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(54) Title: DOWNHOLE PUMP WITH A PRESSURE SEQUENCING VALVE

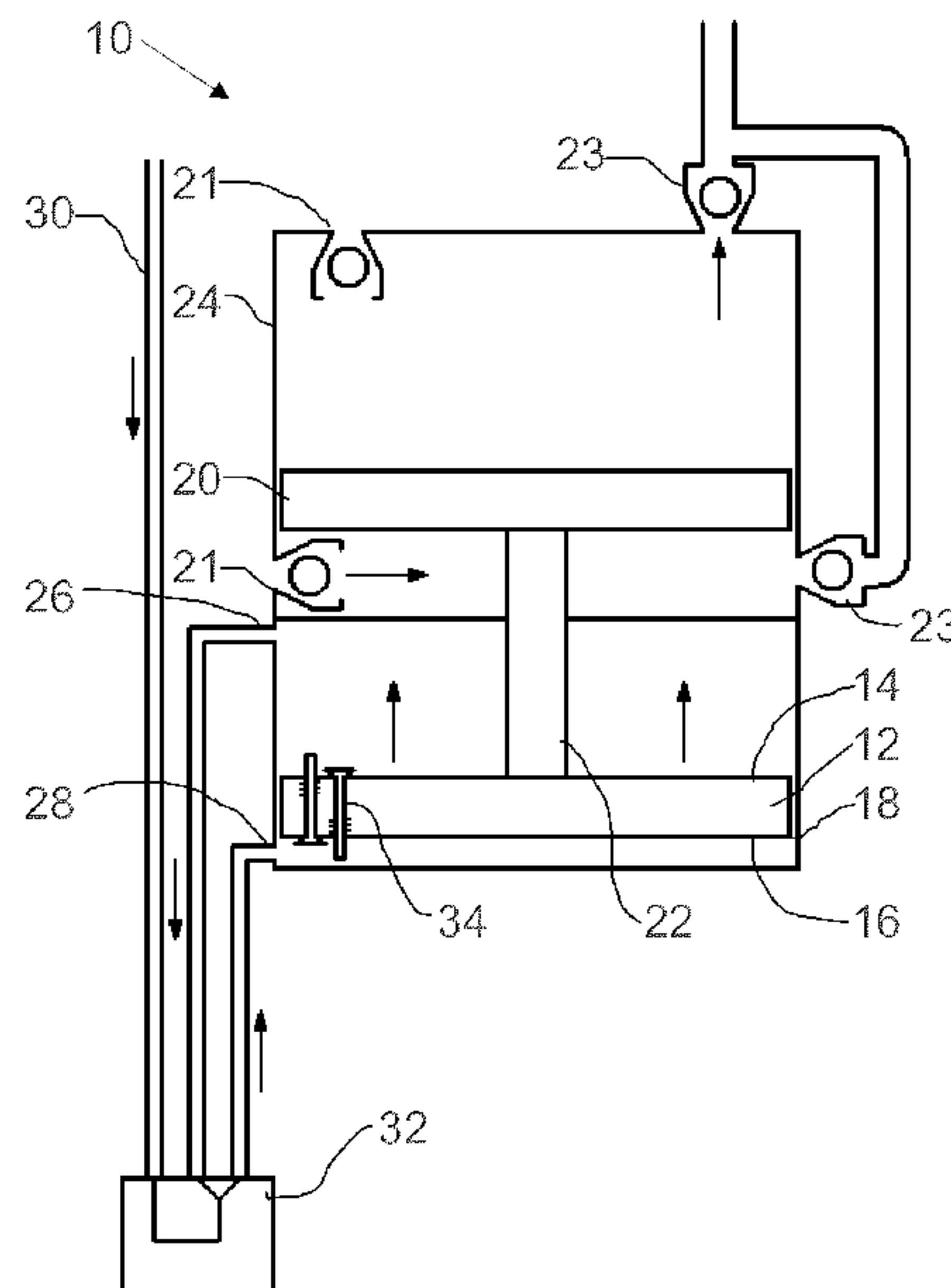


FIG. 1

(57) **Abrégé/Abstract:**

A downhole pump has a master piston having a first side and a second side in a first piston chamber. The first piston chamber has a first inlet and a second inlet for alternately applying fluid pressure to the first side of the master piston to move the piston toward the top of a piston stroke, and to the second side of the master piston to move the piston toward the bottom of the piston stroke. A valve is carried by the master piston that relieves fluid pressure from the respective side of the master piston once the top or bottom of the stroke is reached. There is a sequencing valve with a first state that applies fluid pressure to the first inlet and a second state that applies fluid pressure to the second inlet. The sequencing valve switches between the first state and the second state once a drop in pressure occurs. A slave piston is driven by the master piston in a second piston chamber. The second piston chamber has at least one fluid inlet and at least one fluid outlet.



