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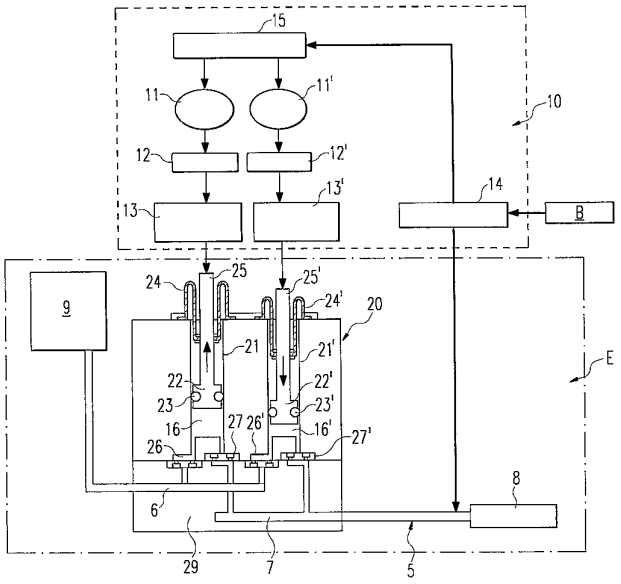
(54) Title: MEDICAL PUMP

(54) Bezeichnung: MEDIZINISCHE PUMPE



(57) Abstract: Medical pumps for water jet surgery are known. The invention relates to a pump comprising at least two pistons provided with piston rods for displacing the pistons in cylinders and for coupling to a pump actuation device, a cylinder head for closing the cylinders, and valve devices for respectively connecting a pressure chamber in the cylinder to at least one fluid inlet and at least one fluid outlet. Said fluid outlet is connected to the fluid inlet in a communicating manner by means of an adjustable pressure regulating valve, in such a way that the pressure in the fluid outlet can be limited to a pre-definable maximum value. In this way, the inventive medical pump can be easily regulated.

(57) Zusammenfassung: Medizinische Pumpen für die Wasserstrahlchirurgie sind bekannt. Es wird eine Pumpe vorgeschlagen, die mindestens zwei Kolben mit Kolbenstangen zum Verschieben der Kolben in Zylindern und zum Ankoppeln an eine Pumpenbetätigungseinrichtung, einen Zylinderkopf zum Abschließen der Zylinder und Ventileinrichtungen umfassen,

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Zur Erklärung der Zweibuchstaben-Codes und der anderen Abkürzungen wird auf die Erklärungen ("Guidance Notes on Codes and Abbreviations") am Anfang jeder regulären Ausgabe der PCT-Gazette verwiesen.

zum Verbinden jeweils eines Druckraumes in den Zylinder mit mindestens einem Fluideinlass und mindestens einem Fluidauslass. Der Fluidauslass ist mit dem Fluideinlass über ein einstellbares Druckregelventil kommunizierend derart verbunden, dass der Druck im Fluidauslass auf einen voreinstellbaren Maximalwert begrenzbar ist. Auf diese Weise wird eine sehr gut einstellbare medizinische Pumpe bereitgestellt.

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"Medical pump"

Description

The invention refers to a medical pump, in particular for water jet surgery.

Water jet surgery has been used for some time in liver surgery as this organ, like no other, has tissue structures of different firmness (parenchyma, blood vessels and bile ducts) and the applied water jet separates the tissue being cut, yet leaves the blood vessels and bile ducts undamaged. Naturally, a precise control of the cutting pressure is required for this.

A further problem of water jet surgery is that the cutting medium must be totally sterile (e.g. Ringer solution) as the liquid comes into contact with body tissue in the closest and most intensive way possible. Ordinary problems such as high reliability, simplicity and economic manufacture must also be considered.

A medical pump for water jet surgery is known from each of the following US 6,216,573 B1, as well as DE 203 09 616 U1, which are exchangeable and thus used only once. The pump efficiency as well as its adjustment, however, do not meet the requirements.

Any discussion of the prior art throughout the specification should in no way be considered as an admission that such prior art is widely known or forms part of common general knowledge in the field.

It is an object of the present invention to overcome or ameliorate at least one of the disadvantages of the prior art, or to provide a useful alternative.

According to the invention, there is provided a medical pump, especially for water jet surgery comprising

at least two pistons with pistons rods for displacing the pistons in cylinders and for coupling to a pump actuation device,

a cylinder head to seal the cylinders,

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valve devices for respectively connecting a pressure chamber in the cylinders with at least one fluid inlet and at least one fluid outlet,

wherein an adjustable pressure control valve is provided, in order to limit the pressure at the fluid outlet to a pre-defined maximum value.

Unless the context clearly requires otherwise, throughout the description and the claims, the words "comprise", "comprising", and the like are to be construed in an inclusive sense as opposed to an exclusive or exhaustive sense; that is to say, in the sense of "including, but not limited to".

This pump comprises at least 2 pistons with piston rods for displacing the pistons in the cylinders and for coupling to a pump actuation device, a cylinder head for closing the cylinders in relation to the pistons, valve devices for connecting the pressure chamber with at least one fluid outlet and at least one fluid inlet, whereby the fluid outlet interacts with the fluid inlet via an adjustable pressure control valve in such a way that the pressure in the fluid outlet can be limited to a pre-defined maximum value.

As the pump is operated with two piston/cylinder units, an improved and especially smoothed out pump capacity can be achieved. The construction is simple so that economic manufacture is guaranteed. The already improved pumping of the working fluid can be improved via the pressure control valve, in particular it can be smoothed out and at the same time be adjusted to the respective application requirements.

The valve devices and/or the pressure control valve comprise an elastic or elastically pressurized valve membrane. This guarantees very economic manufacture and high operational safety.

