. The apparatus of claim 1, wherein the apparatus is connected to the cable.

3. The apparatus of claim 2, wherein the cable includes a wireline or a slickline.

4. The apparatus of claim 1, wherein the gas supply unit comprises a compressed gas storage unit that is fillable with a compressed gas.

5. The apparatus of claim 4, wherein the compressed gas storage unit includes a barrier to initially prevent flow of the compressed gas from the compressed gas storage unit to the gas impulse unit and an activation device for opening the barrier.

6. The apparatus of claim 5, wherein the activation device comprises a squib.

7. The apparatus of claim 5, wherein the barrier comprises a piston or a sealing disk.

8. The apparatus of claim 1, wherein the gas supply unit comprises a gas generator unit that is fillable with a gas generation material.

9. The apparatus of claim 8, wherein the gas generator unit is activable by initiation of a gas-generating reaction in the gas generation material.

10. The apparatus of claim 9, wherein the gas generation material includes a solid propellant.

11. The apparatus of claim 9, comprising an igniter for initiating the reaction.

12. The apparatus of claim 8, wherein the gas generation material comprises a liquefied gas.

13. The apparatus of claim 1, wherein the gas supply unit is configured to hang below the gas impulse unit when being transported to or from the remote location.

14. The apparatus of claim 1, wherein the apparatus is configured to be lowered to the remote location at a depth of at least 50 meters within a well.

15. The apparatus of claim 1, wherein the gas supply unit is configured to be remotely activated via an electrically conducting wire.

16. A method for generating gas impulses at a remote location, the method comprising:

providing a self-contained gas impulse apparatus that includes a gas impulse unit and a gas supply unit that is connected to the gas impulse unit by a gas conduit;

using a cable to transport the apparatus to the remote location; and

activating the gas supply unit to supply pressurized gas to the gas impulse unit such that the gas impulse unit generates a plurality of gas blasts.

17. The method of claim 16, wherein using a cable to transport the apparatus comprises lowering the apparatus into a well to a depth of at least 50 meters.

18. The method of claim 16, wherein remotely activating the gas supply unit comprises transmitting an activation signal to the apparatus.

19. The method of claim 16, wherein remotely activating the gas supply unit comprises setting a delay mechanism.

20. The method of claim 16, wherein remotely activating the gas supply unit comprises opening a barrier that initially prevents flow of the pressurized gas from the gas supply unit to the gas impulse unit, or initiating a process that generates the pressurized gas within the gas supply unit.