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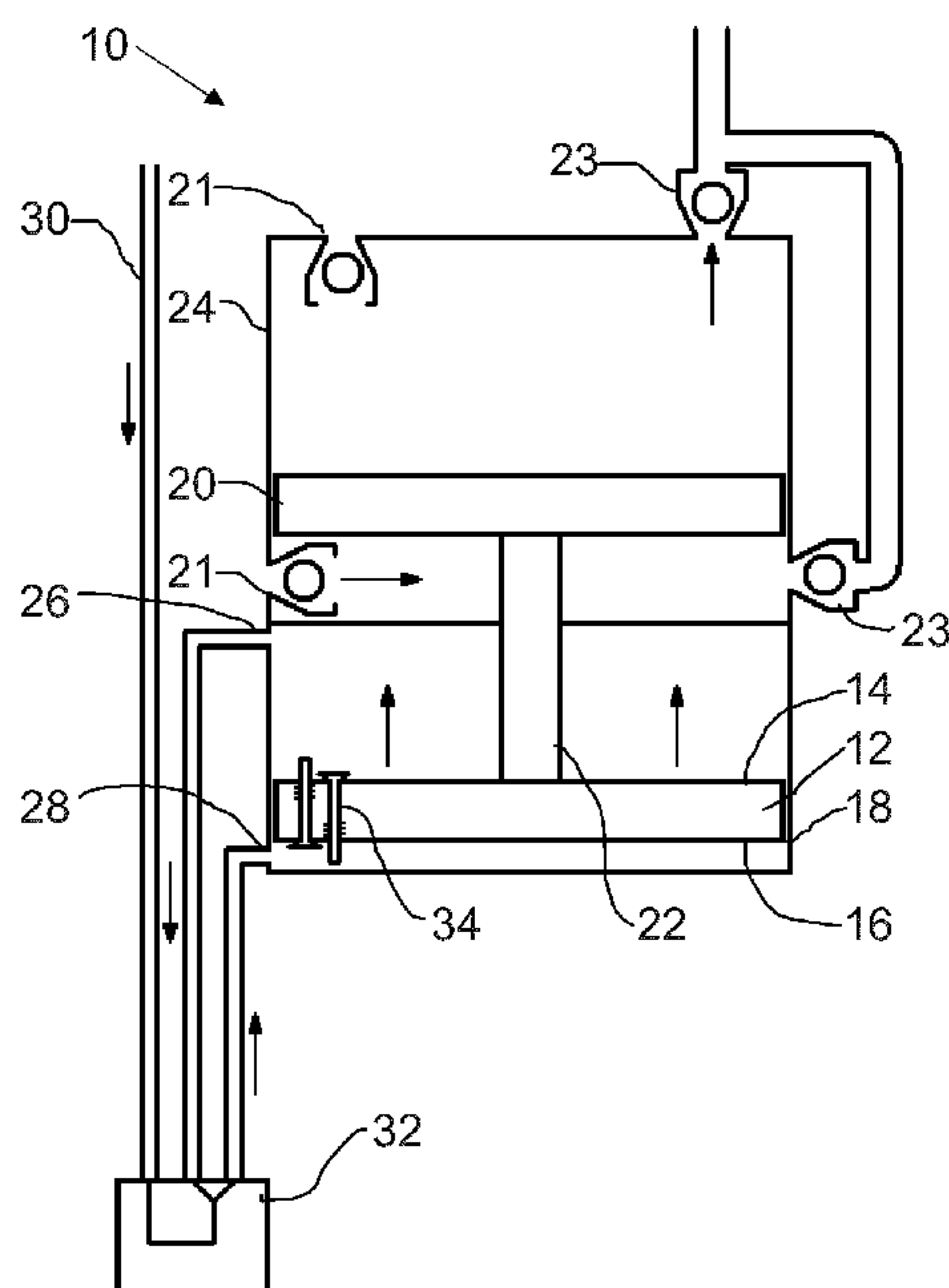


FIG. 1

(57) Abstract: A downhole pump has a master piston having a first side and a second side in a first piston chamber. The first piston chamber has a first inlet and a second inlet for alternately applying fluid pressure to the first side of the master piston to move the piston toward the top of a piston stroke, and to the second side of the master piston to move the piston toward the bottom of the piston stroke. A valve is carried by the master piston that relieves fluid pressure from the respective side of the master piston once the top or bottom of the stroke is reached. There is a sequencing valve with a first state that applies fluid pressure to the first inlet and a second state that applies fluid pressure to the second inlet. The sequencing valve switches between the first state and the second state once a drop in pressure occurs. A slave piston is driven by the master piston in a second piston chamber. The second piston chamber has at least one fluid inlet and at least one fluid outlet.

TITLE

[0001] Downhole pump with a pressure sequencing valve

FIELD

5 [0002] This relates to a downhole pump that uses a pressure sequencing valve

BACKGROUND

[0003] Downhole pumps may be hydraulically driven, such as the pump described in Canadian patent application no. 2,576,693 (Hoffarth) entitled "Hydraulic submersible pump
10 with electric motor drive".