The valve devices can also comprise two spring-loaded ball check valves, which again are simple to produce.

The pressure control valve is preferably constructed as a power driven valve in such a way that the maximum value is adjustable by means of actuating power on a regulator of the pressure control valve. This special form facilitates coupling of the medical pump to the pump actuation device in an advantageous manner, where a particular specific spatial

positioning of the pump in relation to the pump actuation device is not required. Because the pressure adjustment is not proportional to the travel but proportional to the force, coupling of the pressure control valve to a regulating unit is not position-dependent (which would require accurate adjustment of the pump), it is rather the position independent force with which the regulator activates the pressure control valve which is important.

The pressure control valve is preferably arranged between fluid inlet and fluid outlet in such a way, that on exceeding the maximum value, fluid from the fluid outlet can be directed back to the fluid inlet. In this way the pressure can be adjusted independently of the quantity of pumped fluid.

The pistons or pistons rods are preferably connected securely and in a sterile way via bellows, cup seal or similar non-slip seals to the cylinders. Germs can thus not be introduced despite sterile working fluid and sterile transmission pipes, which can be the case with pumps known hitherto. This danger is particularly great as due to piston displacement in the cylinders their back ends (in relation to the pressure chambers) are subjected to streams of ambient air and thus cylinders can be contaminated therewith in this area.

The valve devices and/or pressure control valve are preferably housed in the cylinder head. This results in a simpler setup containing fewer parts.

It is preferred if the cylinders can be connected independently to the cylinder head. This simplifies manufacture.

The outlet preferably has fittings for irreversible connection to a pressure hose. This guarantees that faulty installation of the pump and also non-permissible re-use of the pump is avoided.

The cylinder head preferably comprises holding devices, in particular lugs into which the catches engage, which are attached to the pump actuation device. No special measures are thus needed for mounting the pump to the pump actuation device.

An accumulator is envisaged in a preferred embodiment connected to the fluid outlet, which is constructed in such a way that fluid pressure fluctuations at the fluid outlet are smoothed out due to a low pass function. This results in a further smoothing of the cutting jet and thus an improvement of the equipment cutting function desired. The accumulators are preferably situated in the cylinder head or connected therewith which simplifies the assembly of the entire setup.

Preferred embodiments of the invention follow from the subclaims and subsequent descriptions of examples, which are explained in more detail with the aid of illustrations as follows:

- Fig. 1-3 schematic block diagrams of embodiments of the medical pump,

- Fig. 4 an exploded drawing of an embodiment of the pump,

- Fig. 5 a side view of the pump as per Fig. 4,

- Fig. 6 a section along line VI-VI from Fig. 5,

- Fig. 7 and 8 a partial section through the medical pump in the pressure control valve area in various control positions and

- Fig. 9 a perspective drawing of the cylinder head.

The same reference numbers will be used for the same parts and parts with the same function.

A pump actuation device 10 is intended for the embodiment of the invention shown in Fig. 1, which encompasses a motor control 15 for the control of two motors 11,11', which are connected via gearing 12, 12' and clutch devices 13, 13' to the piston rods 25,25'. One operator B can operate the motor control 15 with suitable switches (foot switch or finger switch), so that the motors 11, 11' displace the piston rods 25, 25' and thus the pistons 22, 22' in the cylinders 21, 21' of pump unit 20 alternately via the

described train, so that the volume of the pressure chambers 16, 16' of the pump unit 20 is alternately enlarged and reduced.

In order to seal the pressure chambers 16, 16' and the pistons 22, 22' in relation to the cylinders 21, 21', seals 23, 23' are envisaged at the pistons 22, 22'. Moreover, the piston rods 25, 25' maintain sterility with cup seals 24, 24'; which are firmly fixed to the cylinders 21, 21' on the one hand and to the pistons rods 25, 25' on the other. In this way germs from the ambient air which without these cup seals 24, 24' settle on the internal walls of the cylinders 21, 21' and pass through the seals 23, 23' can neither mix with the working fluid nor find their way into the same.

Suction valves 26, 26' as well as pressure valves 27, 27' are connected to the pressure chambers 16, 16'. The suction valves 26, 26' are connected via a fluid inlet 6 to a reservoir 9 for the working fluid. The pressure valves 27, 27' are connected to the pressure hose 5 via a fluid outlet 7, which leads to an applicator 8. The pump unit 20 forms a disposable part E together with the reservoir 9 including its contents, pressure hose 5 and applicator 8, which is disposed of after each operation, so that the entire setup meets the highest sterility requirements possible.

A butterfly valve 14 is intended for adjustment of pressure in this simple embodiment of the invention (which in addition to the motor control 15) facilitates adjustment of the fluid flow by operator B.

The embodiment of the invention shown in Fig. 2 differs from that in Fig. 1 by virtue of a pressure control valve 35 being envisaged, which with the aid of a valve membrane 36 can open and close a connecting channel between fluid outlet 7 and fluid inlet 6. The membrane 36 is operated by an actuator 30 via a push rod 34 and a spring 33, as well as a dynamometer 31. The dynamometer 31 supplies a power proportional output signal to a controller 32, via which an operator B can set a maximum pressure. Instead of a separate dynamometer 31 the operating current of the actuator 30 can also be measured which is also power proportional.

This setup guarantees that the fluid pressure can be accurately adjusted at the applicator 8. Moreover, pressure fluctuations resulting from piston operation are smoothed out by

the control valve 35. The important point is that the pressure control valve 35 due to its construction operates with the membrane pressurised by fluid, in a power-controlled and not a travel-controlled manner. No pressure adjustment error can therefore occur even with dimension tolerances during coupling of the pump unit 20 to the pump actuation device 10, as it is not the geometric dimensions (travel) which are important, but the power with which the pressure control valve 35 is operated.

