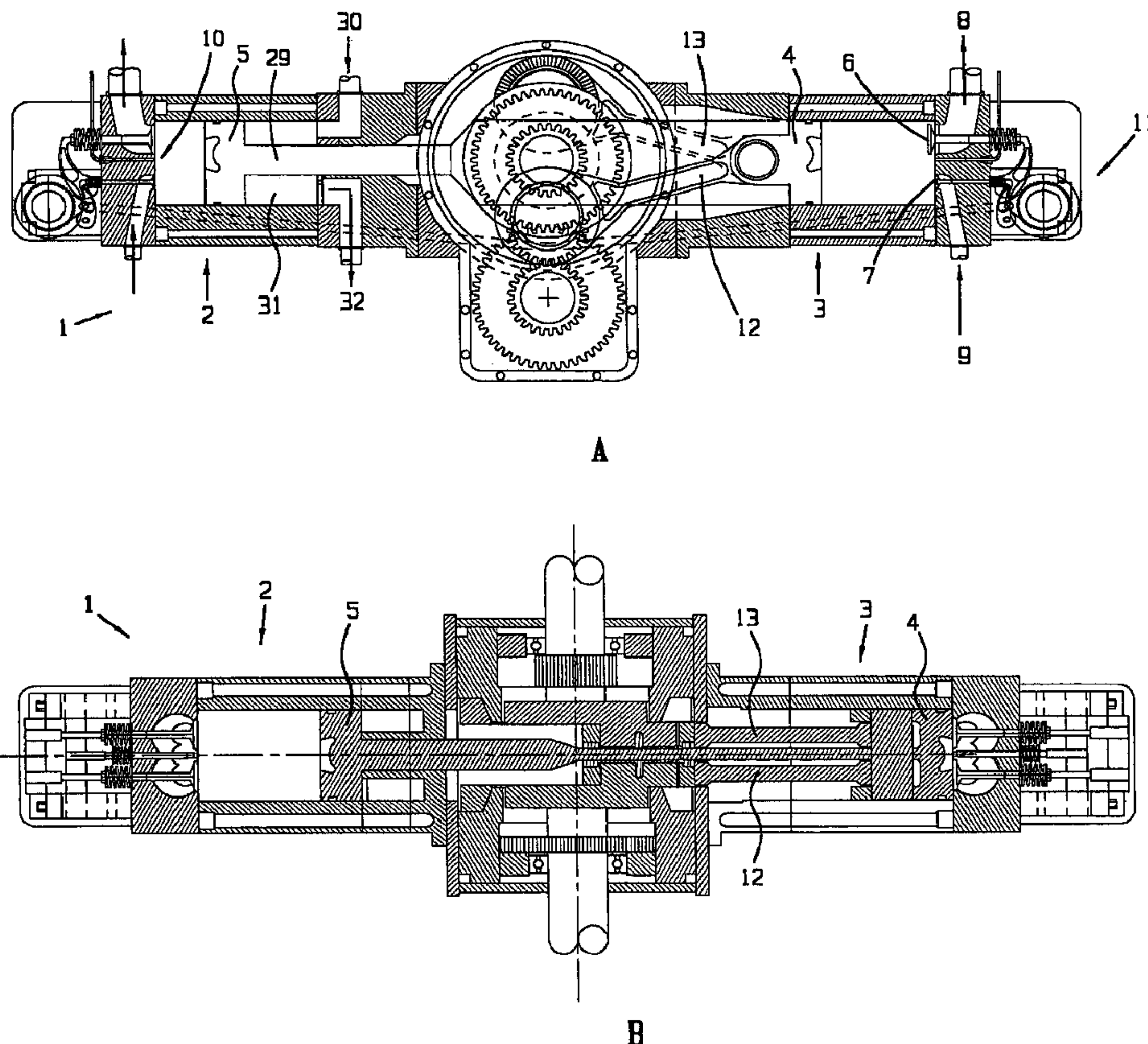




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(54) Titre : METHODE DE FONCTIONNEMENT D'UN MOTEUR A COMBUSTION INTERNE ET MOTEUR A
COMBUSTION INTERNE
(54) Title: METHOD IN AN INTERNAL COMBUSTION ENGINE AND AN INTERNAL COMBUSTION ENGINE



(57) Abrégé/Abstract:

This invention relates to a new type of internal combustion engine, Z-engine. In this the compression part and the working part are separated. New gas is transported to the upper side of the piston below there is a little chamber corner, when the piston comes

(57) **Abrégé(suite)/Abstract(continued):**

nearer the upper hollow part. The combustion gases go out from the cylinder through exhaust-valves. After the changing of the gas before, filling the upper chamber there is a secondary compression, the firing of, the mix, or fire. To advance of the compression can be other than the volume of the working pistons together. The side effect of the piston can be taken away by means of the double cam mechanism.