SUMMARY

[0004] There is provided a downhole pump, comprising a master piston having a first side and a second side in a first piston chamber and a slave piston driven by the master piston
15 in a second piston chamber. The first piston chamber comprises a first inlet and a second inlet for alternately applying fluid pressure to the first side of the master piston to move the piston toward the top of a piston stroke, and to the second side of the master piston to move the piston toward the bottom of the piston stroke. A valve is carried by the master piston that
relieves fluid pressure from the respective side of the master piston once the top or bottom of
20 the stroke is reached. There is a sequencing valve that has a first state that applies fluid pressure to the first inlet and a second state that applies fluid pressure to the second inlet. The sequencing valve switches between the first state and the second state once a drop in pressure occurs. The second piston chamber has at least one fluid inlet and at least one fluid outlet. The valve may be a poppet valve that opens a flow passage through the master piston. The
25 slave piston may be a double-acting piston and the second piston chamber may have a fluid inlet and a fluid outlet on each side of the slave piston

[0005] According to another aspect, there is provided a downhole pump, comprising a master piston in a first piston chamber, a slave piston in a second piston chamber, and a
30 travelling liquid seal carried by the slave piston that engages an inner surface of the second piston chamber. The travelling liquid creates a seal against fluid while permitting gas to pass. The second piston chamber comprises a fluid inlet and a first outlet on a first side of the slave piston and a second outlet on a second side of the slave piston, wherein the gas that passes the

travelling liquid seal exits through the second outlet.

BRIEF DESCRIPTION OF THE DRAWINGS

[0006] These and other features will become more apparent from the following
5 description in which reference is made to the appended drawings, the drawings are for the purpose of illustration only and are not intended to be in any way limiting, wherein:

FIG. 1 is a side elevation view in section of a downhole pump at the bottom of a stroke.

10 **FIG. 2** is a side elevation view in section of the downhole pump at the top of the stroke.

FIG. 3 is a side elevation view in section of an alternative downhole pump.

FIG. 4 is a detailed side elevation view in section of a poppet valve system.

FIG. 5 is a detailed side elevation view in section of the liquid seals.

15 DETAILED DESCRIPTION

[0007] Referring to **FIG. 1**, a downhole pump, generally identified by reference numeral
10 has a master piston 12 with a first side 14 and a second side 16 in a first piston chamber 18.
There is also a slave piston 20 driven by master piston 12 by a shaft 22 that is positioned in a
second piston chamber 24. First piston chamber 18 has a first inlet 26 and a second inlet 28
20 on either side of master piston 12. As fluid pressure is alternately applied to either side 14
and 16, master piston 12 moves between the bottom of a piston stroke, as shown in **FIG. 1**,
toward the top of a piston stroke as shown in **FIG. 2**. As master piston 12 reciprocates, it
drives slave piston 20, which pumps fluid through second piston chamber 24 using fluid inlets
21 and fluid outlets 23. While slave piston 20 and second piston chamber 24 are configured
25 as a double-acting piston, it may also be configured as a single acting piston. Furthermore,
while second piston chamber 24 is shown above first piston chamber 18, it will be understood
that the actual orientation may be changed, depending on the preferences of the user, and the
conditions of the well being pumped. Referring to **FIG. 4**, master piston 12 is sealed against
first piston chamber 18 by travelling seals 25. Referring to **FIG. 5**, slave piston 12 will also
30 have seals 42, although the seals may be different as slave piston 12 encounters “dirty” fluid,
whereas master piston 12 will generally only encounter clean hydraulic fluid.

[0008] Referring to **FIG. 1**, fluid is supplied to first inlet 26 and second inlet 28 by a supply of fluid 30. As is common in the art, this may be hydraulic oil from a hydraulic pump on surface. Other fluids and pumps may also be used, as is known in the art. A sequencing valve 32 controls where the fluid flows. In particular, sequencing valve 32 has a first state that applies fluid pressure to first inlet 26 and a second state that applies fluid pressure to second inlet 28. Sequencing valve 32 switches between the two states once a drop in pressure occurs. The drop in pressure is induced by a valve 34 that is carried by master piston 12. Sequencing valve 32 also preferably has a pressure relief valve (not shown) to protect it. Valve 34 relieves fluid pressure from the respective side of master piston 12 once the top or bottom of the stroke is reached. Referring to **FIG. 4**, as shown, valve 34 is made up of two poppet valves 36 carried by the master piston. Poppet valves 36 are biased closed by a spring 38, and each has a corresponding flow channel 40. As master piston 12 reaches the bottom of the stroke, one of the poppets 36 is depressed, which opens flow channel 40. This causes the fluid pressure on first side 14 to reduce the pressure toward the pressure on second side 16 of master valve 12. This pressure drop triggers sequencing valve 32 to switch to the other state, and causes pressure to be applied in the opposite direction, thus causing master valve 12 to reciprocate. It will be understood that valve 34 may take other forms other than the depicted poppet valves that are activated to release pressure when the piston reaches the end of its stroke. While not shown, it will be understood that, as master piston 12 moves, fluid on the opposite side is vented, either back to the source of hydraulic fluid, or directly into the wellbore.