The embodiment shown in Fig. 3 differs from the previously shown embodiments by virtue of an accumulator 40 being envisaged, which encompasses a cylinder 44 containing piston 42 sealed by a seal 43, which is pressurized by a spring 41. The chamber situated above the piston is connected to the fluid outlet, so that with increasing pressure at the fluid outlet 7 the spring 41 is compressed and with decreasing pressure the spring 41 drives the piston 42. In this way the pressure directed to the applicator 8 is smoothed out due to its low pass function. This accumulator 40 is arranged in a cylinder head 29 which seals the cylinders 21, 21'.

It is naturally possible to combine the variants show here. In particular the pressure control valve 35 can be combined with the accumulator 40.

Fig. 4 shows a constructive embodiment of the pump device 20 in an exploded view. In this embodiment the pressure and suction valves 26/27 encompass balls 19, which are pressed onto the valve seats via springs 18 (not visible in the illustration), which is known in principle.

The cylinder head 29 has two sections to which the cylinders 21, 21' are coupled, whereby the valves sit between the cylinders 21, 21' and the cylinder head 29.

It can further be seen from Fig. 4, that the piston rods 25, 25' have coupling projections 17, 17' at their distal ends which serve to create mechanical connections with the coupling systems 13, 13'.

The pistons in this embodiment of the invention are formed by the proximal ends of the piston rods 25, 25' fitted with caps 28, which simultaneously hold seals 23, 23' firmly on the piston rods 25, 25'.

The pressure hose 5 is fastened irreversibly to the cylinder head 29 via a connecting piece 37, a crimping piece 38 and an internal pipe which is inserted into the pressure hose 5, whereby after assembly of the connecting piece 37 (in a known way) in the cylinder head 29 by means of a catch 45, the connecting piece is held irreversibly in the cylinder head 29.

From figs. 5 and 6 details of the layout become clear in particular in relation to the construction of the suction valve 26, 26' or the pressure valve 27, 27' and especially the layout of the valve seats in the cylinder head 29 on the one hand and the relevant allocated cylinders 21, 21' on the other.

Figs. 7 and 8 show a section through the pressure control valve 35, which shows that the membrane 36 can be pressed by the push rod 34 onto a valve seat (Fig. 7 shows the open position and Fig. 8 the closed), so that between fluid outlet 7 and fluid inlet 6, depending on the position of the membrane 36, a more or less greater "short circuit" of the pump unit 20 is produced. As the membrane 36 is pressurized by the fluid outlet 7, a power-controlled valve is present.

Fig. 4 shows further construction related details of the cylinder head 29 and the valve devices (suction valve, pressure valve and pressure control valve) contained therein. Moreover, Fig. 9 shows the lugs, which are coupled via the pump unit 20 to the pump actuation device 10 or they can be held firmly on the same.

In an embodiment of the invention not shown here not only the pressure control valve 35 is designed as a membrane valve, but also the two pressure valves 27, 27' or suction valves 26, 26' are designed as membrane valves instead of the ball valves shown here. This makes the setup even more economic. Finally, it is also possible to create the setup in such a way that not only are all the valves membrane valves but all membranes are connected in one piece, so that the number of components is decreased still further.

Accordingly, it is advantage of at least a preferred embodiment of the invention to make available a medical pump, in particular for water jet surgery, which despite simple suitable construction and therefore single use facilitates improved cutting performance.

Reference list

E	Disposable part
B	Operator
5	Pressure hose
6	Fluid inlet
7	Fluid outlet
8	Applicator
9	Reservoir
10	Pump actuation device
11, 11'	Motor
12, 12'	Gearing
13, 13'	Clutch system
14	Butterfly valve
15	Motor control
16, 16'	Pressure chamber
17, 17'	Coupling projection
18	Spring
19	Ball
20	Pump unit
21, 21'	Cylinder
22, 22'	Piston
23, 23'	Seal
24, 24'	Cup seal
25, 25'	Piston rod
26, 26'	Suction valve
27, 27'	Pressure valve
28	Cap
29	Cylinder head
30	Actuator
31	Dynamometer
32	Controller
33	Spring

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34	Push rod
35	Pressure control valve
36	Valve membrane
37	Connecting piece
38	Crimp tube
39	Internal tube
40	Accumulator
41	Spring
42	Piston
43	Seal
44	Cylinder
45	Catch
46	Lugs

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THE CLAIMS DEFINING THE INVENTION ARE AS FOLLOWS:-

1. Medical pump, especially for water jet surgery comprising

at least two pistons with pistons rods for displacing the pistons in cylinders and for coupling to a pump actuation device,

a cylinder head to seal the cylinders,

valve devices for respectively connecting a pressure chamber in the cylinders with at least one fluid inlet and at least one fluid outlet,

wherein an adjustable pressure control valve is provided, in order to limit the pressure at the fluid outlet to a pre-defined maximum value.

2. Medical pump according to claim 1, wherein the pressure control valve is connected to the fluid inlet and the fluid outlet in such a way that, on exceeding the maximum value, fluid from the fluid outlet is piped back to the fluid inlet.

3. Medical pump according to any one of the previous claims, wherein the valve devices and /or the pressure control valve comprise an elastic or elastically pressurized valve membrane.

4. Medical pump according to any one of the previous claims, wherein the valve devices comprise spring-loaded non-return ball valves.

5. Medical pump according to any one of the previous claims, wherein the pressure control valve is constructed as a power-controlled valve in such a way that the maximum value can be adjusted by a displacement force acting on an actuator of the pressure control valve.