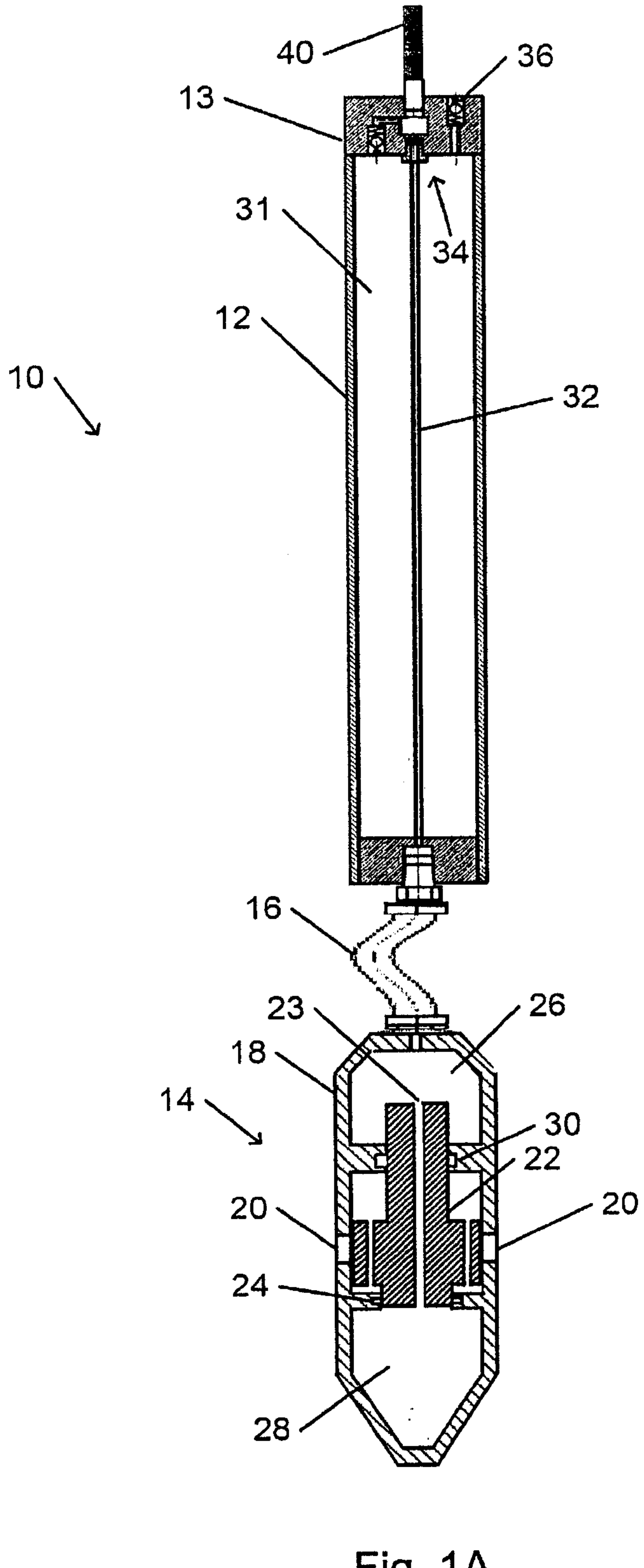

Fig. 1A

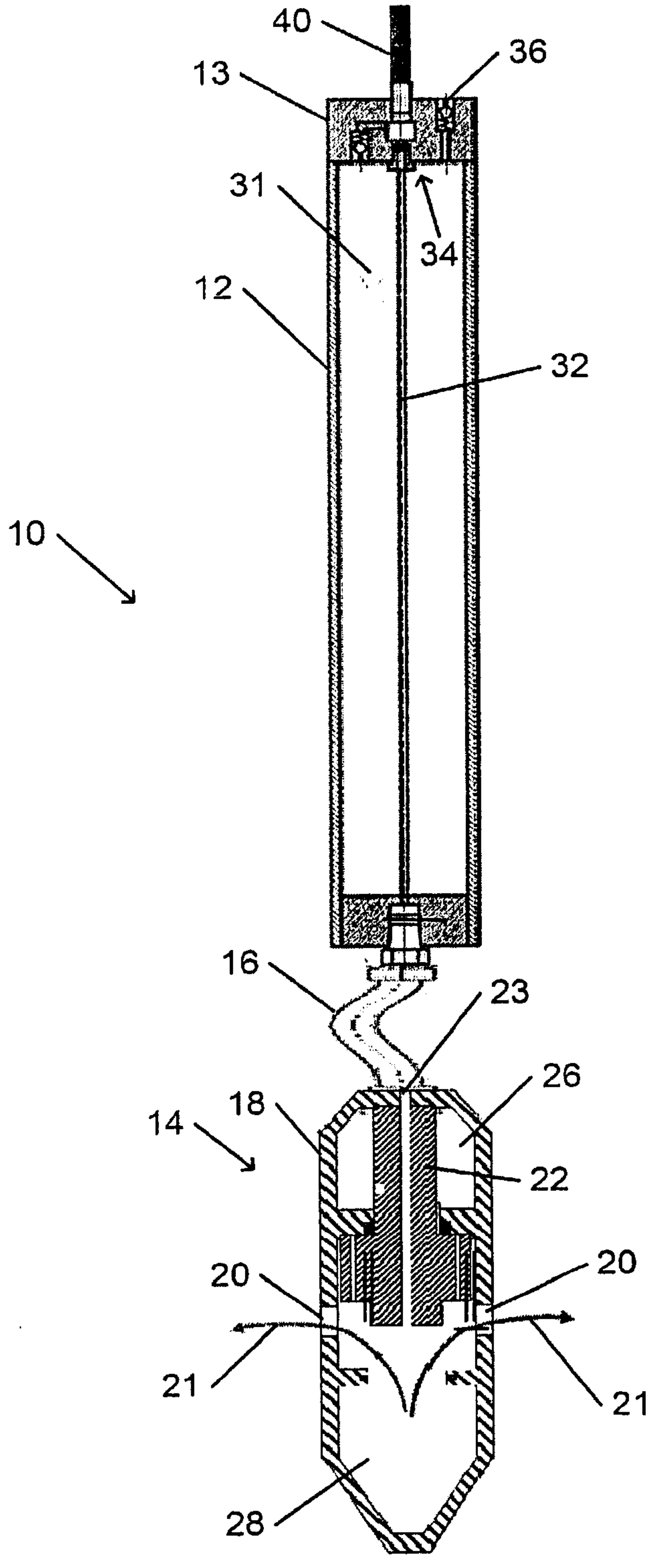

