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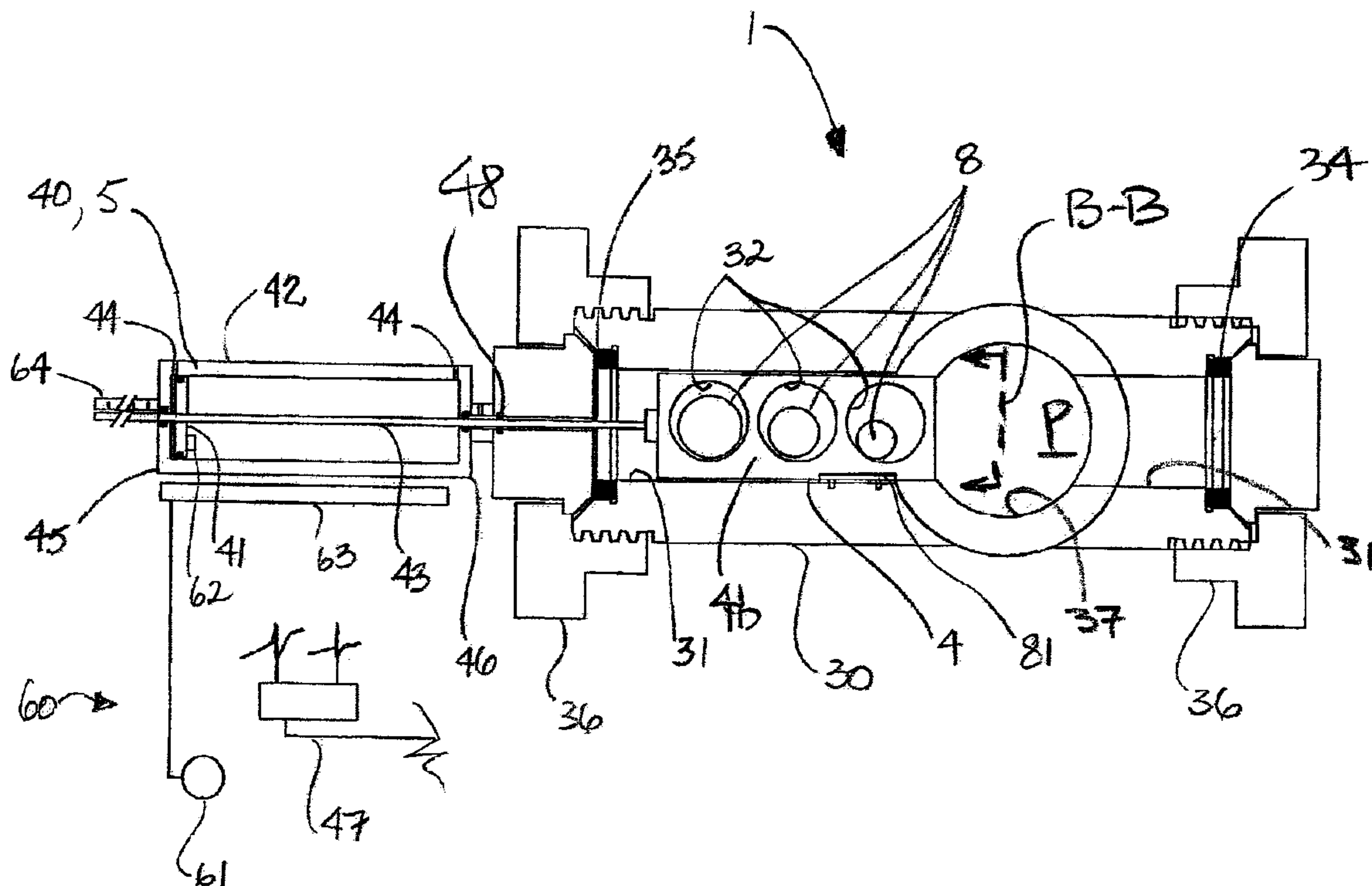
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(54) Titre : INJECTEUR DE BILLES POUR EXPLOITATION DES PUITS DE FORAGE

(54) Title: BALL INJECTING APPARATUS FOR WELLBORE OPERATIONS



(57) Abrégé/Abstract:

Apparatus is provided injecting drop balls into a wellbore, such as for actuating downhole tools. A ball magazine adapted for storing drop balls, in two or more transverse ball chambers, is axially movable in a magazine housing mounted at a transverse port to a fluid passage in fluid communication with the wellbore. The magazine is serially actuatable for aligning a first and subsequent chambers with the transverse port for injecting stored balls to the wellbore. An indicator, such as a rod extending from the magazine housing, can be used to indicate the relative location of the chamber and transverse port. The apparatus can be used in a system and methodology for actuating two or more downhole tools spaced at intervals along the wellbore.



1 **"BALL INJECTING APPARATUS FOR WELLBORE OPERATIONS"**
2

3 **FIELD OF THE INVENTION**

4 This invention relates generally to apparatus and method for
5 injecting balls into a wellbore, such as drop balls, frac balls, packer balls and
6 other balls for interacting with downhole tools or for blocking perforations in
7 casing in the wellbore. More particularly, the apparatus and method uses an
8 actuator and ball magazine for controllably releasing balls into a fluid stream
9 which is pumped into the wellbore.
10

11 **BACKGROUND OF THE INVENTION**

12 It is known to conduct fracturing or other stimulation procedures in a
13 wellbore by isolating zones in the wellbore using packers and the like and
14 subjecting the isolated zone to treatment fluids at treatment pressures. In a
15 typical fracturing procedure, for example, the casing of the well is perforated to
16 admit oil and/or gas into the well and fracturing fluid is then pumped into the well
17 and through the perforations into the formation. Such treatment opens and/or
18 enlarges draining channels in the formation, enhancing the producing ability of
19 the well.

20 It is typically desired to stimulate multiple zones in a single
21 stimulation treatment, typically using onsite stimulation fluid pumping equipment.
22 A series of packers in a packer arrangement is inserted into the wellbore, each of
23 the packers located at intervals for isolating one zone from an adjacent zone. It
24 is known to introduce a drop ball through the wellbore to selectively engage one
25 of the packers in order to block fluid flow therethrough permitting creation of an

1 isolated zone uphole from the packer for subsequent treatment or stimulation.
2 Once the isolated zone has been stimulated, a subsequent drop ball is dropped
3 to block off a subsequent packer, uphole of the previously blocked packer, for
4 isolation and stimulation thereabove. The process is continued until all the
5 desired zones have been stimulated. Typically the balls range in diameter from a
6 smallest ball, suitable to block the most downhole packer, to the largest diameter,
7 suitable for blocking the most uphole packer.

8 At surface, the wellbore is fit with a wellhead including valves and a
9 block, such as a frachead, which provides fluid connections for introducing
10 stimulation fluids including sand, gels and acid treatments into the wellbore.
11 Conventionally, operators manually introduce drop balls to the wellbore through
12 an auxiliary line, coupled through a valve, to the wellhead. The auxiliary line is fit
13 with a valved tee or T-configuration connecting the wellhead to a fluid pumping
14 source and to a ball introduction valve. The operator closes off the valve at the
15 wellhead to the auxiliary line, introduces one drop ball and blocks the valved
16 T-configuration. The pumping source is pressurized to the auxiliary line and the
17 wellhead valve is opened to introduce the ball. This procedure is repeated
18 manually, one at a time, for each ball. This operation requires personnel to work
19 in close proximity to the treatment lines through which fluid and balls are pumped
20 at high pressures and rates. The treatment fluid is energized which is highly
21 dangerous.

22 Aside from being a generally dangerous practice, other operational
23 problems have occurred, such as valves malfunctioning and balls becoming stuck
24 and not being pumped downhole. These problems have resulted in failed well
25 treatment operations, requiring re-working which is very costly and inefficient. At

1 times re-working of a well formation following an unsuccessful stimulation
2 treatment may not be successful, which results in production loss.

3 Other alternative methods and apparatus for the introduction of the
4 drop balls have included an array of remote valves positioned onto a multi-port
5 connection at the wellhead with a single ball positioned behind each valve. Each
6 valve requires a separate manifold fluid pumper line and precise coordination
7 both to ensure the ball is deployed and to ensure each ball is deployed at the
8 right time in the sequence, throughout the stimulation operation. The multi-port
9 arrangement, although workable, has proven to be very costly and inefficient.
10 Further, this arrangement is dangerous to personnel due to the multiplicity of
11 lines under high pressure connected to the top the wellhead during the
12 stimulation operation. It is known to feed a plurality of perforation-sealing balls
13 using an automated device as set forth in US 4,132,243 to Kuus. Same-sized
14 balls are used sealing perforations and are amenable feeding one by one from a
15 stack of balls. The apparatus appears limited to same-sized balls and there is
16 not positive identification whether a ball was successfully indexed from the stack
17 for injection.

18 There remains a need for a safe, efficient and remotely operated
19 apparatus and mechanism for introducing drop balls to a wellbore.