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6. Medical pump according to any one of the previous claims, wherein the pistons or the piston rods are connected to the cylinders via bellows, a cup seal or similar non-slip seals in a sealed manner which maintains sterility.

7. Medical pump according to any one of the previous claims, wherein the valve devices and /or the pressure control valve are fitted at least in part in the cylinder head.

8. Medical pump according to any one of the previous claims, wherein the cylinders can be individually connected with the cylinder head.

9. Medical pump according to any one of the previous claims, wherein the fluid outlet has connecting devices for irreversible connection with a pressure hose.

10. Medical pump according to any one of the previous claims, wherein the cylinder head has holding devices in particular lugs for the engagement of holding catches, which are attached to the pump actuation device.

11. Medical pump according to any one of the previous claims, wherein an accumulator is constructed and connected to the fluid outlet in such a way that pressure fluctuations of the fluid at the fluid outlet can be smoothed out by means of a low pass function.

12. Medical pump according to claim 11, wherein the accumulator is arranged in the cylinder head or is connected with the same.

13. Medical pump substantially as herein described with reference to any one of the embodiments of the invention illustrated in the accompanying drawings and/or examples.

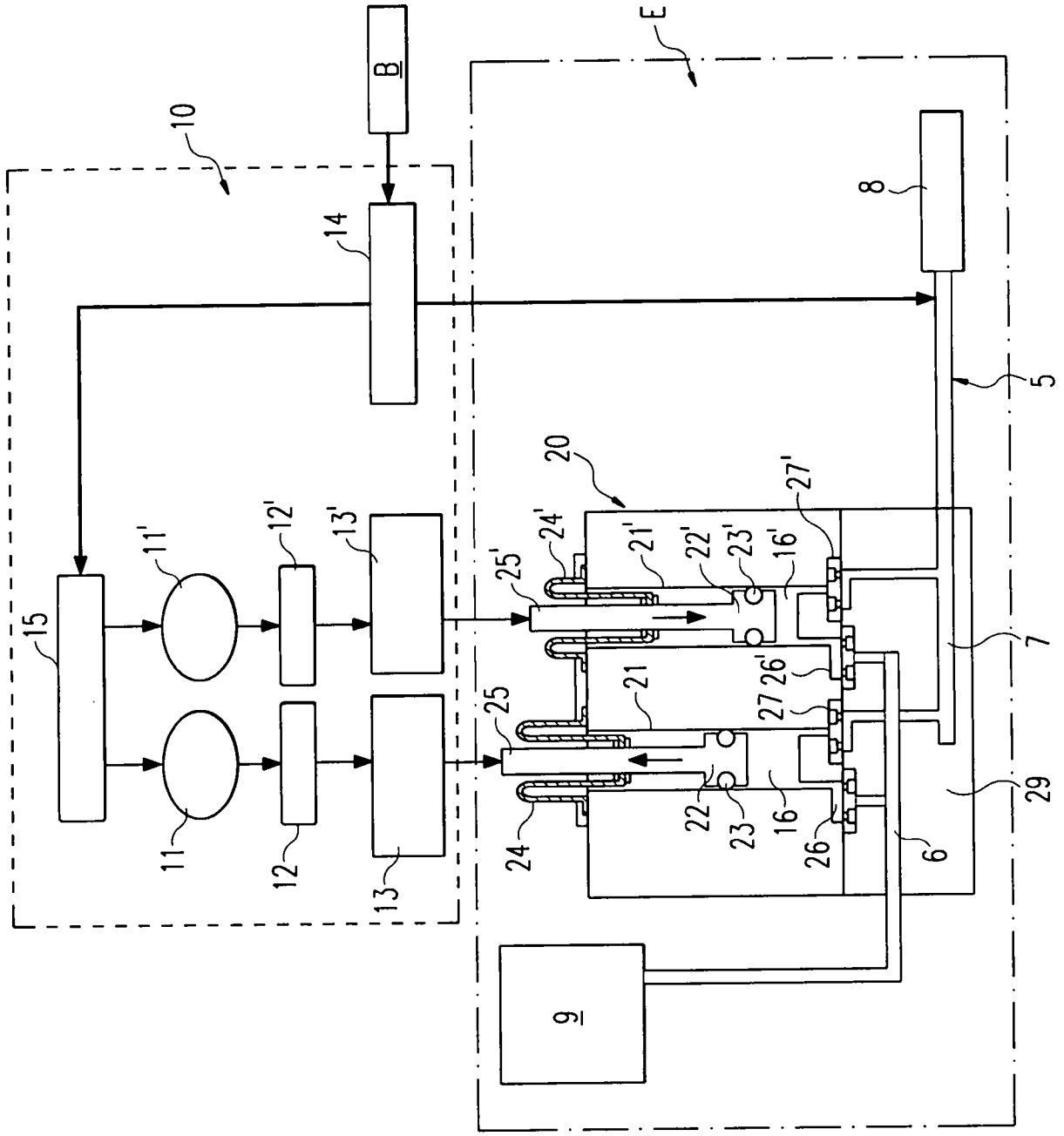
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Fig. 1