Fig. 1B

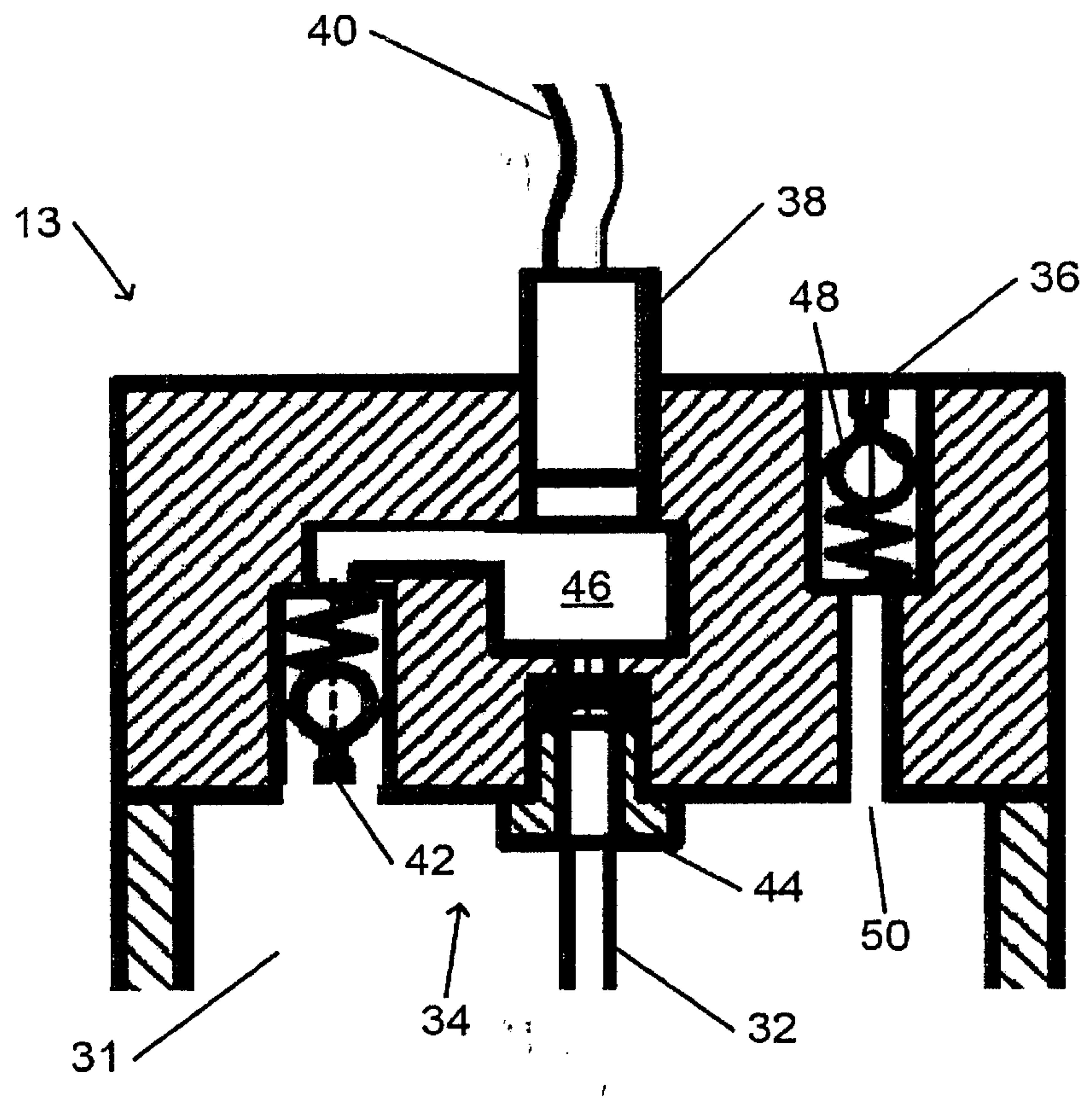

Fig. 2