20

1 BRIEF DESCRIPTION OF THE DRAWINGS

2 Figure 1A is a schematic view of a well undergoing stimulation
3 operation using an embodiment of the invention connected to a top of a wellhead
4 and a fanciful representation of downhole tools and zones along the wellbore;

5 Figure 1B is a schematic view of a well undergoing stimulation
6 operation using an embodiment of the invention connected to the wellbore
7 through a fluid line and having a separate fluid pump connected thereto;

8 Figure 1C is a schematic view of a well undergoing stimulation
9 operation using an embodiment of the invention wherein the apparatus is fluidly
10 connected to the stimulation fluid flow line through a bypass;

11 Figure 2 is a side view of a wellhead illustrating typical fracturing
12 fluid side entrances and insertion of a drop ball through the top of a wellhead;

13 Figure 3A is a top, cross-sectional view of a ball magazine and
14 actuator according to an embodiment of the invention, with the wellhead removed
15 for clarity;

16 Figure 3B is an end view of the ball magazine of Fig. 3A along
17 section B-B illustrating a magazine alignment keyway formed therein;

18 Figures 4A – 4D are top cross-sectional views of the ball magazine
19 of Fig. 3, illustrating the loaded ball magazine and the sequential deployment of
20 three drop balls, a first small ball, a second medium ball and a third large ball,
21 respectively;

22 Figures 5A-5C are sequential longitudinal plan sectional views of an
23 embodiment of the invention illustrating a system for indicating position of the
24 magazine within the housing, more particularly

1 Fig. 5A illustrates a first position wherein no chambers within the
2 magazine are aligned with the wellbore and an indicator rod engages a first
3 indicator pin;

4 Fig. 5B illustrates a second position wherein a first chamber and
5 ball are aligned with the wellbore and the indicator rod engages a second
6 indicator pin, the first pin having been removed to permit movement of the
7 magazine; and

8 Fig. 5C illustrates a subsequent position wherein a last chamber
9 and ball are aligned with the wellbore and the indicator rod engages a final
10 indicator pin; and

11 Figure 6 is a side longitudinal sectional view according to Fig. 5A.

12

- 1 align the first chamber with the transverse port for injecting the first drop ball from
- 2 the first chamber and through the transverse port to the flow passage. As
- 3 needed, one serially repeats the actuating step for each subsequent chamber for
- 4 serially injecting each of the subsequent drop balls from the subsequent
- 5 chambers.

1 DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

2 Embodiments of the invention are discussed herein in the context of
3 the actuation of a series of packers within a wellbore for isolating subsequent
4 zones within the formation for fracturing of the zones. A series of packers
5 typically use a series of different sized balls for sequential blocking of adjacent
6 packers. One of skill in the art however would appreciate that the invention is
7 applicable to any operation requiring the dropping of one or more balls into the
8 wellbore.

9 It has been known to drop a ball from surface through a tubular in a
10 wellbore and into a seat of a downhole tool for blocking flow and permitting
11 changes in pumped pressure to actuate downhole equipment such as movement
12 of a sliding sleeve, opening and closing of a port, movement of a valves,
13 fracturing of a frangible element, release of cementing wiper plugs, control of
14 downhole packers, sealing perforations and the like. The diameter of the ball and
15 the sequence of the release one or more drop balls into the wellbore is relevant
16 to actuation of a series of packers for operations which can include as fracturing,
17 acid stimulation and other stimulation procedures directed to zones of interest
18 within the formation surrounding the wellbore.

19 In embodiments of the invention, a ball injecting apparatus 1 is
20 fluidly connected to a wellbore 2 for positively introducing a specific ball into a
21 fluid stream for injecting the ball into the wellbore.

22 In embodiments of the invention, as shown in Figs. 1A-1C and 3A,
23 flow passage P is fluidly connected to a wellbore 2 such as through a wellhead 3.
24 To minimize the risk of ball hang-up, the flow passage P can be fluidly connected
25 along a non-tortuous path such as to through a top of the wellhead or an angled

1 port. A ball injecting apparatus 1 is fit to the flow passage P and generally
2 comprises a ball magazine 4 loaded with one or more balls 8 and actuator 5 for
3 positioning the magazine 4 for aligning a ball 8 with the flow passage P and
4 assuring injection of the ball.

5 With reference to Figs. 1A -1C, and in the context of fracturing or
6 treating sequential zones within a formation accessed by the wellbore 2, the
7 wellhead 3 is connected to pump trucks 6 through a fluid line 7 for supplying a
8 fracturing or stimulation fluid to the wellbore 2. The wellhead 3 can be fit with a
9 frac head or a wellhead isolation tool having a bore sufficiently large to permit the
10 passage of the balls 8 therethrough. The pump trucks 6 are generally connected
11 to a blender 9 and treatment fluid tanks 10 through which the components of the
12 fracturing fluid, including sand or other proppant 11, are blended for delivery
13 through the fluid lines 7 to the wellhead 3 and to the wellbore 2 connected
14 thereto. The wellhead 3 forms the flow passage P to the wellbore 2.

15 As shown in the embodiment of Fig. 1A, the ball injecting apparatus
16 1 is connected to the flow passage P by directly mounting to the wellhead 3.
17 Balls 8 can be injecting directly into the wellhead 3 by gravity or fluid which urges
18 the balls 8 from the magazine 4 and into the flow passage P. In many instances,
19 a flow of fluids F is introduced through flow passage P or other ports in the
20 wellhead to the wellbore 2 therebelow. By injecting the ball 8 directly into the flow
21 passage P to join the flow fluid F one avoids accidental lodging of the ball 8 in
22 side ports or other cavities such as in some prior art T-configuration injection
23 apparatus.

24 Alternatively, as shown in Fig. 1B, the flow of fluid F can flow
25 through the ball injecting apparatus 1. The ball injecting apparatus 1 can be

1 fluidly connected to the wellhead 3 intermediate a separate fluid supply line 14
2 and pump 15 for fluidly injecting balls 8 into the flow of fluids F being conducted
3 in the wellbore 2. In an embodiment of the invention, frac fluid is introduced to
4 the wellbore 3 through side ports 16 in a frac head 17 mounted below the fluid
5 connection of the ball injecting apparatus 1. The ball injecting apparatus 1 and
6 separate fluid supply line 14 are connected to the wellhead 3 at a top port 18 of
7 the wellhead 2 which is substantially in-line with the wellbore 2. The ball injecting
8 apparatus 1 and the flow passage P can be connected through known angled
9 multi-ports (not detailed) of a frac head, typically angled in the range of 30 to 45
10 degrees.

11 Further, as shown in the embodiment of Fig. 1C, and particularly in
12 the case of operations for injecting fluids containing no proppant, the ball injecting
13 apparatus 1 may be fluidly connected to the wellhead 3 through a bypass 19 from
14 a main treatment fluid supply line 20. Valves are provided to route fluids through
15 the bypass 19 to propel the balls 8 from the magazine 4 and along the flow
16 passage P to the wellhead 3.

17 As shown in the wellhead configuration of Fig. 2, where the ball 8 is
18 introduced along a flow passage P which is generally in-line with wellbore 2, the
19 ball 8 does not need to change direction and is reliably introduced into the flow of
20 fluids F through the wellhead 3 for delivery down the wellbore.

21 Generally, as shown in Fig. 3A and 3B, and in embodiments of the
22 invention, the ball injecting apparatus 1 comprises a tubular magazine housing 30
23 having an axial bore 31 formed therein for receiving the magazine 4. The
24 housing 30 is fit with a transverse port 37, generally transverse to the axial bore
25 for forming a single point of egress for an injected ball 8 and becomes fluidly

1 connected and contiguous with the flow passage P. The transverse port 37 is
2 adapted for fluid connection with a bore 12 of the wellhead 3 (Fig. 1A) or
3 intermediate a fluid line 14,20 (Figs. 1B,1C), referred to collectively herein as the
4 flow passage P. When connected intermediate a flow line 14,20, the transverse
5 port is a flow-through port having fluid connections on opposing sides of the
6 magazine housing 30. The magazine 4 comprises a piston-like linearly-extending
7 body 4b having two or more of chambers 32 for storing two or more drop balls 8,
8 one ball per chamber. Each chamber 32 can receive, store and discharge an
9 individual drop ball 8. Each chamber 32 is typically a transverse, substantially
10 cylindrical passageway or bore through the body 4b for forming entrance and exit
11 openings 33,33. When a selected chamber 32 is axially and rotationally aligned
12 with the transverse port 37, the chamber 32 and transverse port 37 are fluidly
13 contiguous with the flow passage P. The chambers 32 and the apparatus 1 itself
14 can be sized to accept a range of diameters of balls up to the largest ball required
15 for the particular operation.

16 The bore 31 is sealed at opposing ends of the housing 34,35 so as
17 to retain fluid pressure in the flow passage P. The magazine 4 can be
18 removeably secured in the bore 31 of the magazine housing 30 using quick
19 release unions 36,36 such as hammer union assemblies, that permit easy access
20 to the magazine housing 30 to remove, load and replace a loaded magazine 4.
21 Alternatively the magazine 4 may be secured within the magazine housing 30
22 using other releasable connections. The apparatus 1 is designed to American
23 Petroleum Institute (API) standards for the particular design criteria including
24 pressure and fluid characteristics. The magazine housing 30 is fluidly connected
25 to the flow passage P for injecting the one or more balls 8 from the magazine 4.

1 Best shown in Fig. 6, in embodiments of the invention, the
2 transverse port 37 forms a contiguous passage between the openings 33 of the
3 ball chambers 32 and the flow passage P. In the case where the apparatus 1 is
4 mounted intermediate a fluid flow line 14,20 (Figs. 1B and 1C) connected to the
5 flow passage P, the transverse port 37 is formed on opposing sides of the
6 magazine housing 30. When one of the chambers' is axially aligned with the
7 transverse port 37, the chamber 32 is fluidly connected to the flow passage P, for
8 release of the ball 8 thereto. Where an axis CA of each of the two of more
9 chambers 32 is parallel to the axis of each other chamber 32, mere axial
10 positioning of the magazine 4 will align each chamber in turn with the transverse
11 port 37. In the case where the apparatus 1 is connected directly to the wellhead
12 3 (Fig. 1A), the drop balls 8 can dropped out of the transverse port 37 by gravity
13 and directly into the wellhead 3.

14 The magazine 4 is reciprocally actuated within the housing's bore
15 31 for manipulating the magazine 4 axially along the bore 31 so as to sequentially
16 position, or align, each chamber 32 in-line with the transverse port 37 and flow
17 passage P for deploying the drop balls 8 therein. The chambers 32 are axially
18 spaced therealong. The chambers 32 can be evenly and axially spaced for ease
19 of indexing the movement of the magazine 4.

20 The magazine 4 is actuated between an initial loaded position (Figs.
21 3A,4A), where none of the chambers 32 are aligned with the transverse port 37,
22 and an injection position (Figs 4B-4D), where one selected chamber 32 is moved
23 into alignment with the transverse port 37. When aligned, a drop ball 8 for the
24 selected chamber 32 is injected through the transverse port 37 along the flow
25 passage P to the wellbore 2.