[0009] In some wells, gas may be present in the downhole fluids, which can cause problems in a pump if not addressed properly. Referring to **FIG. 3** and **5**, an option of dealing with this is to replace seals 25 with deliberately leaky seals 42. Leaky seals 42 would be sufficient to seal against liquid, but would permit gas to pass by piston 20. In the depicted embodiment, slave piston 20 and second piston chamber 24 are configured as a single-acting piston. Second piston chamber 24 has inlet 21 and outlet 23, and an additional gas outlet 44 on the opposite side from inlet 21 and outlet 23. As fluid enters inlet 21, gas would be permitted to migrate past slave piston 20. The remaining fluid would be ejected through

outlet 23 on the downstroke, with the gas being ejected through outlet 44 on the upstroke. This design may be also used with other types of pumps aside from those described herein, such as a pump with another type of drive mechanisms. Seals 42 may be made “leaky” in the way that they are cut. This design also has the added advantage of reducing the wear on seals
5 42, or being able to make them more robust, such that their service life is extended.

[0010] The motive fluid used to drive master piston 12 may vary, as will the means for exhausting the motive fluid. Referring to **FIG. 1**, motive fluid is exhausted back through sequencing valve, where it may be returned to surface, or it may be expelled into the
10 wellbore. Alternatively, referring to **FIG. 3**, motive fluid may be expelled directly from first piston chamber 18 through a fluid line 46 by check valves 48. As shown, fluid line 46 is connected downstream from check valve 23 off chamber 24, such that the motive fluid travels to surface with the produced fluids.

15 [0011] While a liquid, such as hydraulic fluid or water, may be used to drive master piston 12, gas may also be used to drive piston 12. This may be particularly useful if the embodiment in **FIG. 3** is used, as the gas may be used to help lift the produced fluids and any formation fines to surface. For example, say the pressure in the tubing is 5 psi. If the gas in first chamber 18 is at 500 psi and the volume of first chamber 18 is 1.9 gal, then there will be
20 an equivalent volume of 190 gal in the outlet tubular, which would be more than enough to clear an outlet tubular with a volume of between 40 and 50 gal. Other volumes and pressures may be encountered and used. Another benefit is that, as there will be less pressure required to pump the fluids to surface, this may result in a smaller pressure differential across seals 25 in first chamber 18, which reduces the wear on seals 25.

25

[0012] In this patent document, the word "comprising" is used in its non-limiting sense to mean that items following the word are included, but items not specifically mentioned are not excluded. A reference to an element by the indefinite article "a" does not exclude the possibility that more than one of the element is present, unless the context clearly requires that
30 there be one and only one of the elements.

[0013] The following claims are to be understood to include what is specifically illustrated and described above, what is conceptually equivalent, and what can be obviously substituted. Those skilled in the art will appreciate that various adaptations and modifications of the described embodiments can be configured without departing from the scope of the claims. The illustrated embodiments have been set forth only as examples and should not be taken as limiting the invention. It is to be understood that, within the scope of the following claims, the invention may be practiced other than as specifically illustrated and described.

What is Claimed is:

1. A downhole pump, comprising:

5 a master piston having a first side and a second side in a first piston chamber, the first piston chamber comprising a first inlet and a second inlet for alternately applying fluid pressure to the first side of the master piston to move the piston toward the top of a piston stroke, and to the second side of the master piston to move the piston toward the bottom of the piston stroke;

10 a valve carried by the master piston that relieves fluid pressure from the respective side of the master piston once the top or bottom of the stroke is reached;

a sequencing valve having a first state that applies fluid pressure to the first inlet and a second state that applies fluid pressure to the second inlet, the sequencing valve switching between the first state and the second state once a drop in pressure occurs; and

15 a slave piston driven by the master piston in a second piston chamber, the second piston chamber having at least one fluid inlet and at least one fluid outlet.

2. The downhole pump of claim 1, wherein the valve is a poppet valve that opens a flow passage through the master piston.

20

3. The downhole pump of claim 1, wherein the slave piston is a double-acting piston and the second piston chamber has a fluid inlet and a fluid outlet on each side of the slave piston.

4. The downhole pump of claim 1, wherein the master cylinder is driven by a gas.

25

5. The downhole pump of claim 1, wherein the gas expelled from the master cylinder is expelled into at least one fluid outlet of the second piston chamber.

6. The downhole pump of claim 1, further comprising a travelling liquid seal carried by the slave piston that engages an inner surface of the second piston chamber, the travelling liquid creating a seal against fluid while permitting gas to pass.

30

7. The downhole pump of claim 6, wherein the second piston chamber comprises a first outlet on a first side of the slave piston and a second outlet on a second side of the slave piston, wherein the gas that passes the travelling liquid seal exits through the second outlet.