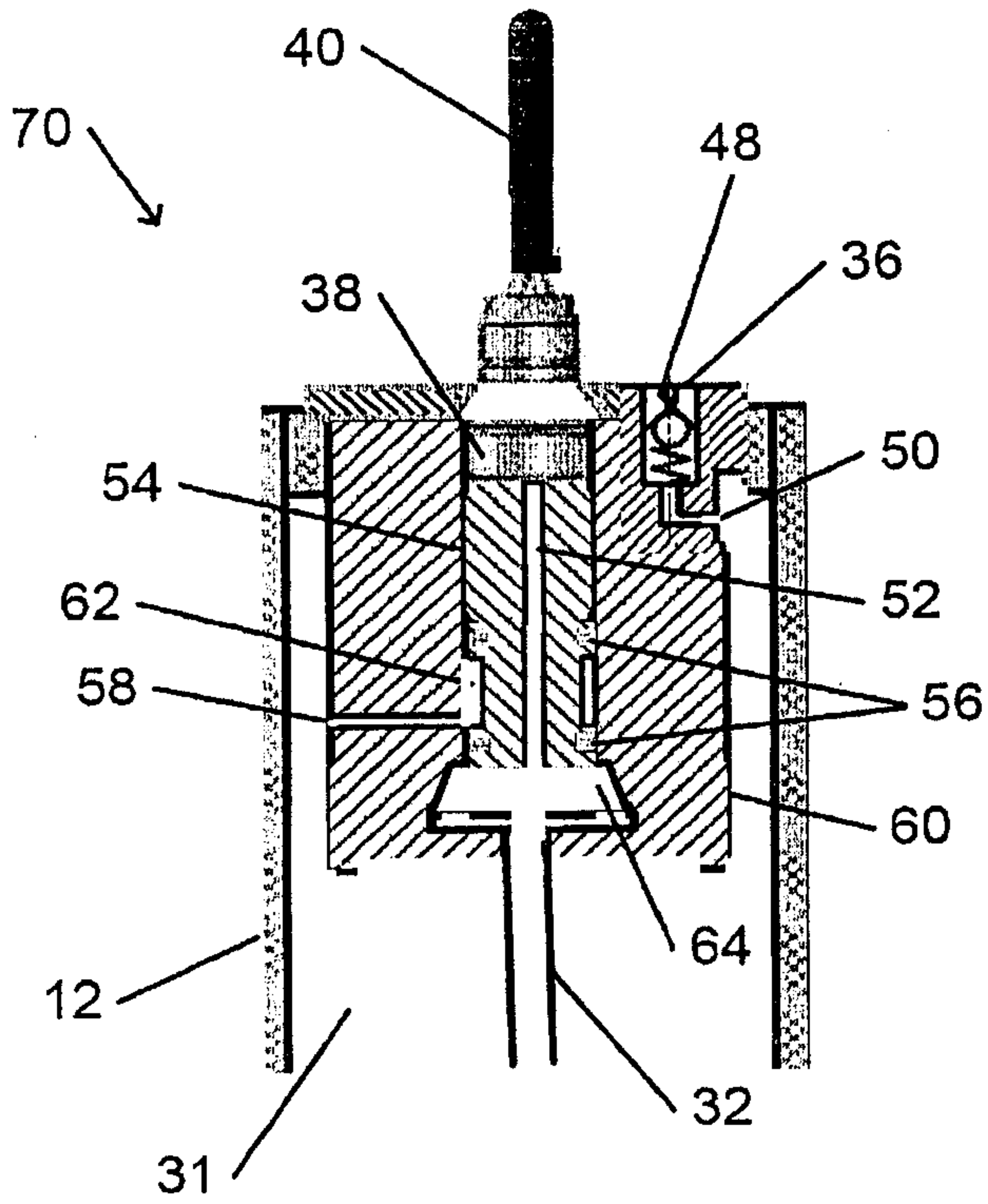
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Fig. 3A