1 The magazine 4 is actuated reciprocally axially within the bore 31
2 by the actuator 5. The magazine 4 itself, and the actuation thereof, is insensitive
3 to the size of the balls. Each chamber 32 can be sized for a particular-sized drop
4 ball or similarly sized so as to receive and store one drop balls of a range of balls
5 diameters without interference with the actuation and injection of drop balls
6 therefrom. All chambers 32 can be sized to accommodate the largest diameter of
7 the anticipated drop balls 8.

8 A suitable actuator 5 is a conventional double-acting hydraulic ram
9 40 having a piston 41 in a cylinder 42. The piston 41 is operatively connected to
10 the magazine 4, such as through a piston rod 43. A piston rod seal or seals 48
11 are positioned between the magazine housing 30 and the piston rod 43 wherein
12 the transverse port 37 and wellbore 2 are contained and further are isolated from
13 the actuator 5. As shown in Fig. 3A, ports 44 are provided at opposing ends
14 45,46 of the cylinder 42 for connection to a control valve 47 (connection not
15 illustrated) as understood by one of skill in the art, and which can be actuated
16 remotely.

17 Illustrative of the apparatus 1 in operation, as shown in Figs. 4A to
18 4D, and in an embodiment of the invention, the magazine 4 is preloaded with
19 three drop balls 8 of different, increasing diameter in three similar-sized,
20 corresponding chambers 32 of the magazine 4. Another embodiment capable of
21 operation with up to five drop balls is illustrated in Figs. 5A-6.

22 With reference to Figs. 4A – 4D, the loaded magazine 4 is inserted
23 into the bore 31 of the magazine housing 30 and the connection 36 is secured.
24 The balls 8 of increasing diameter can be differently and incrementally sized to
25 actuate a series of downhole tools fit with corresponding ball seats. As shown in

1 Fig. 4A, the preloaded magazine 4 is initially positioned into the magazine
2 housing 30 with no chambers 32 aligned with the transverse port 37 or flow
3 passage P so that no balls 8 are injected until actuated.

4 Subsequently, as shown in Fig. 4B, the actuator 5 is actuated to
5 advance the magazine 4 in the magazine housing 30 to position a first chamber
6 32a, housing a first, small diameter drop ball 8a, into alignment with the flow
7 passage P for injecting the ball 8a therein. The ball 8a can fall under gravity (into
8 the sheet of Fig. 4C) or otherwise carried by a flow stream if intermediate the flow
9 passage P. The first ball 8a is typically sized to block a first downhole tool.

10 As shown in Fig. 4C, the actuator 5 is further actuated to advance
11 the magazine 4 to position a second chamber 32b, housing a medium diameter
12 drop ball 8b, into alignment with the flow passage P. Note the first chamber 32a
13 is now empty, the first ball 8a having been previously injected into the flow
14 passage P. The second ball 8b is typically sized to block a second downhole
15 tool, uphole from the first downhole tool.

16 As shown in Fig. 4D, the actuator 5 is further actuated to advance
17 the magazine 4 to position a third chamber 32c, housing a third and largest
18 diameter drop ball 8c, into alignment with the flow passage P. Note the first and
19 second chambers 32a, 32b are now empty and, in this embodiment, the first
20 chamber 32a happens to move axially beyond the flow passage P. The third ball
21 8c is typically sized to block a third downhole tool, uphole from the second
22 downhole tool.

23 As the magazine 4 is serially actuated, the body 4b passes through
24 the flow passage P and a distal end 49 enters a passage 50 at the distal end 34
25 of the bore 31 which accepts the axial length of the magazine 4. The distal end

1 49 of the magazine 4 rests inside the distal end 34 of the bore 31 and can be
2 further supported thereby.

3 As shown in Figs. 5A-6, additional chambers 32 for housing
4 additional balls 8 can be implemented within an extended linear magazine 4 to
5 operate a greater number of downhole tools. A length of the magazine housing
6 30, the magazine 4, the passage 50 and the stroke of the actuator 5 is adjusted
7 accordingly.

8 In embodiments of the invention of Figs. 3A-6, an indicator system
9 60 is provided for confirmation of alignment of a chamber 32 with the flow
10 passage P and further for confirming which of the chambers 32 is aligned with the
11 flow passage P so as to ensure a known drop ball 8 of known size is injected
12 when required.

13 As shown in Fig. 3A the indicator 60 may comprise an electronic
14 indicator 61 for indicating relative position of the magazine and transverse port
15 37. Such an indicator 60 could include devices between the housing and
16 magazine or on the actuator 5. For example, a magnet 62 and pickup 63 could
17 be arranged on a hydraulic ram 40 or alternatively a graded rod 64 (Fig. 3A)
18 connected to the hydraulic cylinder 42. The indicator 60 precisely confirms the
19 selected chamber 32 and drop ball 8 which is positioned for injection
20 downstream.

21 As shown in Figs. 5A-5C and 6, the indicator system 60 may
22 comprise an indicator rod 65 extending from an end 66 of the magazine 4 and
23 through the magazine housing 30 opposite the hydraulic ram 40. An indicator rod
24 seal or seals 51 are positioned between the magazine housing 30 and the
25 indicator rod 65 wherein the transverse port 37 and wellbore 2 are contained.

1 In an embodiment, the indicator rod 65 extends through an indicator
2 housing 67 and includes an indicator disc 68 mounted thereto at a distal end 69.
3 The indicator housing 67 is bored axially therealong with holes 70 at spaced
4 intervals which correspond to the position of each of the chambers 32 in the
5 magazine 4 when each chamber 32 is aligned with the flow passage P.

6 Indicator stops or pins 71 can be inserted into the holes 70 against
7 which the indicator disc 68 engages or stops, indicating that a chamber 32 is
8 aligned with the transverse port 37. First and subsequent indicator pins 71 can
9 be sequentially or serially removed, enabling manual advancing the magazine 4
10 until the rod disk 68 engages each subsequent pin 71. U-shaped pins are
11 illustrated using pairs of holes 70, for ease of handling, although straight pins,
12 discs and slots or other removable stops could be used.

13 Alternatively, the indicator pins 71 may be shear pins. A slight but
14 measurable increase in pressure at the actuator 5 would indicate to an operator
15 that the disc 68 had engaged an indicator pin 71 and that a drop ball 8 had been
16 aligned and dropped into the flow passage P. For releasing a subsequent drop
17 ball 8, the magazine 4 would then be actuated under sufficient pressure to shear
18 the indicator pin 71 and shift the magazine 4 axially until the indicator disc 68
19 engaged the next indicator pin 71.

20 In the embodiment of Figs. 5A-5C, as opposed to that shown in Fig.
21 3A, the addition of the indicator rod system 60, through the indicator seal 51 at
22 the opposite end 66 of the magazine housing 30 to the hydraulic ram 40, acts to
23 balance the fluid force on the piston rod 43. Thus, lower forces are required to
24 advance the piston 41 and magazine 4, reducing stress on the moving

1 components. Further, only a small cylinder 42 is then required which acts to
2 reduce the weight of the ball injecting apparatus 1.

3 Optionally, sophisticated hydraulic rams 40 could have built-in
4 mechanical or electrical measurement systems effective to indicate when the
5 chambers 32 have been aligned with the flow passage P.

6 With reference to Figs 3A, 3B, 4C and 5C, in embodiments of the
7 invention, rotational alignment means 80 are provided for ensuring that the
8 magazine 4, having two or more parallel and spaced chambers 32 formed
9 therein, remains rotationally oriented during axial manipulation of the magazine 4
10 for aligning each of the chambers 32 in turn with the transverse port 37. While
11 the magazine housing 30 and magazine can have a cross-sectional profile which
12 resists rotation, such as a corresponding polygonal profile, pressure conditions of
13 the wellbore 2 encourage selection of a generally cylindrical housing 30 and
14 magazine 4. Accordingly, means are provided for preventing rotation of the
15 magazine 6 relative to the magazine housing 30. One of skill in the art would
16 appreciate that alignment of the magazine 4 within the magazine housing 30 may
17 be accomplished in a number of different ways including the use of splines, key
18 and keyway combinations, locking nuts and the like.

19 As shown in Figs. 3A,3B and in an embodiment of the invention, the
20 magazine 4 is splined to the magazine housing 30 for retaining proper alignment
21 of the chambers 32 throughout the axial manipulation of the magazine 4. As
22 shown, the spline may include a simple key 81 formed within the magazine
23 housing 30 and keyway 82 formed in the magazine 4.

24 Alternately, in an embodiment as shown in Figs. 5A-5C, the
25 indicator rod housing 67 is formed having a spline 83 extending therealong and

1 the rod disc 68 has a keyway 84 formed therein for preventing rotation of the
2 indicator rod 65 within the rod housing 67 and the magazine 4 connected thereto.
3 Further, the indicator rod 65 may be connected to the magazine 4 through a
4 connector employing co-operating polygonal openings and rod end profiles for
5 preventing rotation of the magazine 4 relative to the aligned indicator rod 65 and
6 the magazine 4 attached thereto.

7

8 Example- Wellbore Operations

9 With reference to Figs. 1A and 4A - 4D, a system and method for
10 conducting operations on a wellbore 2 are provided. The wellbore 2 is fit with two
11 or more downhole tools T1,T2,T3, such as packers spaced at intervals along the
12 wellbore for isolation of a first zone and subsequent zones Z1,Z2,Z3. The system
13 and methodology can implement an embodiment of the ball injecting apparatus 1
14 of the present invention.

15 With assistance of the embodiment illustrated in Fig. 1A, the ball
16 injecting apparatus 1 is mounted with the transverse port 37 fluidly connected
17 directly atop a stimulation multi-port wellhead 3. A flow F of stimulation fluids 7
18 can be provided to the wellhead 3 and the apparatus 1 can inject drop balls 8 into
19 the flow path P for delivery down the wellbore 2. As is known by those of skill in
20 the art, operations on the wellbore can include actuating a first packer T1 for
21 blocking flow therebelow so that stimulation operations can be conducted on a
22 zone Z1 uphole of that first packer. One or more subsequent packers T2,T3,...
23 Tn are provided uphole of the first packer T1.