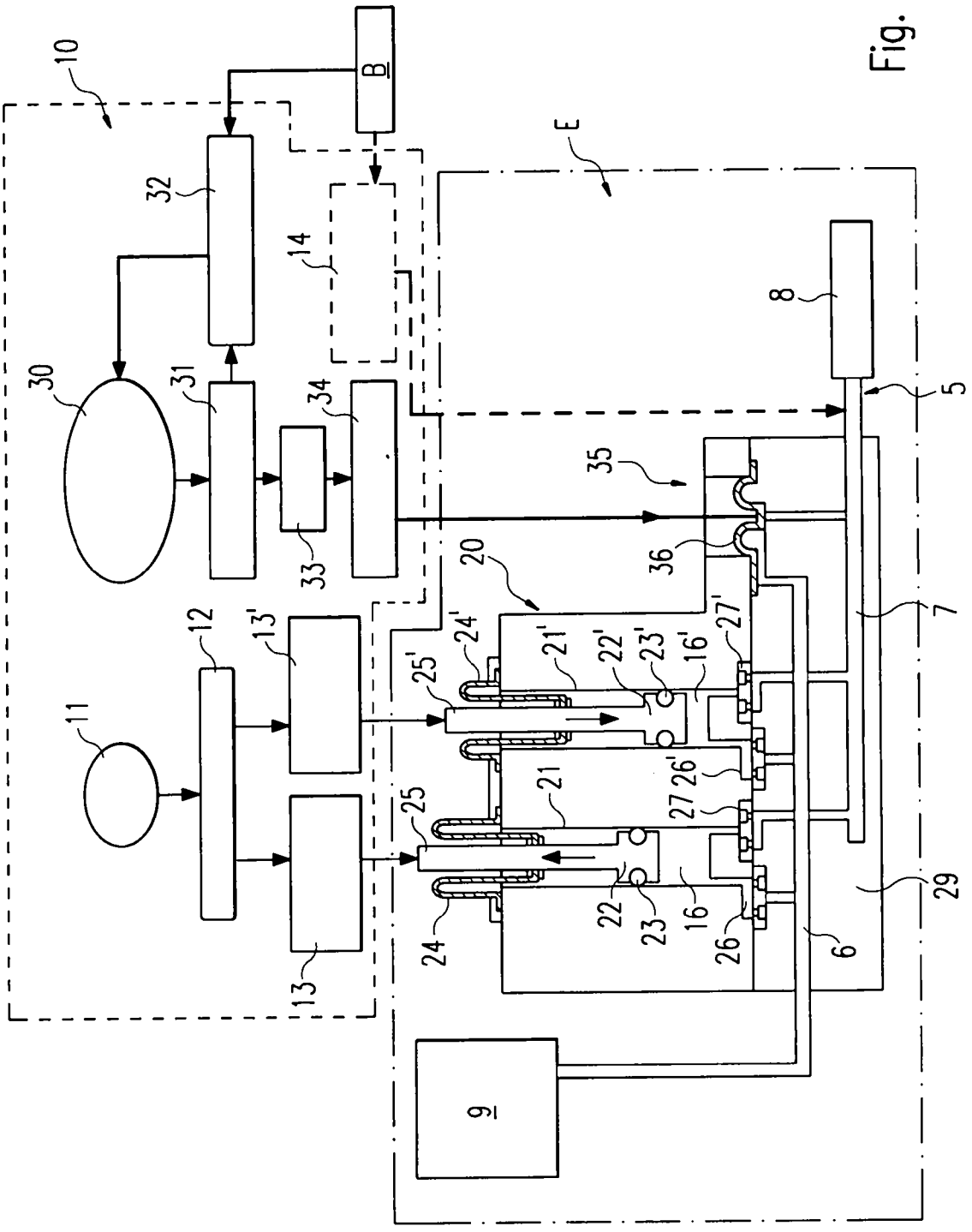
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Fig. 2

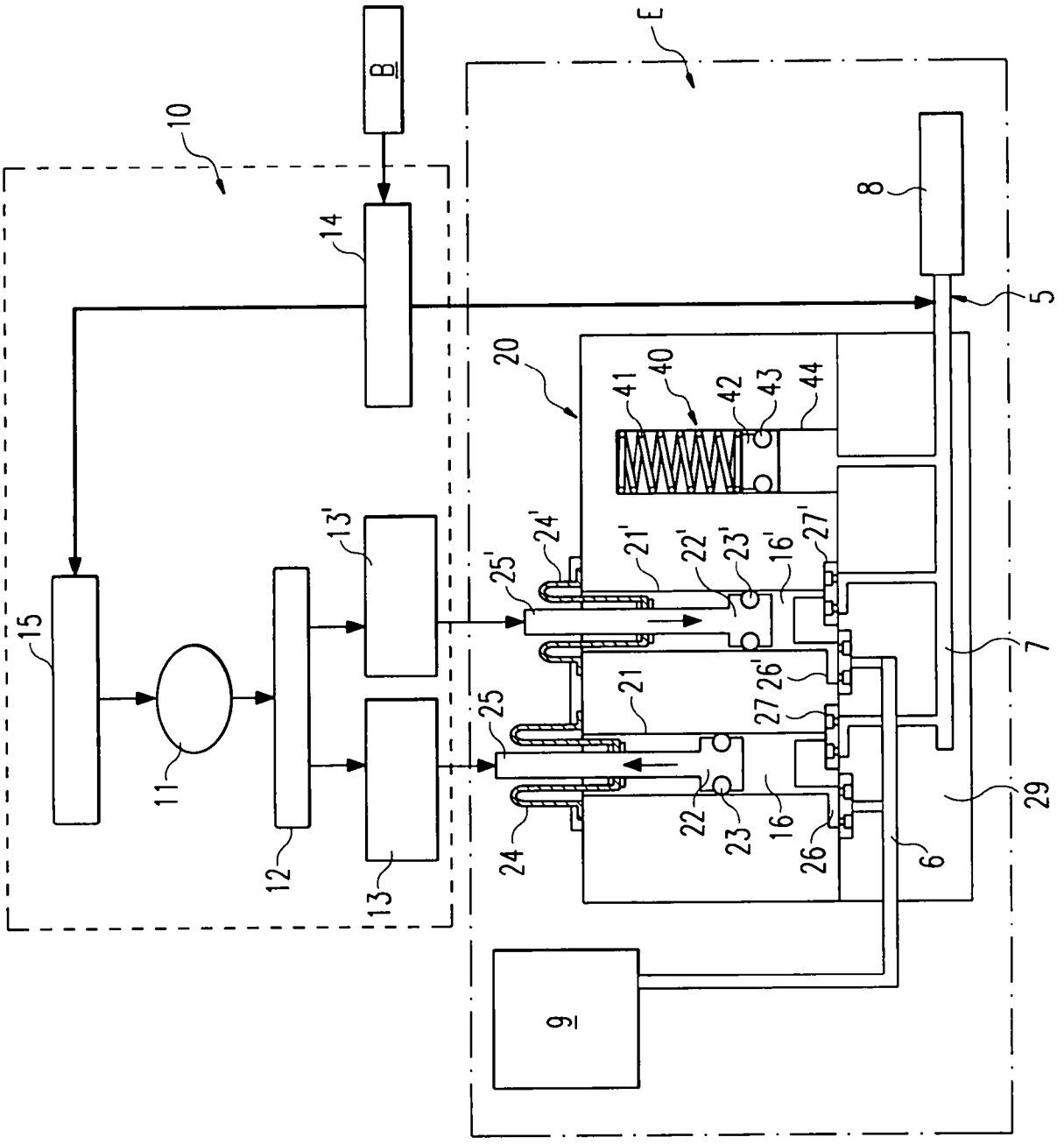
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Fig. 3