5

8. A downhole pump, comprising:

a piston in a piston chamber;

a motive force for driving the piston;

10 a travelling liquid seal carried by the piston that engages an inner surface of the second piston chamber, the travelling liquid creating a seal against fluid while permitting gas to pass; and

the second piston chamber comprising a fluid inlet and a first outlet on a first side of the slave piston and a second outlet on a second side of the slave piston, wherein the gas that passes the travelling liquid seal exits through the second outlet.

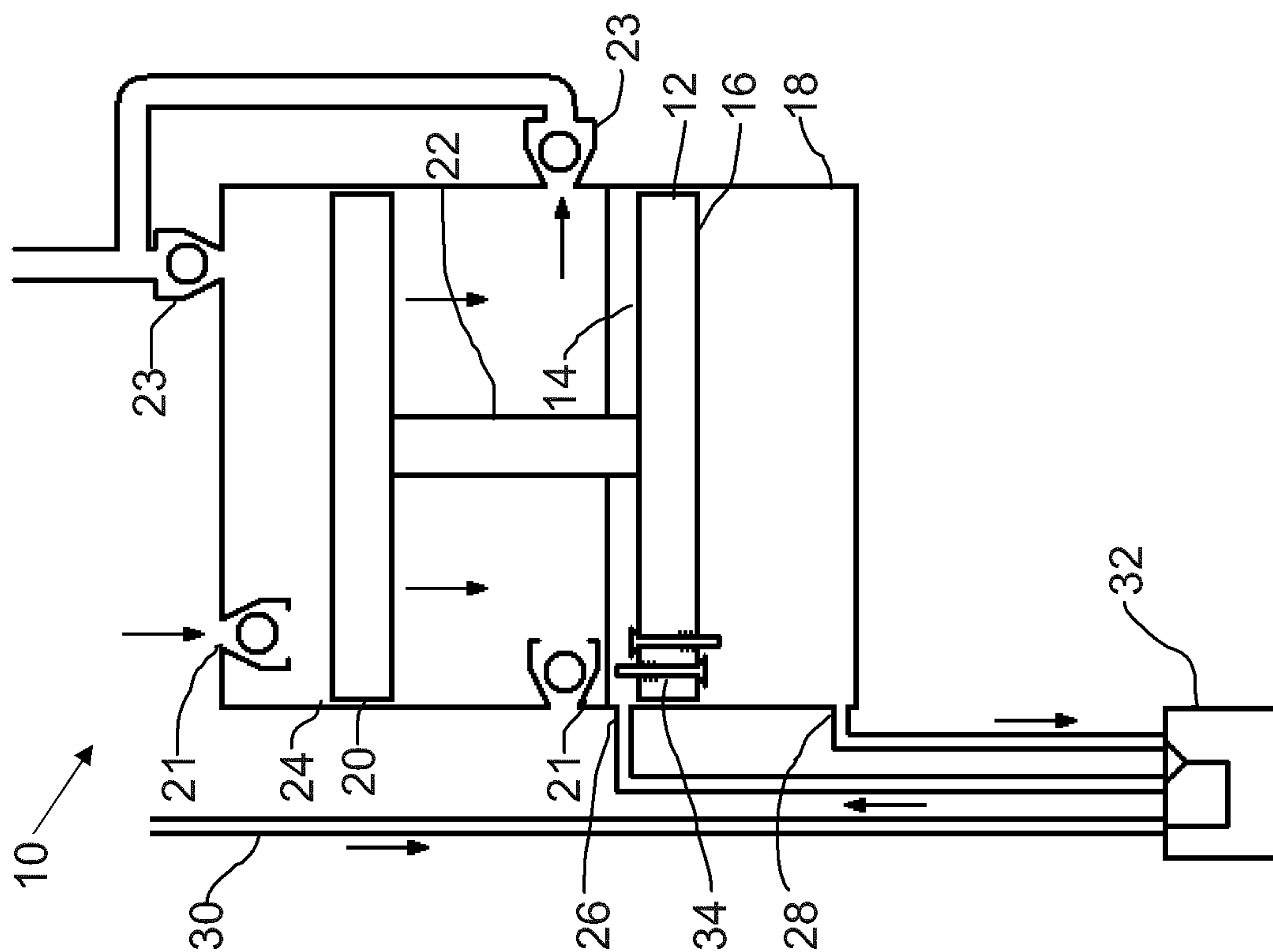


FIG. 1