24 As shown in Fig. 4A, the magazine 4 of a hydraulic actuated ball
25 injecting 1 is preloaded with three different sized drop balls 8a,8b,8c of increasing

1 diameter required for the stimulation operation. As the magazine 4 is
2 incrementally inserted into the magazine housing 30 the drop balls 8 are loaded
3 into the chambers 32 in the sequence in which they are to be injected. Once all
4 the drop balls 8 are loaded, the magazine 4 is fully engaged within the housing
5 bore 31 and the hammer union 36 or other appropriate connection is secured.

6 As shown in Fig. 4B, the actuator 5 is actuated for moving the
7 magazine and axially aligning a first or selected chamber 32a with the transverse
8 port 37 for injecting the first drop ball 8a into the flow path P. The first drop ball
9 moves downhole, in the wellbore, passing each of the subsequent packers Tn ...
10 T3, T2 until it engages the corresponding, first packer T1 for actuating or blocking
11 the wellbore at the first packer. The drop ball 8a engages a ball seat for isolating
12 the zone Z1, in the wellbore uphole of the first packer T1, from the wellbore
13 therebelow.

14 Once stimulation for the zone Z1 above the first packer T1 is
15 complete, a new zone is isolated uphole of the first packer. As shown in Fig. 4C,
16 the actuator 5 is actuated again for axially aligning a second and subsequent
17 selected chamber 32b with the transverse port 37 for injecting the subsequent
18 drop ball 8b into the flow path P. The subsequent drop ball 8b traverses the
19 wellbore 2, passing each of the subsequent packers Tn ... T3 until the ball
20 engages and actuates the corresponding, second and subsequent packer T2.
21 The drop ball 8b engages a corresponding ball seat of the subsequent packer T2
22 for isolating zone Z2 uphole of the subsequent packer.

23 If there is a need and yet another subsequent packer, the actuator 5
24 can be actuated again for axially aligning yet another subsequent selected

- 1 chamber 32c with the transverse port 37 for injecting a third and subsequent drop
- 2 ball 8c for actuating the subsequent packer T3.
- 3 The system and method is serially repeated for each packer and
- 4 corresponding drop ball provided.

1 **THE EMBODIMENTS OF THE INVENTION IN WHICH AN**
2 **EXCLUSIVE PROPERTY OR PRIVILEGE IS CLAIMED ARE DEFINED AS**
3 **FOLLOWS:**
4

5 1. A ball injecting apparatus for injecting drop balls into a
6 wellbore comprising:

7 a magazine housing having an axial bore formed therethrough and
8 a transverse port, the transverse port being adapted for fluidly connecting to the
9 wellbore;

10 a magazine axially movable in the axial bore, the magazine having
11 two or more transverse chambers spaced axially therealong, each chamber being
12 adapted for receiving an individual drop ball therein; and

13 an actuator for axially positioning the magazine within the axial bore
14 between a loaded position where none of the two or more chambers are axially
15 aligned with the transverse port, and an injection position where one selected
16 chamber of the two or more chambers is moved into alignment with the
17 transverse port wherein a drop ball for the selected chamber is injected from the
18 selected chamber and through the transverse port to the wellbore.

19
20 2. The ball injecting apparatus of claim 1 wherein each
21 chamber is a transverse, substantially cylindrical bore through the magazine
22 which is parallel and axially spaced from each other chamber.

23
24 3. The ball injecting apparatus of claim 2 wherein the magazine
25 is rotationally constrained for maintaining rotational alignment of the selected
26 chamber with the transverse port.

1

2 4. The ball injecting apparatus of claim 3 further comprising
3 rotational alignment means for rotationally aligning the magazine and the
4 magazine housing.

5

6 5. The ball injecting apparatus of claim 4 wherein the rotational
7 alignment means is a co-operating key and keyway between the magazine
8 housing and the magazine.

9

10 6. The ball injecting apparatus of claim 4 wherein the rotational
11 alignment means is a co-operating key and keyway on the actuator.

12

13 7. The ball injecting apparatus of any one of claims 1 to 6
14 further comprising:

15 an indicator rod extending from an end of the magazine opposite to
16 the actuator, the indicator rod extending axially through the housing; and

17 an indicator seal between the housing and the indicator rod.

18

19 8. The ball injecting apparatus of claim of any one of claims 1 to
20 6 further comprising an indicator for signaling the position of the selected
21 chamber.

22

23 9. The ball injecting apparatus of claim 8 wherein the indicator
24 is an electronic sensor for sensing relative position of the magazine with respect
25 to the housing.

1

2 10. The ball injecting apparatus of claim 8 wherein the indicator

3 comprises:

4 an indicator rod extending from an end of the magazine opposite to

5 the actuator, the indicator rod extending axially through the magazine housing;

6 an indicator seal between the housing and the indicator rod;

7 an indicator disc at a distal end of the indicator rod;

8 an indicator housing extending about the indicator rod and fixed

9 relative to the magazine housing;

10 a plurality of holes bored through the housing each of which is axial

11 spaced at intervals to correspond to the axial spacing of the two or more

12 chambers in the magazine; and

13 removable stop pins for positioning in the plurality of holes along the

14 indicator housing and acting between the indicator disc and the indicator housing

15 for engaging the indicator disc thereagainst for signaling when one of the one or

16 more chambers is aligned with the transverse port.

17

1 11. The ball injecting apparatus of claim 10 wherein the pins are
2 shear pins acting between the indicator disc and the indicator housing, the
3 actuator being actuatable to cause one of the shear pins to shear and permit
4 movement of the magazine to a subsequent shear pin to axially align the selected
5 chamber with the transverse port.

6

7 12. The ball injecting apparatus of any one of claims 1 to 11
8 wherein the two or more chambers are similarly sized.

9

10 13. The ball injecting apparatus of any one of claims 1 to 12
11 wherein each chamber is axially and equally spaced from each other chamber.

12

13 14. The ball injecting apparatus of any one of claims 1 to 13
14 wherein the actuator comprises a double-acting hydraulic ram having a piston in
15 a cylinder, the piston being operatively connected to the magazine.

16

17 15. The ball injecting apparatus of claim 14 wherein the piston is
18 connected to magazine by a piston rod.

19

20 16. The ball injecting apparatus of claim 15 further comprising a
21 piston rod seal between the magazine housing and the piston rod wherein the
22 wellbore is isolated from the actuator.

23

1 17. A method for injecting drop balls into a flow passage
2 comprising:
3 providing a ball injecting apparatus having
4 a magazine housing having an axial bore formed
5 therethrough and a transverse port, the transverse port being adapted for
6 fluidly connecting to the wellbore;
7 a magazine axially movable in the axial bore, the magazine
8 having two or more transverse chambers spaced axially therealong, a first
9 of the two or more of the chambers having a first drop ball loaded therein
10 and each subsequent chamber having a subsequent drop ball loaded
11 therein; and
12 an actuator for axially positioning the magazine within the
13 axial bore between a loaded position where none of the two or more
14 chambers are axially aligned with the transverse port, and an injection
15 position where one selected chamber of the two or more chambers is
16 moved into alignment with the transverse port;
17 mounting the ball injecting apparatus so that the transverse port is
18 fluidly connected to the flow passage;
19 actuating the actuator to move the magazine in the magazine
20 housing to axially align the first chamber with the transverse port for injecting the
21 first drop ball from the first chamber and through the transverse port to the flow
22 passage; and
23 serially repeating the actuating step for each subsequent chamber
24 for serially injecting each of the subsequent drop balls from the subsequent
25 chambers.

1

2 18. The method of claim 17 wherein the mounting step
3 comprising mounting the ball injecting apparatus to a top of a wellbore for forming
4 the flow passage extending downward from the transverse port to the wellbore,
5 wherein the selected ball is injected to the flow passage by gravity.

6

7 19. The method of claim 17 wherein the mounting step
8 comprises mounting the ball injecting apparatus intermediate a fluid flow line
9 connected to the wellbore for forming the flow passage through transverse port of
10 the ball injecting apparatus, wherein the selected ball is injected to the flow
11 passage by fluid passing through the fluid flow line and the transverse port and to
12 the wellbore.

13

14 20. A system for injecting one or more balls into a wellbore for
15 actuating a series of downhole tools comprising:

16 a ball injecting apparatus having

17 a magazine housing having an axial bore formed
18 therethrough and a transverse port, the transverse port being adapted for
19 fluidly connecting to the wellbore;

20 a magazine axially movable in the axial bore, the magazine
21 having two or more transverse chambers spaced axially therealong, a first
22 of the two or more of the chambers having a first drop ball loaded therein
23 and each subsequent chamber having a subsequent drop ball loaded
24 therein; and

1 an actuator for axially positioning the magazine within the
2 axial bore between a loaded position where none of the two or more
3 chambers are axially aligned with the transverse port, and an injection
4 position where one selected chamber of the two or more chambers is
5 moved into alignment with the transverse port;

6 two or more downhole tools spaced at intervals along the wellbore,
7 the two or more downhole tools comprising a first downhole tool actuable upon
8 receipt of the first drop ball and each subsequent downhole tool actuable upon
9 receipt of each subsequent drop ball;

10 wherein when the actuator is actuated to move the magazine in the
11 magazine housing to axially align the first chamber with the transverse port, the
12 first drop ball is injected from the first chamber and through the transverse port to
13 the wellbore for actuating the first downhole tool; and

14 serially actuating the actuator for each subsequent chamber for
15 serially injecting each of the subsequent drop balls from the subsequent
16 chambers to serially actuate each of the subsequent downhole tools.