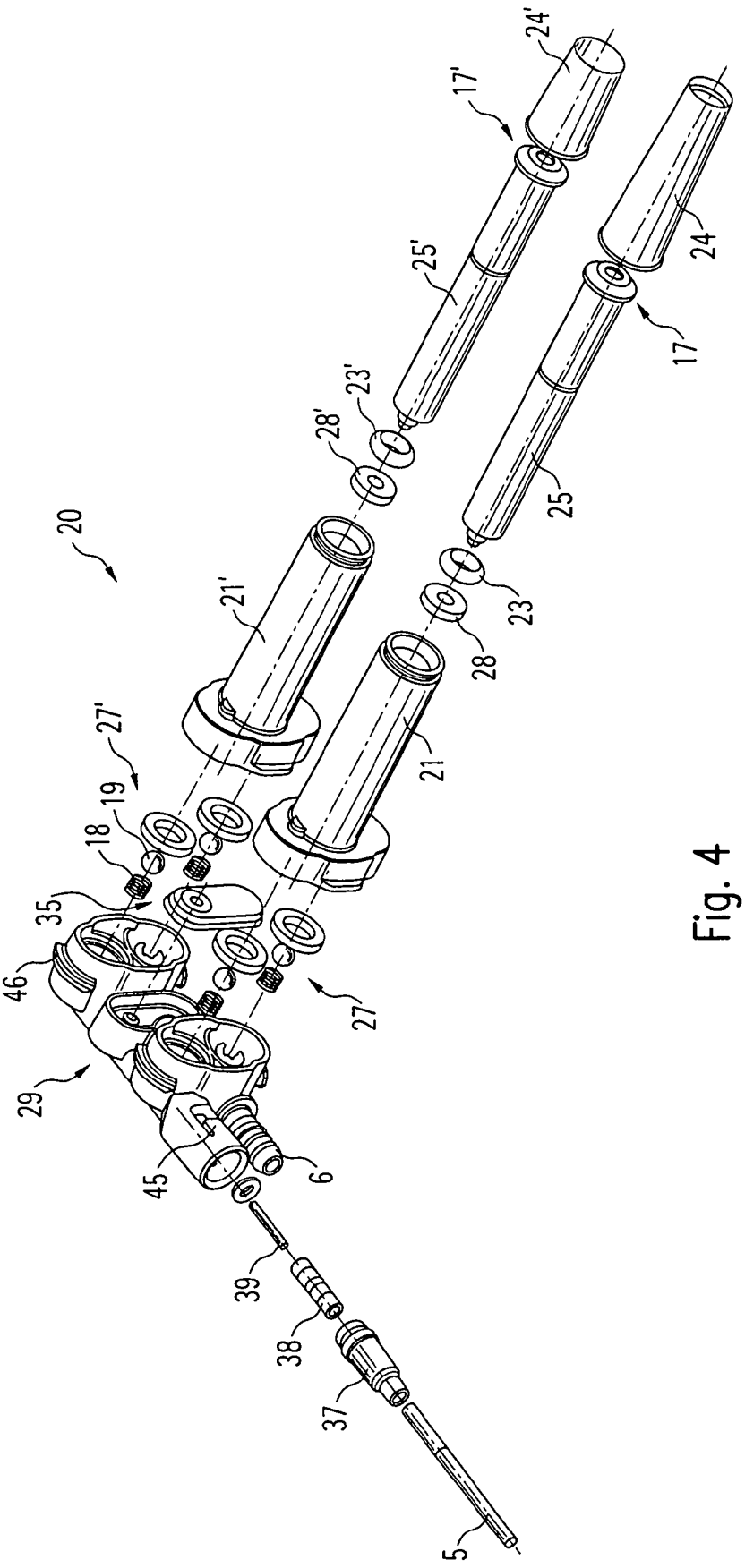
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Fig. 4