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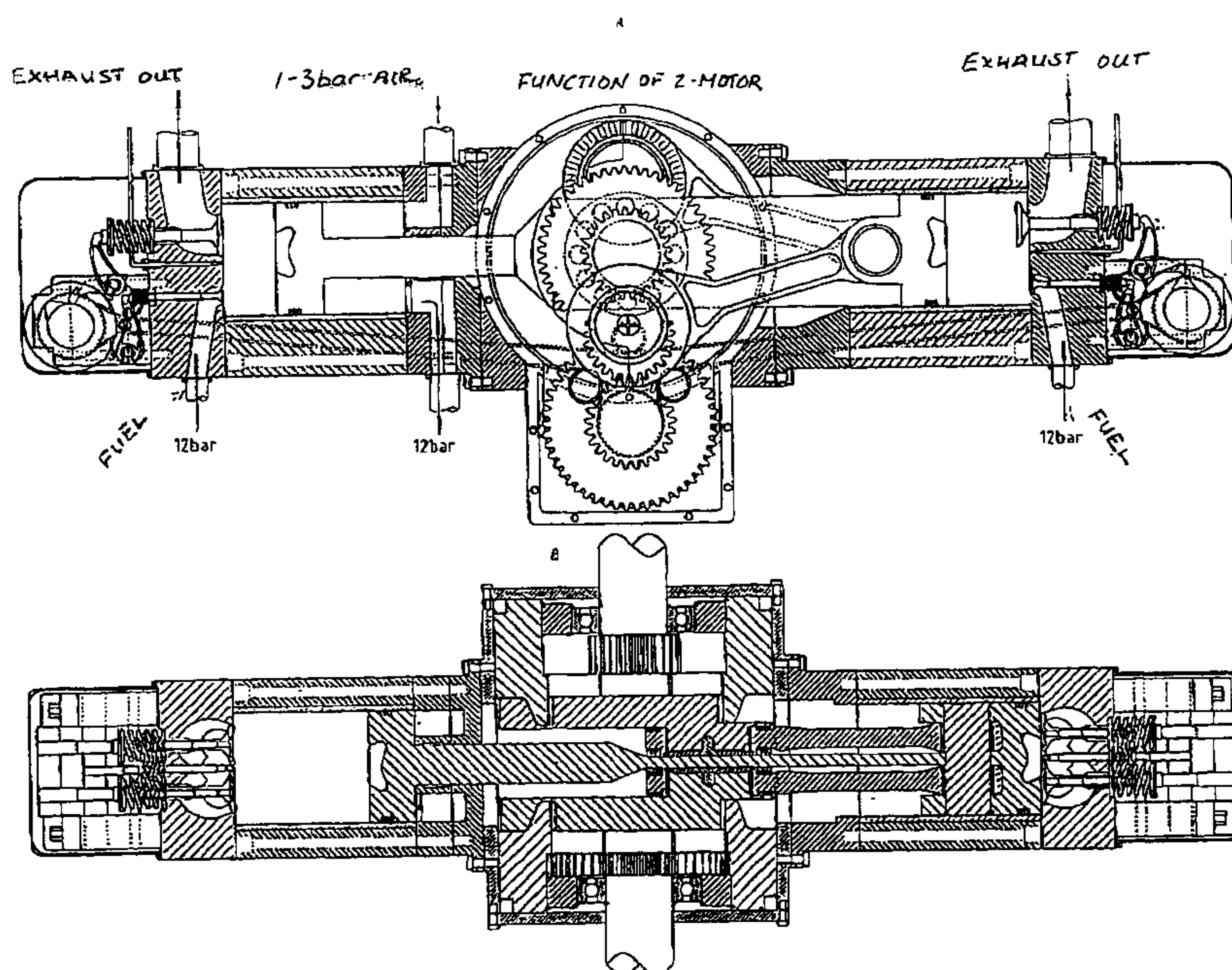
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(54) Title: Z-ENGINE