17

18 21. The system of claim 20 wherein

19 the two of more downhole tools are a first and subsequent packers
20 for isolating a first zone and subsequent zones along the wellbore and the first
21 packer is actuable upon receipt of the first drop ball for blocking the wellbore
22 below the packer, and each subsequent packer is actuable upon receipt of the
23 subsequent drop ball for blocking the wellbore below the subsequent packer;

24 the subsequent drop ball has a diameter greater than the first drop
25 ball and each subsequent ball has a diameter greater than an immediately

1 preceding subsequent drop ball wherein each of the drop balls does not actuate
2 the subsequent packer.

3

4 22. The method of claim 20 or 21 further comprising:

5 a wellhead fluidly connected to the wellbore, wherein the ball
6 injecting apparatus is mounted to a top of the wellhead for forming a flow
7 passage extending downward from the transverse port to the wellbore, wherein
8 the selected ball is injected to the flow passage by gravity.

9

10 23. The method of claim 20 or 21 further comprising:

11 a wellhead fluidly connected to the wellbore; and

12 a fluid flow line for flowing fluid to the wellhead, wherein the ball
13 injecting apparatus is mounted intermediate the fluid flow line forming a flow
14 passage through transverse port of the ball injecting apparatus and to the
15 wellbore, wherein the selected ball is injected to the flow passage by fluid passing
16 through the fluid flow line and the transverse port and to the wellbore.

17

18 24. The system of claim 22 or 23 wherein the wellhead further
19 comprises a wellhead isolation tool having a bore of sufficient size to accept the
20 first and subsequent drop balls.