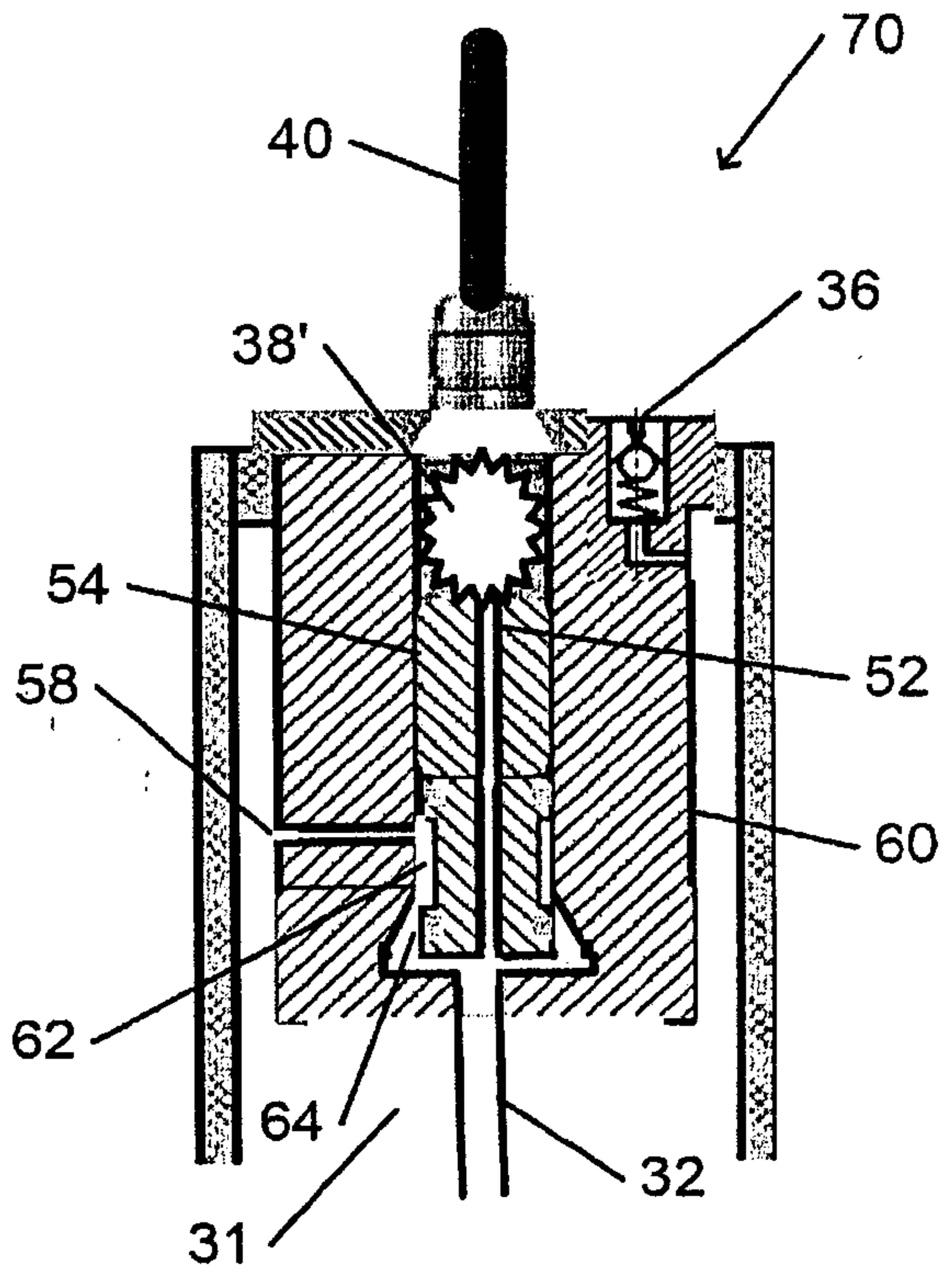
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Fig. 3B