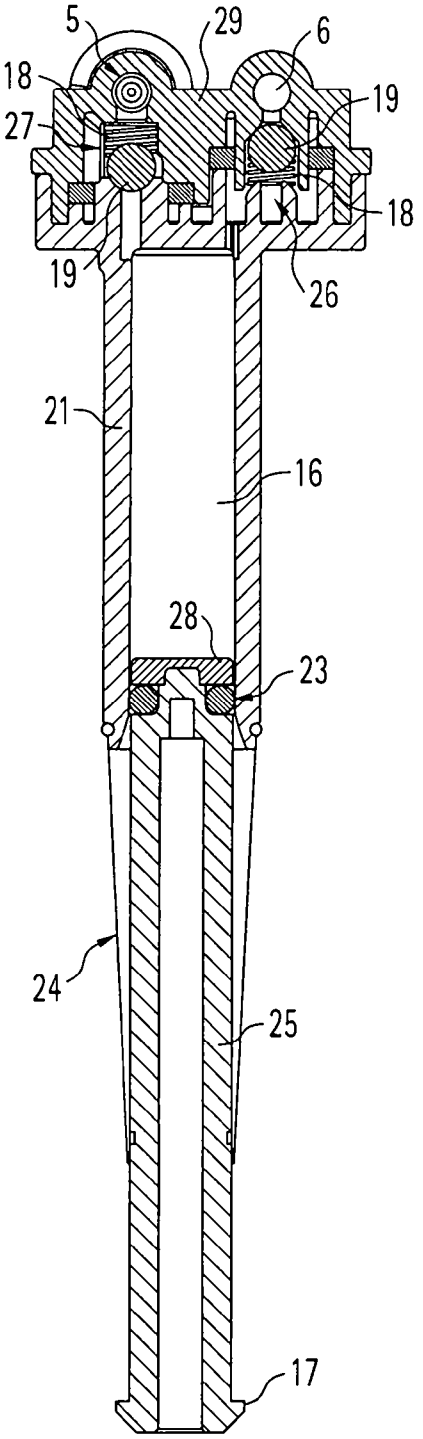
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Fig. 6

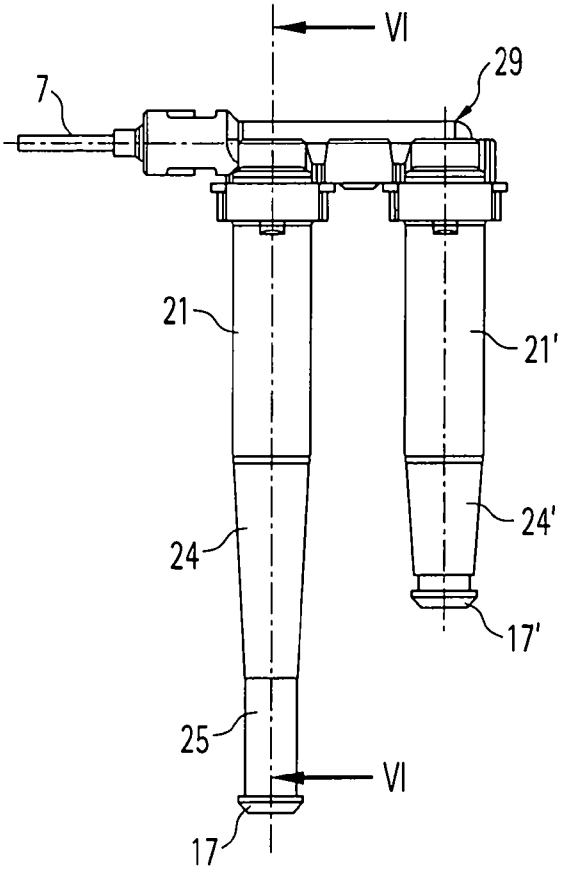
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Fig. 5