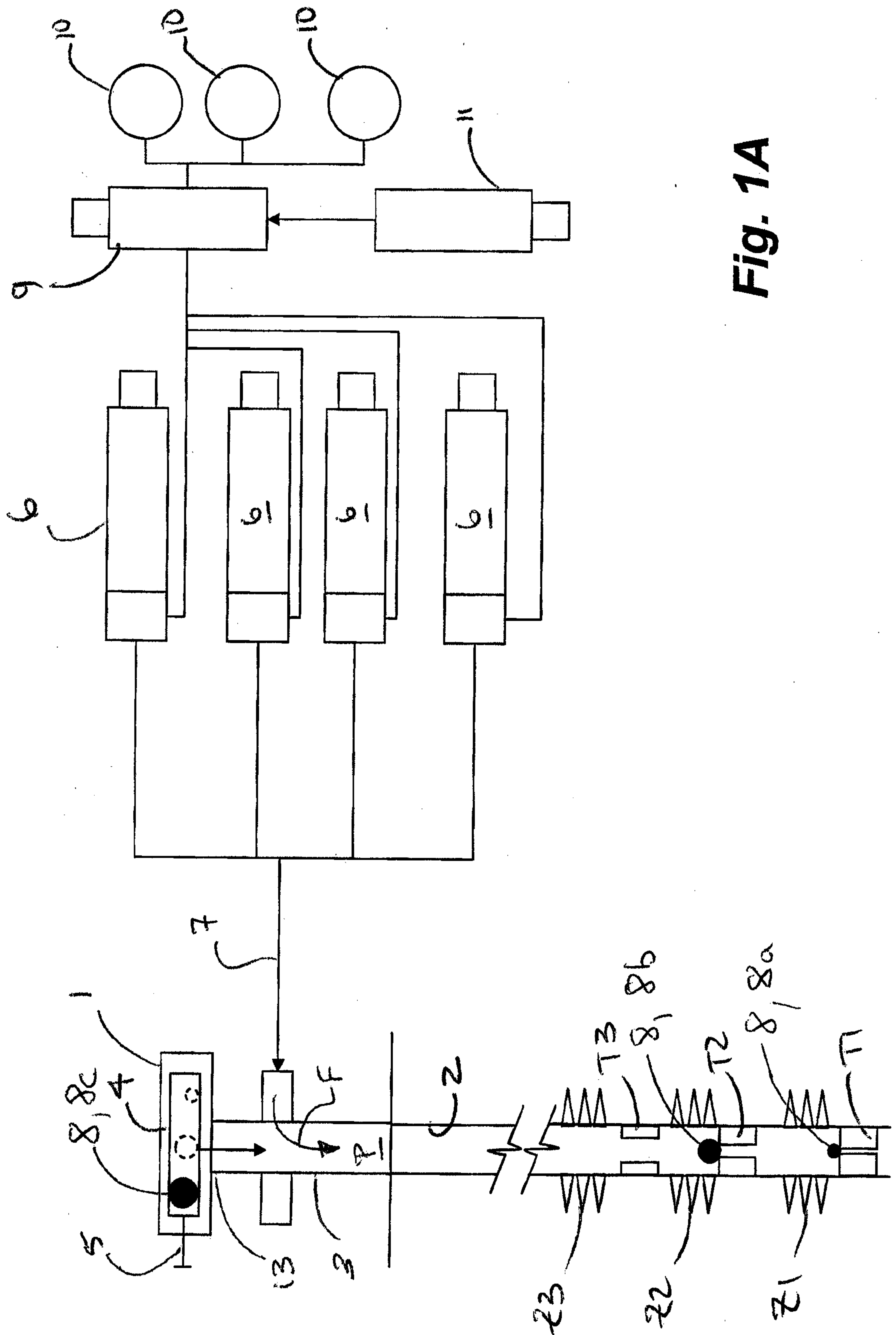


Fig. 1A

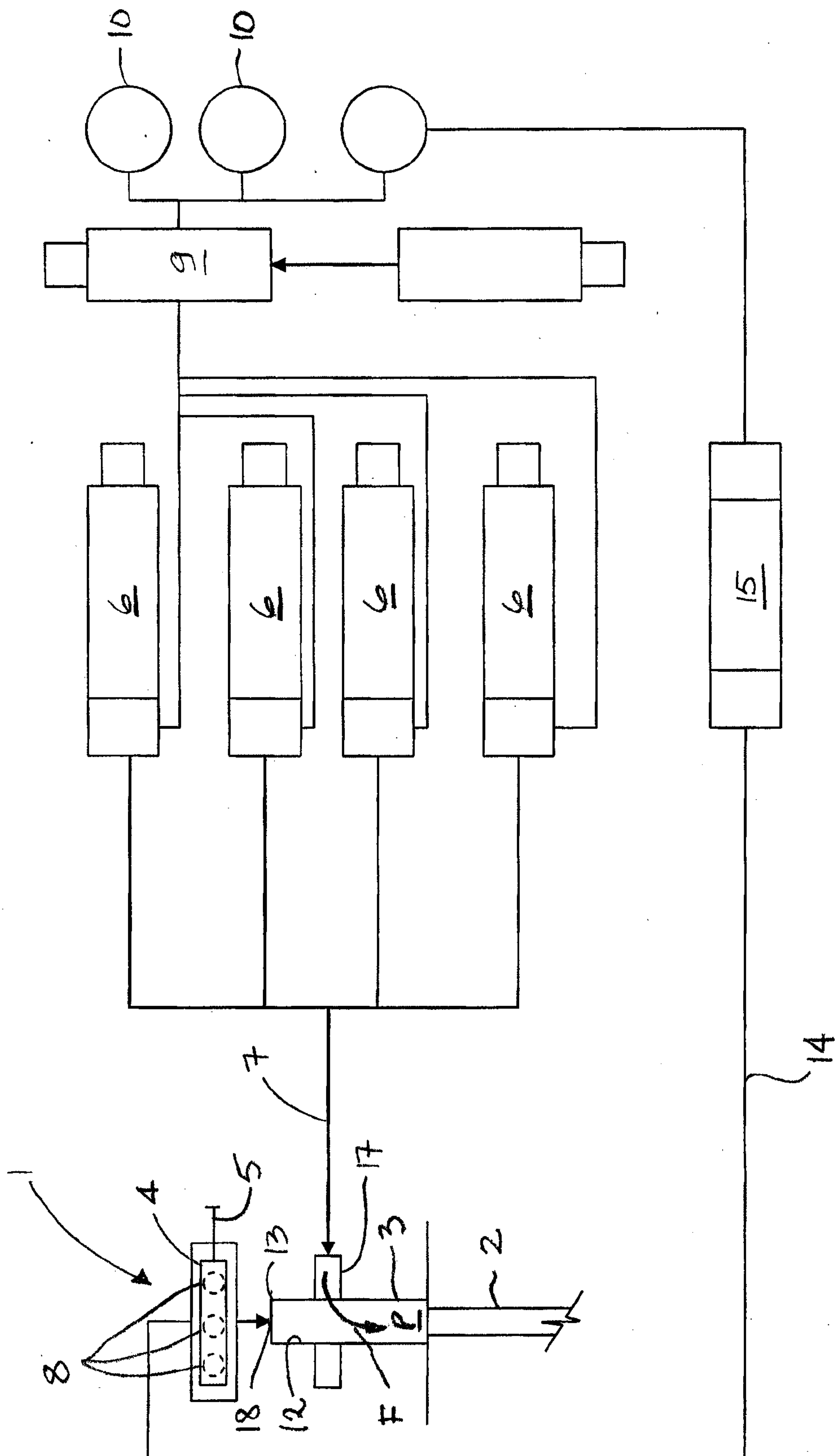


Fig. 1B

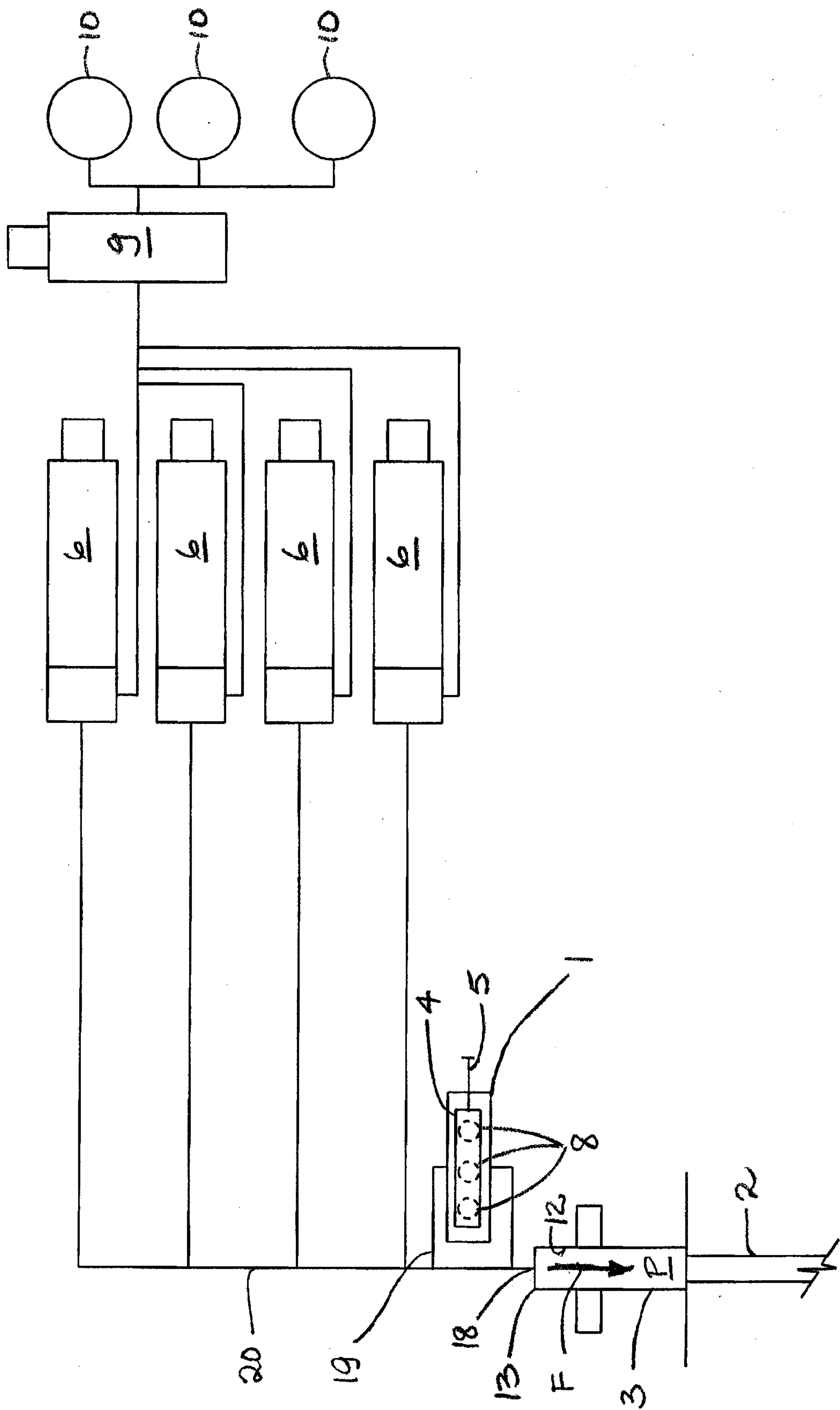


Fig. 1C

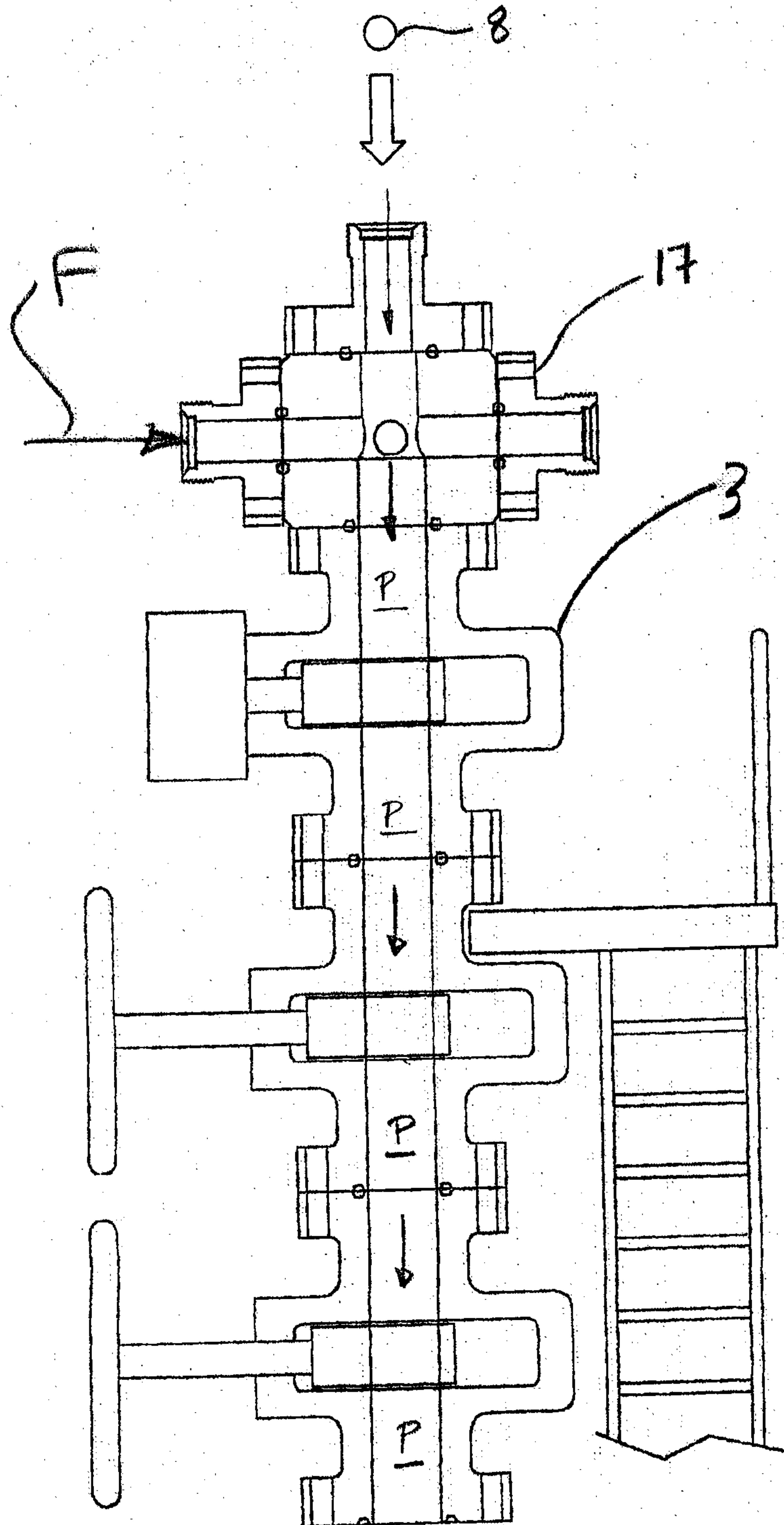
Fig. 2

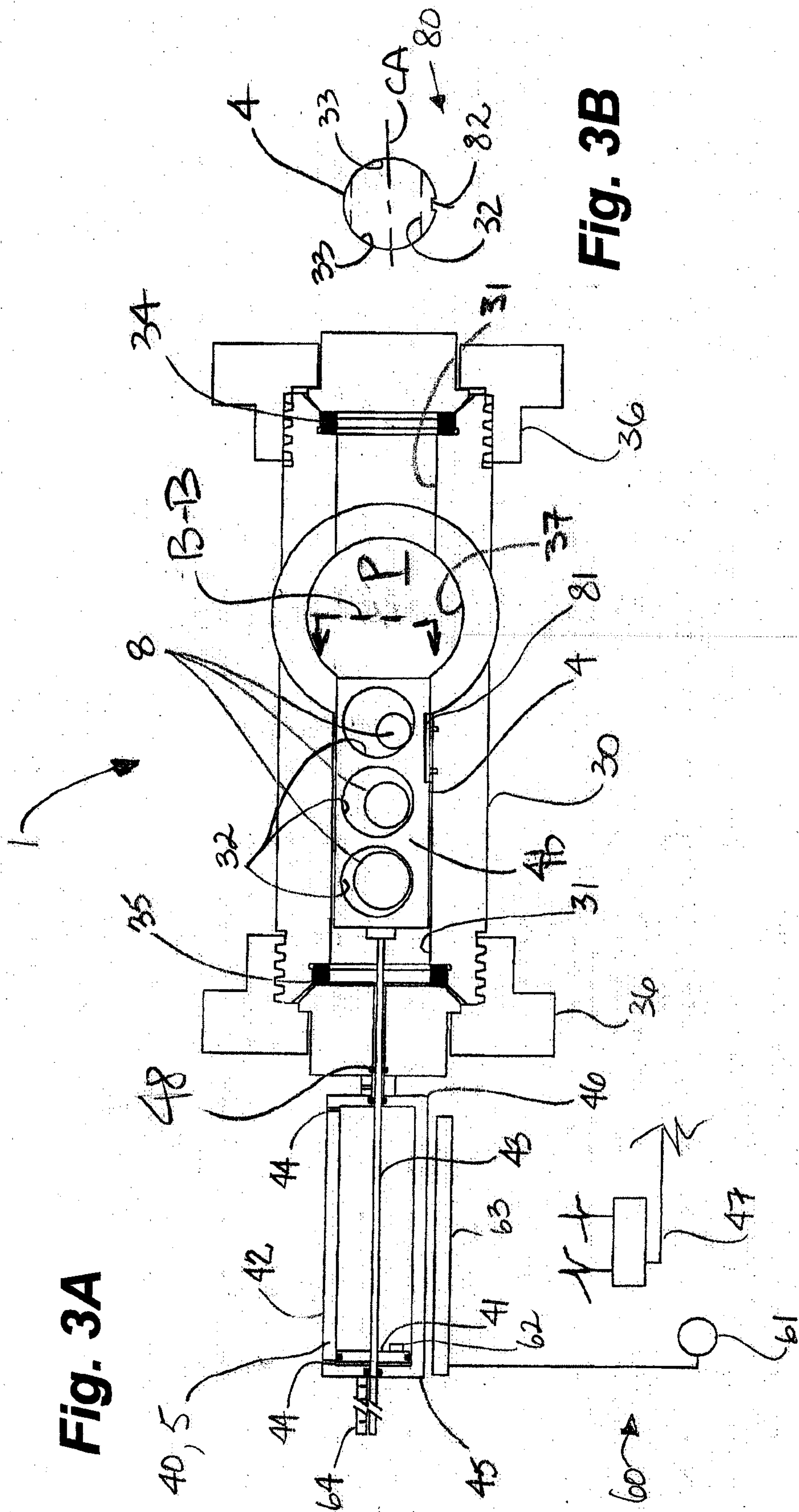