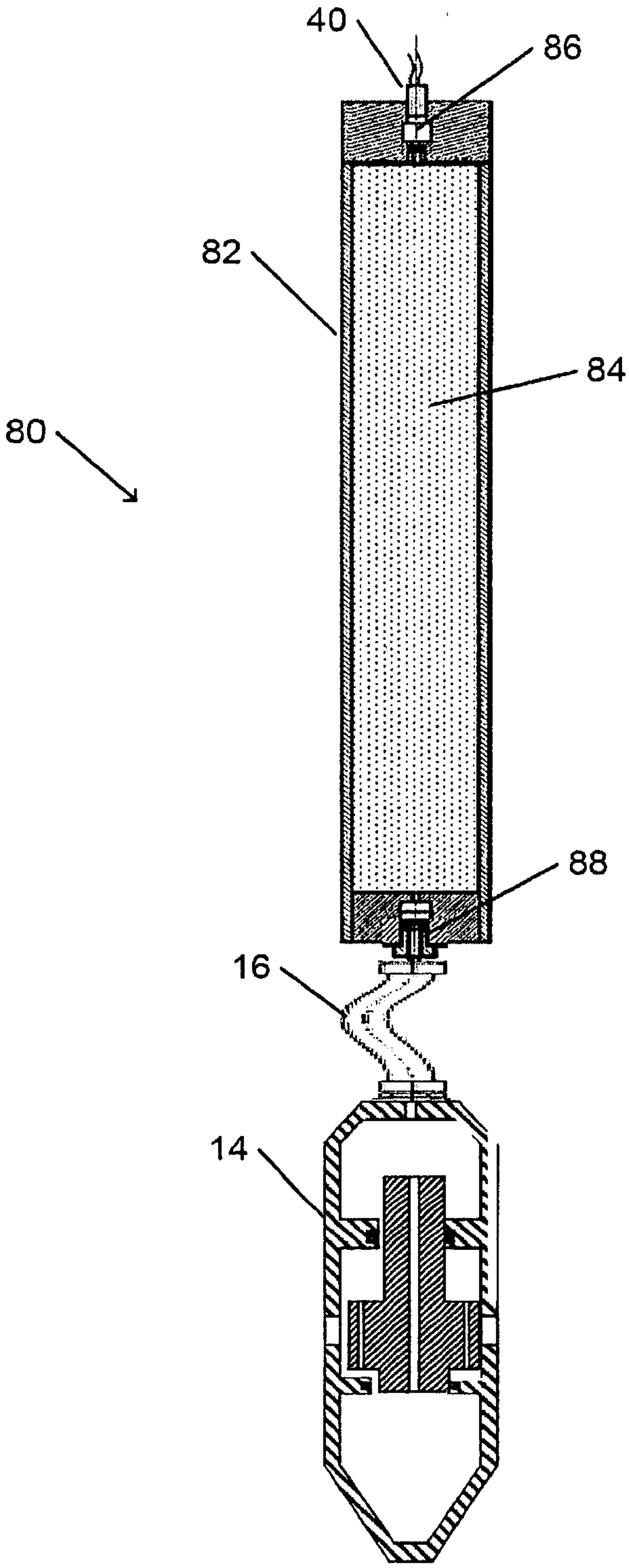


Fig. 4