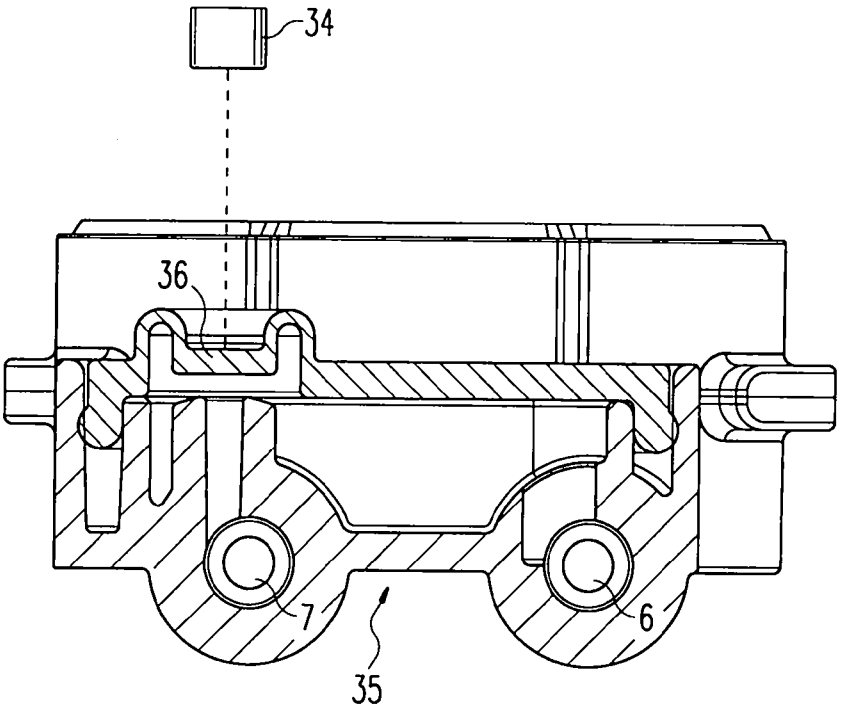

Fig. 7

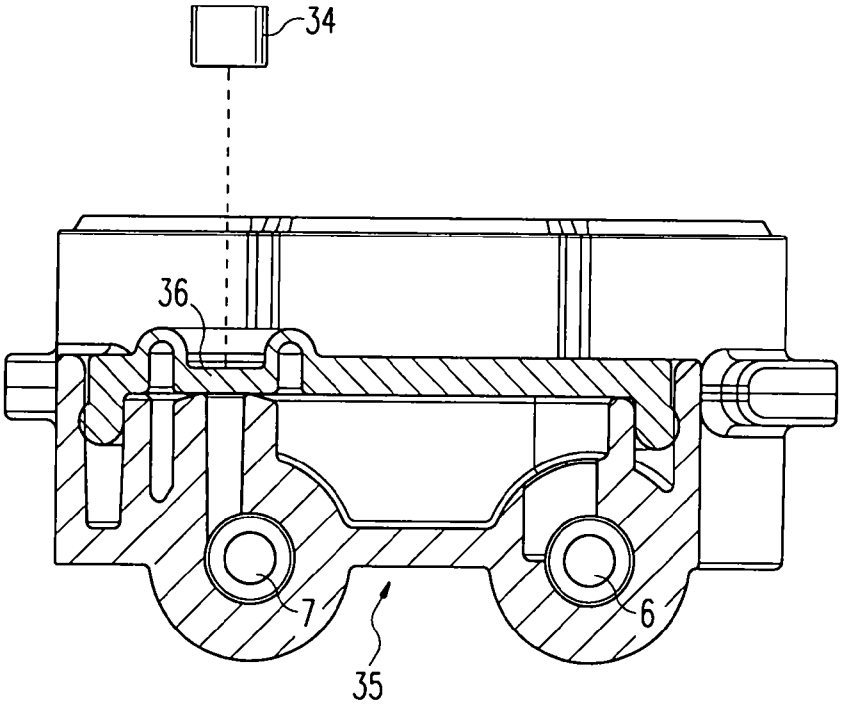

Fig. 8

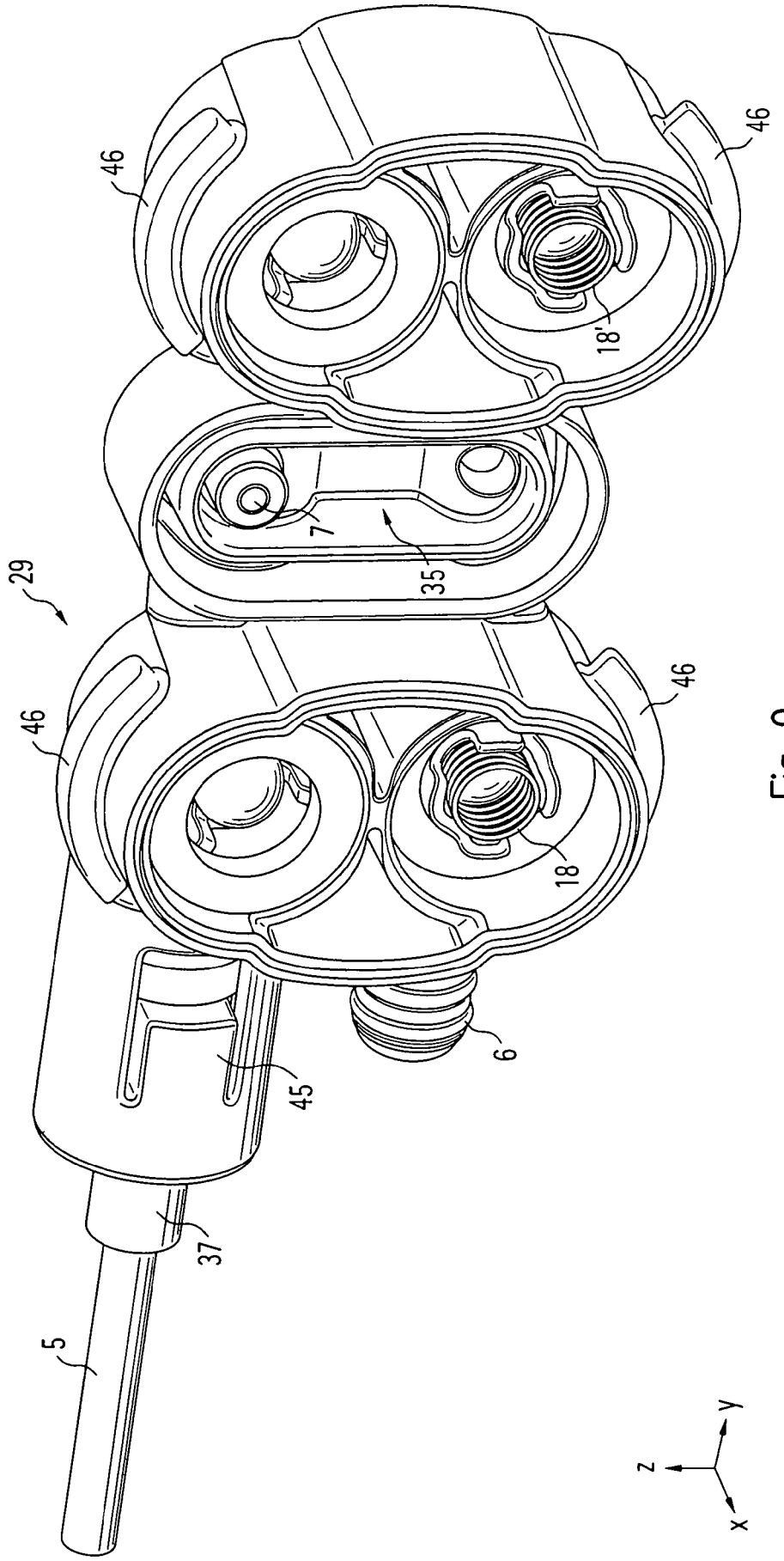

Fig. 9