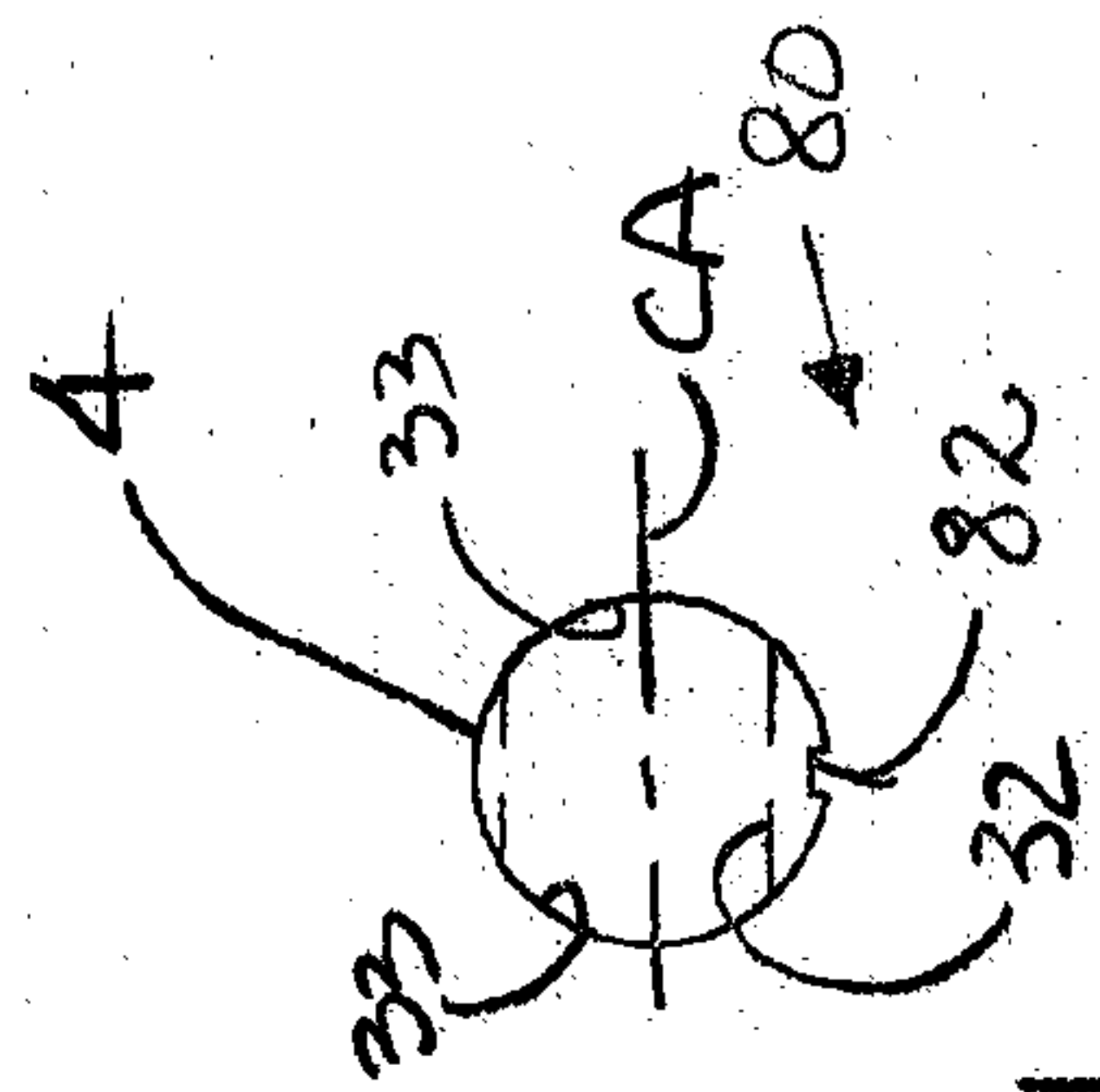
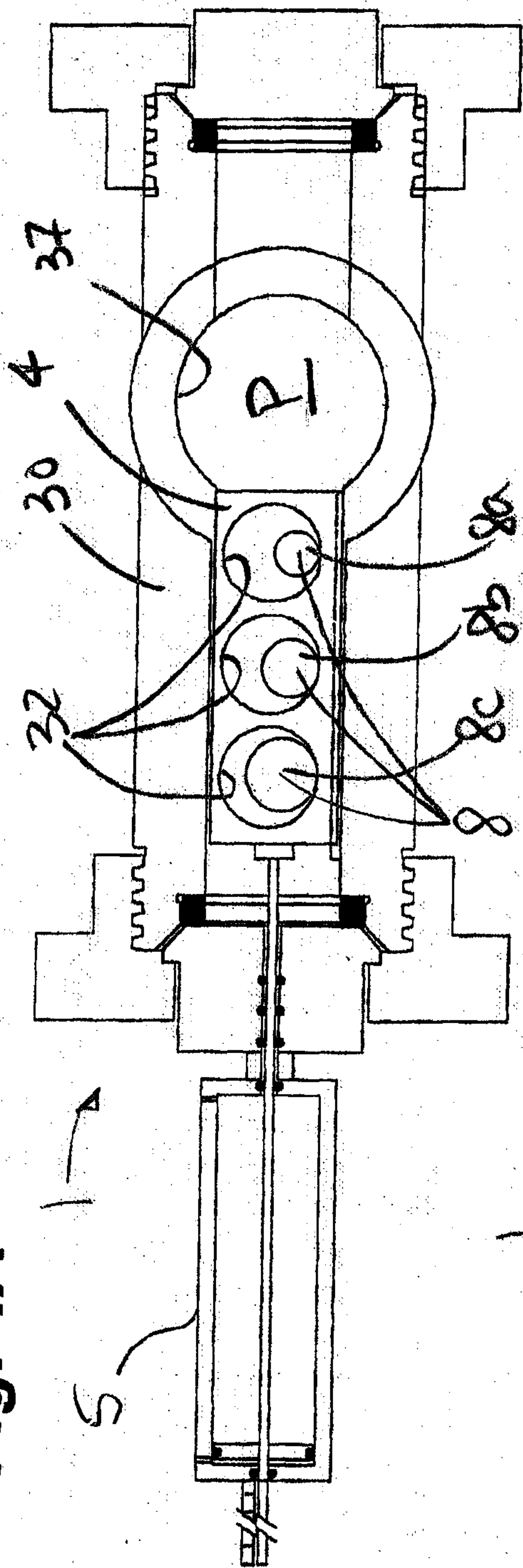
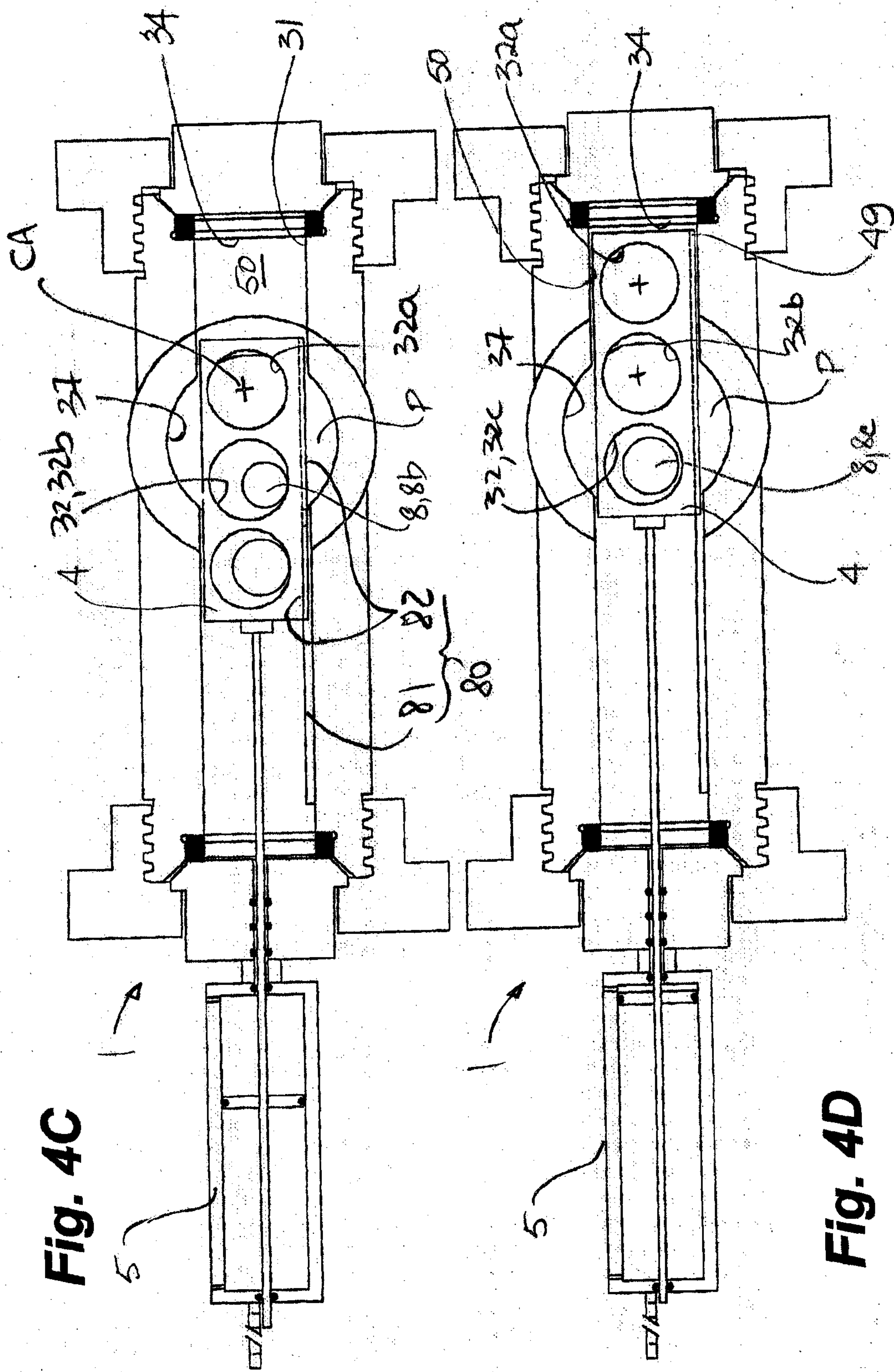
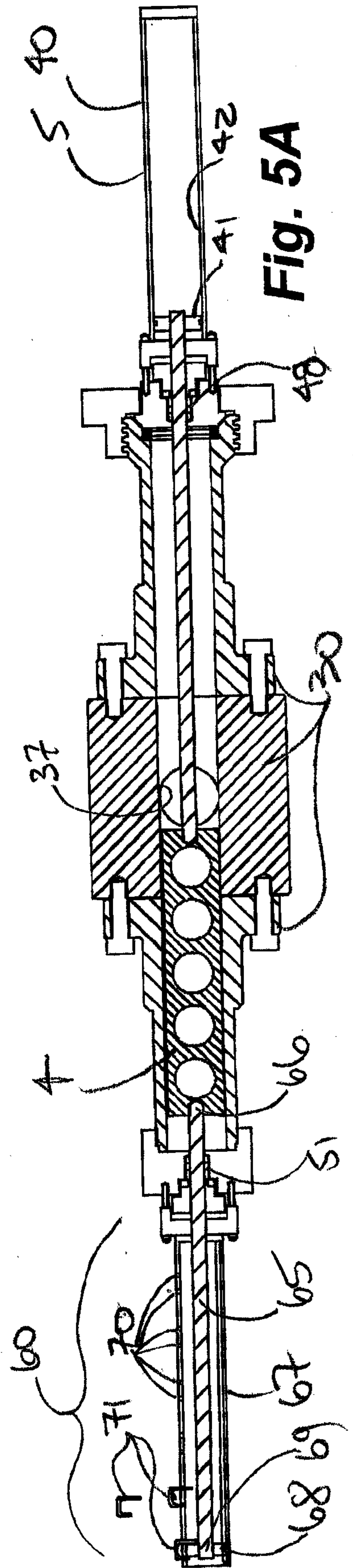
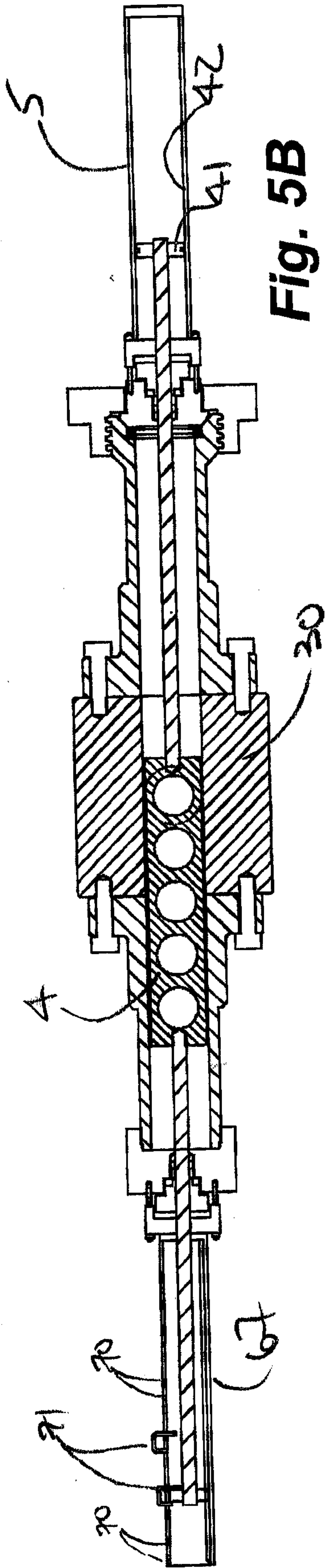
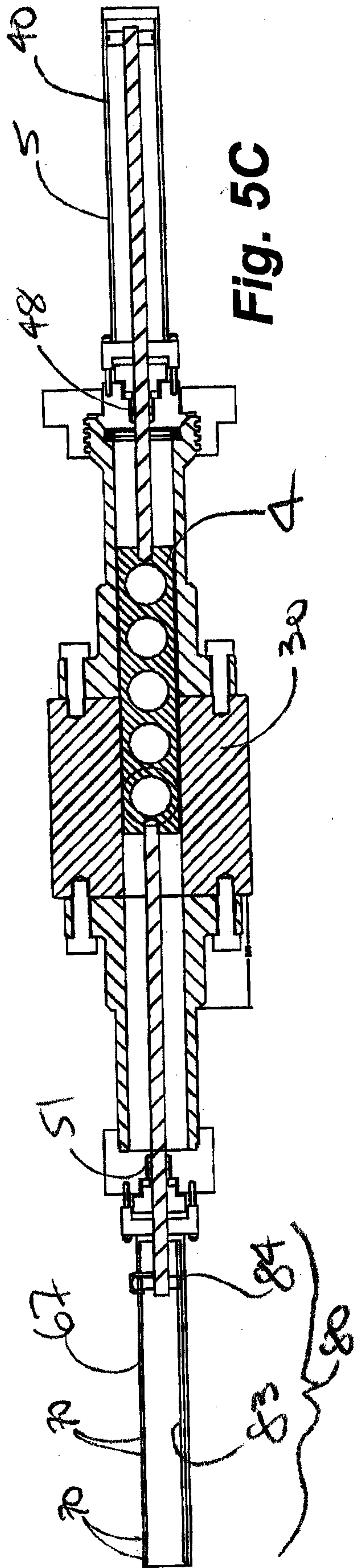
Fig. 3A**Fig. 3B**