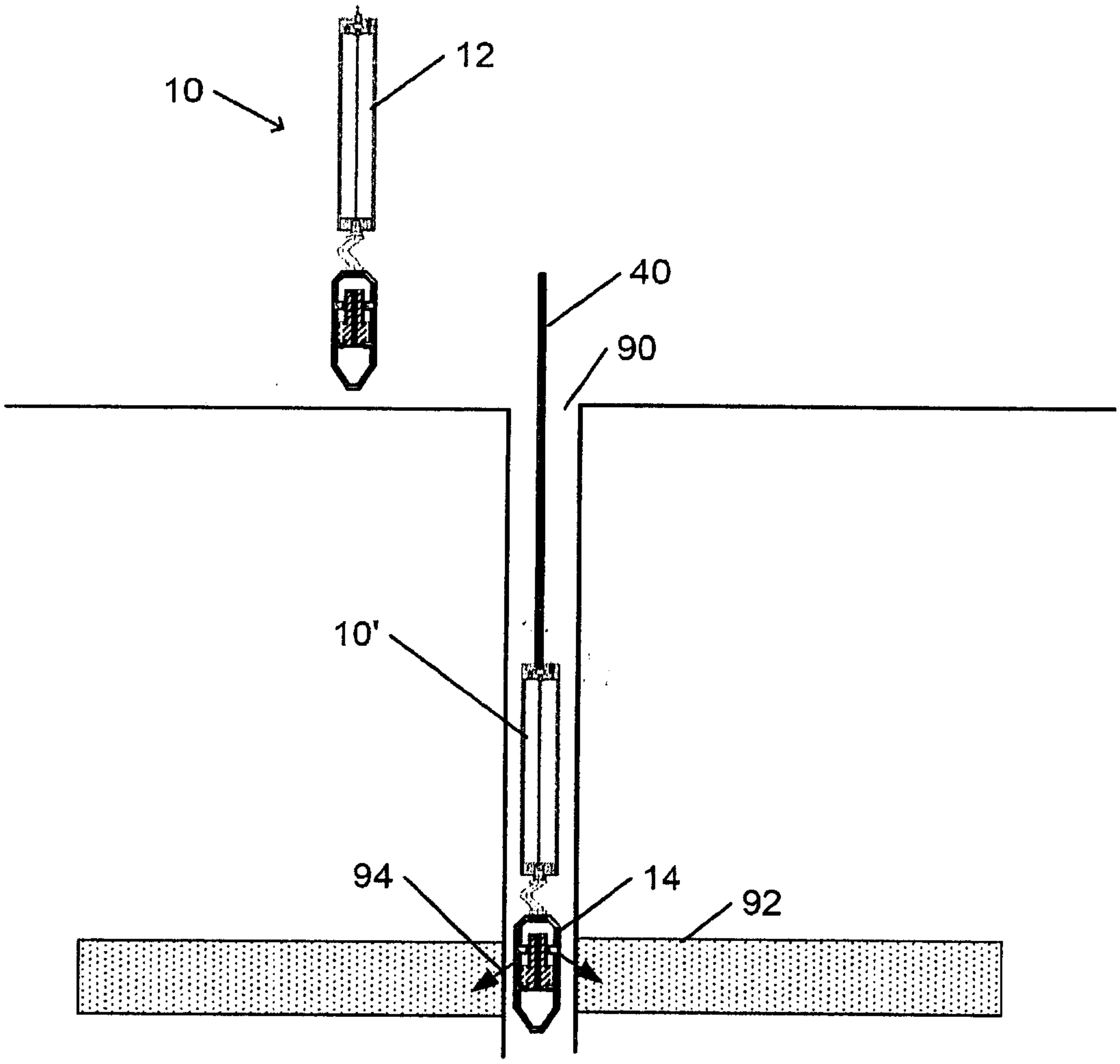
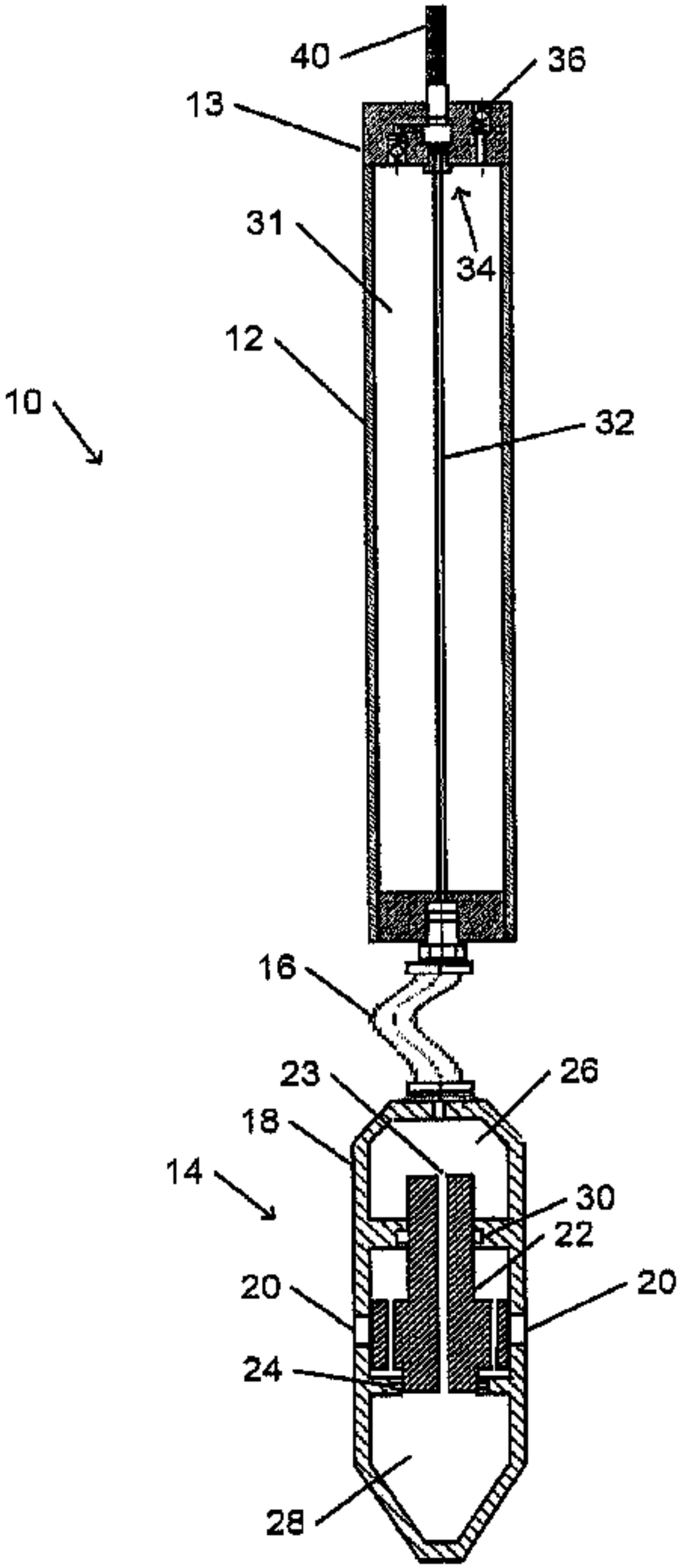


Fig. 5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