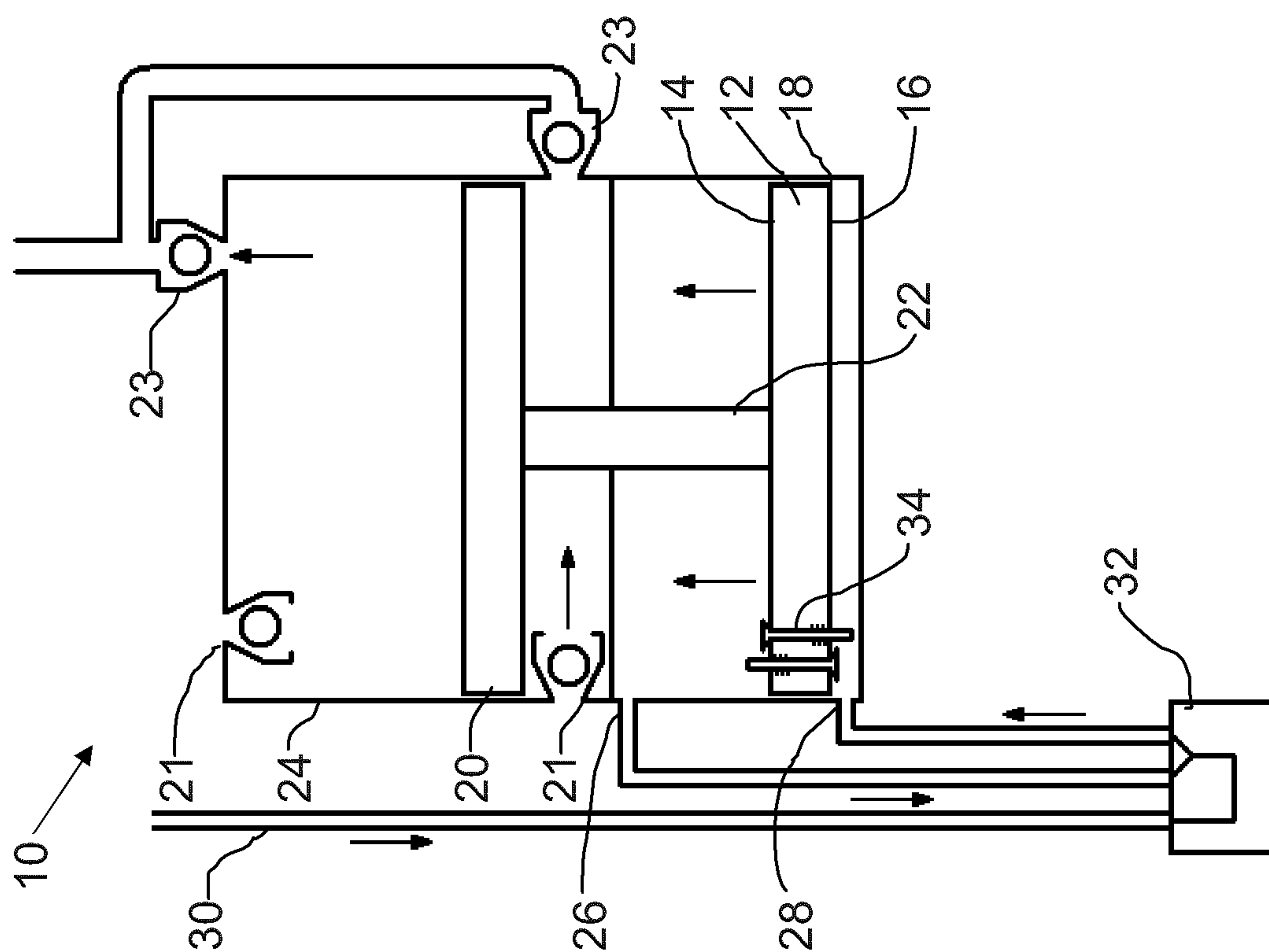


FIG. 2

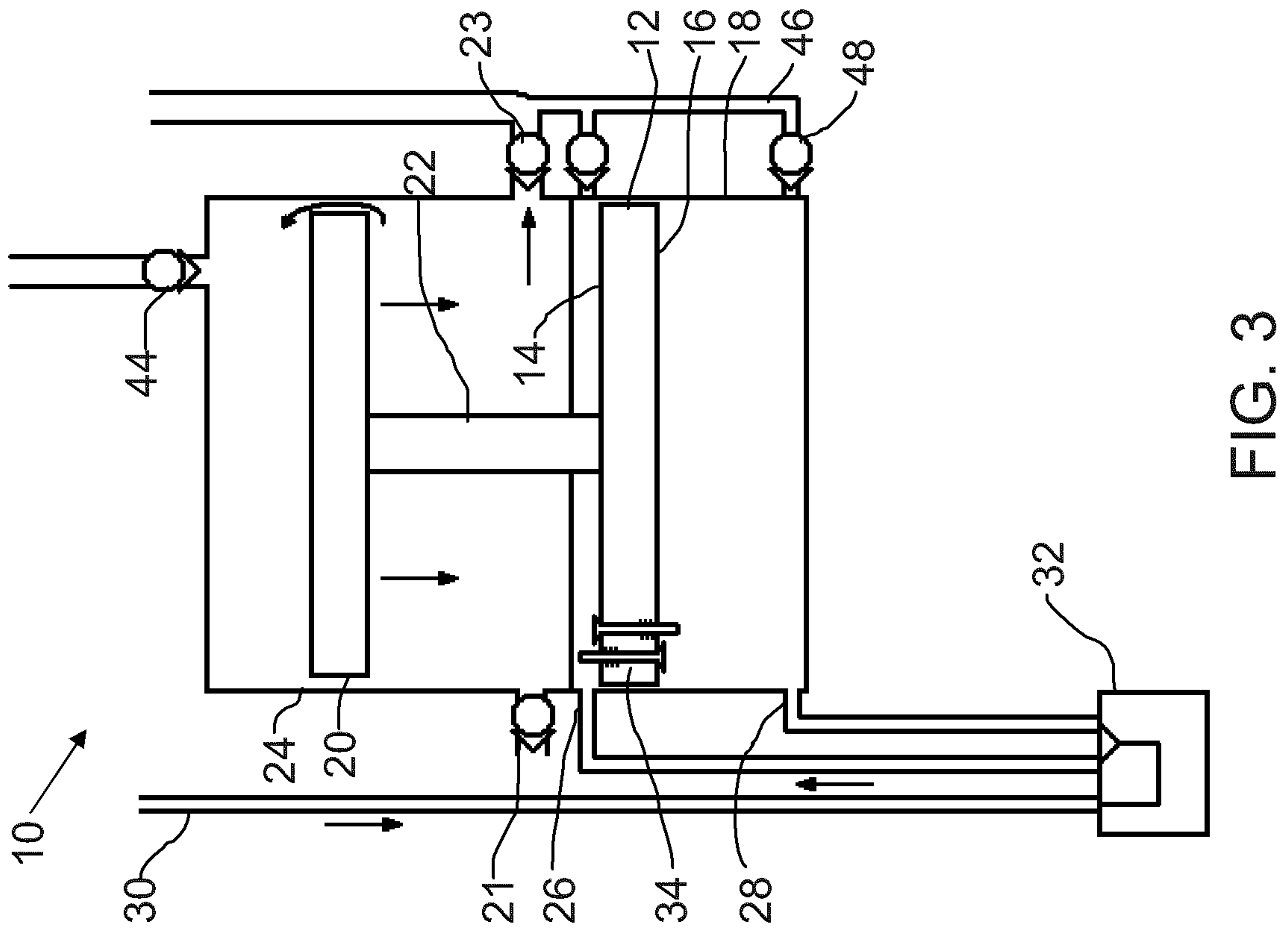


FIG. 3

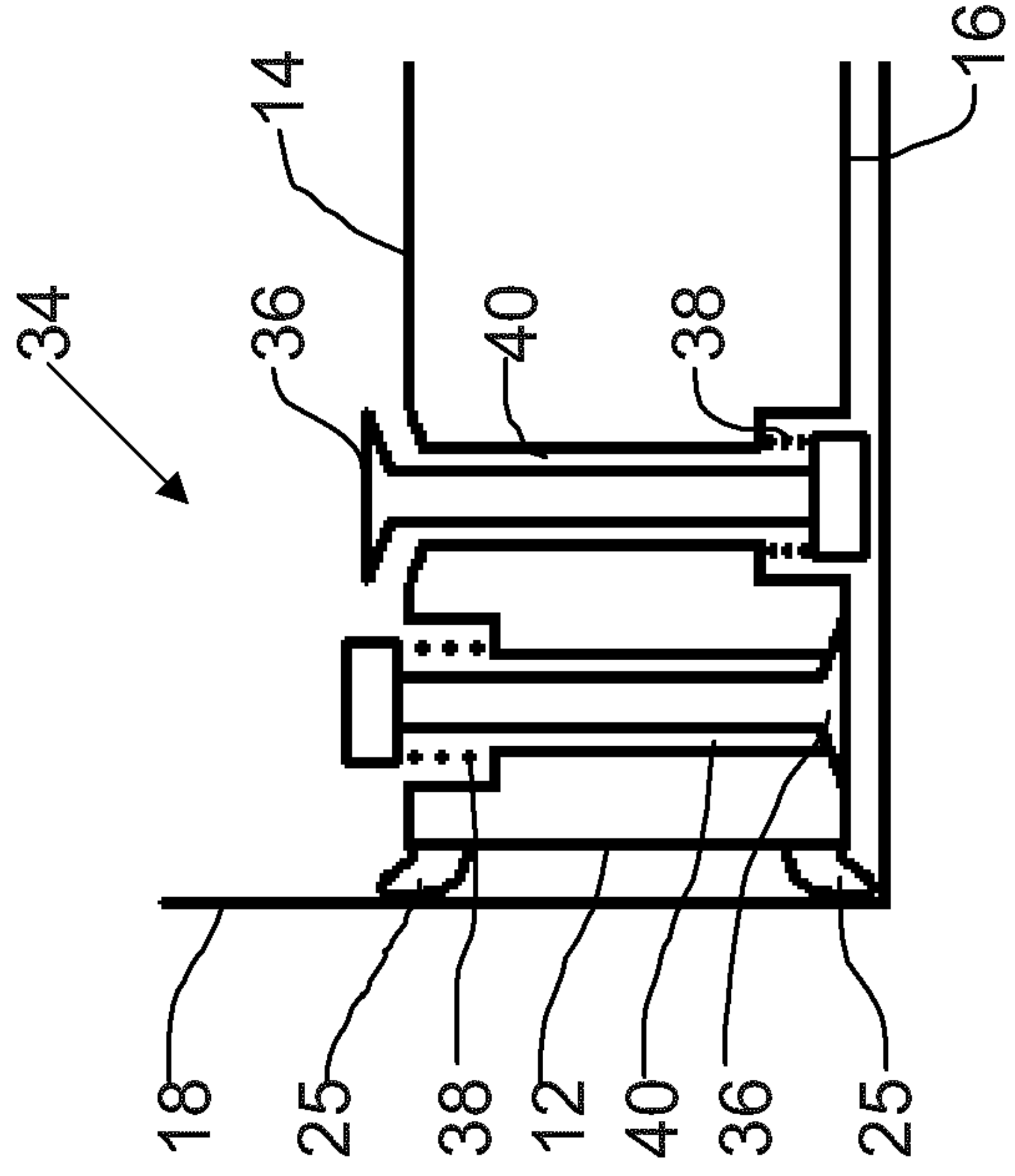


FIG. 4

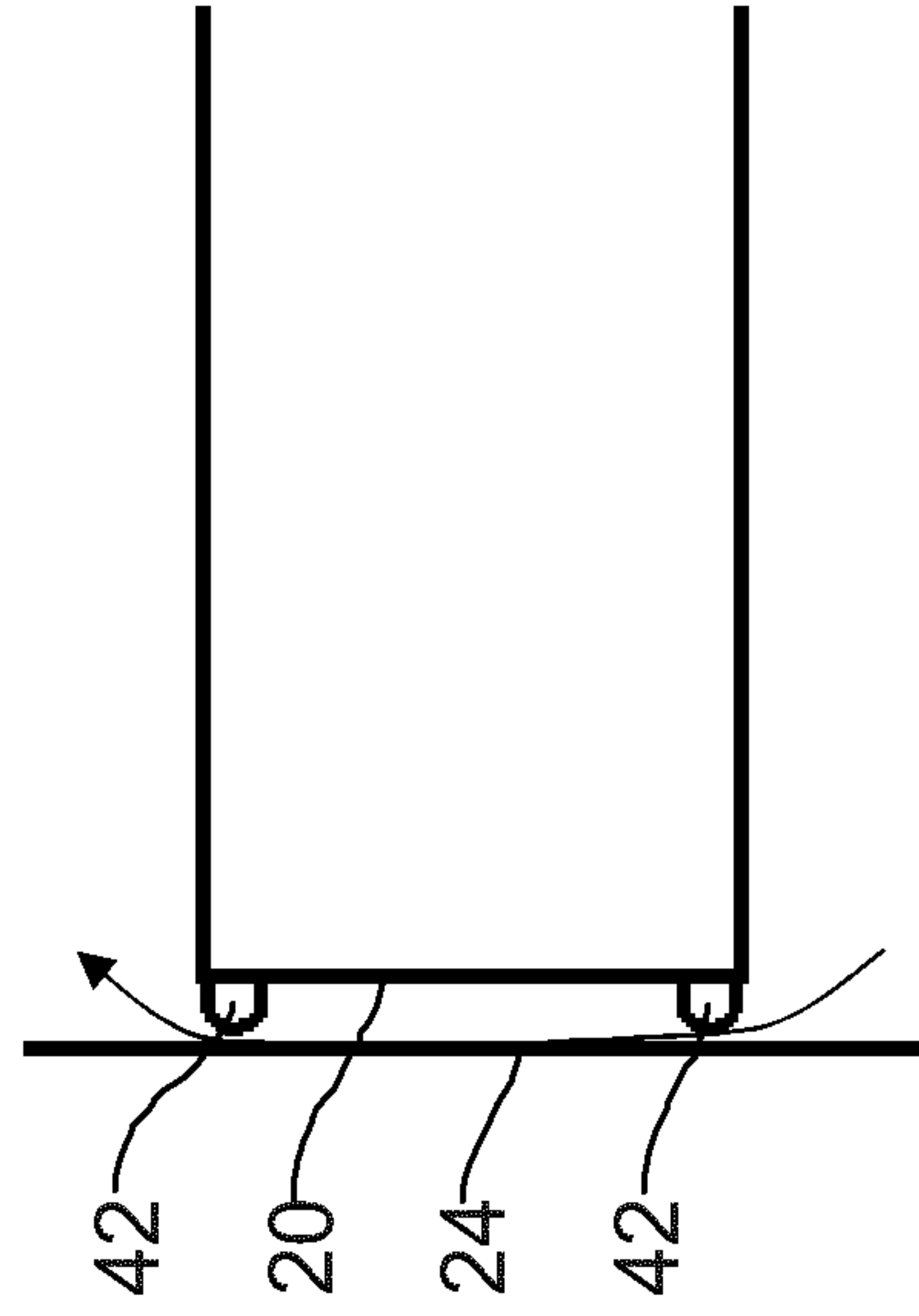


FIG. 5



FIG. 1