Fig. 4A**Fig. 4B**





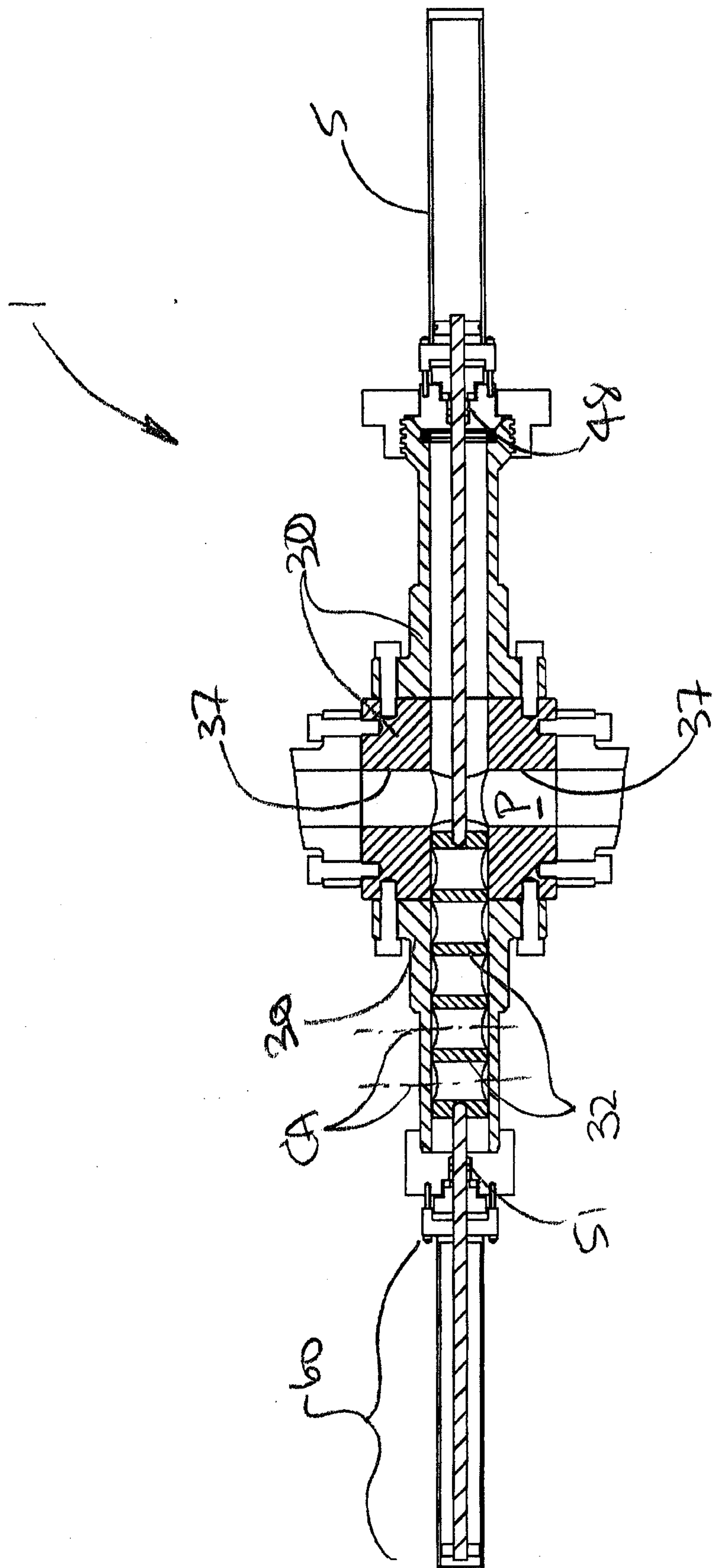


Fig. 6