(57) Abstract: This invention relates to a new type of internal combustion engine, Z-engine. In this the compression part and the working part are separated. New gas is transported to the upper side of the piston below there is a little chamber corner, when the piston comes nearer the upper hollow part. The combustion gases go out from the cylinder through exhaust-valves. After the changing of the gas before, filling the upper chamber there is a secondary compression, the firing of, the mix, or fire. To advance of the compression can be other than the volume of the working pistons together. The side effect of the piston can be taken away by means of the double cam mechanism.

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Method in an internal combustion engine and an internal combustion engine

The present invention relates to a method in an internal combustion engine and
5 also to an internal combustion engine.

The internal combustion engines may be roughly divided into the categories of
diesel engines, in which the ignition of the mixture of fuel and air is effected by the
aid of pressure and otto engines in which the ignition of the mixture is effected by
10 the aid of a spark plug.

When divided in a different way, the engines may be divided into groups based on
their working principle; four-stroke engines and two-stroke engines.

15 All types of engines have their advantages and disadvantages. Two-stroke
engines produce power in each rotation of the crankshaft, but the control of the
scavenging of the exhaust gases from the cylinder has been very difficult. The
main disadvantage of the four-stroke engines has been the fact that the work cycle
is effected only at every second rotation of the crankshaft. Controlling of the fuel
20 mixture and exhaust gases is in the four-stroke engines much easier than in two-
stroke engines. In four-stroke engines the size of the engine tends to increase and
the mechanical losses are higher than in two-stroke engines. The increase of the
compression ration in a diesel engine improves the efficiency, but rises at the
same time the compression temperature and thus the temperature during the
25 combustion. This means that the thermal losses and the amount of the nitrogen
oxides, NO_x increase. In general, the side force of the piston is one of the biggest
sources of the friction losses in the engine and it should be removed.

According to the state of the art numerous attempts to avoid the disadvantages of
30 the known engine construction have been made. Some of those are described in
the following.

US-patent 5285752 deals a very complicated engine construction having three
pistons aligned in a cylinder set, two of these pistons are scavenging piston and

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the work piston is located in between the same. Power output is effected by the aid of one of the scavenging pistons. The latter has two connecting rods which have been connected to two interconnected gear wheels to rotate them. The angle of the connecting rods become quite wide.

5

The engine has a compressor part in two parts and its compressor pressure (scavenging pressure) is low, perhaps 1-2 bar. The gas exchange occurs at the bottom dead centre of the piston and occurs through grooves in the piston shaft. The shaft of the piston must be tightened against the high combustion pressure and temperature.

10

In the two-stroke otto engine described in the publication DE 2703316 there is a separate compressor piston in addition to a work piston. The compressor piston moves on the average 10-15 crank shaft angle in advance compared with the work piston or about 90 crank shaft angle after it. It has a heat insulation in the upper part of the cylinder, at the top of the piston and in the gas exchange duct where the ignition of the fuel/air mixture happens. The construction includes at least one swirl chamber.

15

In US patent 5505172 the efficiency of the two-stroke otto engine has been tried to be improved by using two separate gas mixtures, whereby the rest of the exhaust gases in the cylinder and the new air/fuel mixture are compressed and ignited in the cylinder, but the new air/fuel mixture is sprayed to a restricted chamber in the upper part of the cylinder.

20

EP 0779421 deals with the removing of the side force of the piston by means of crank shafts, synchronized with bevel gears. The connecting rod has been divided in two in the lower part of the same. The upper part makes linear movements and the outer ends of the lower parts have been connected to the crankshafts.

25

In the engine according to US patent 5857436 there is a compressor and work piston pair, moving synchronous and a connecting duct, which connects the same and is equipped with a heat exchanger in order to heat the compressed air more. The volume of the connecting duct is equal to the delivery of one stroke of the

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compressor piston. The gas exchange occurs at the top of the dead centre of the piston at zero volume.

US patent 3880126 deals with an engine having a spark ignition and consisting of
5 cylinder head pairs, equipped with a normal crank mechanism. The cylinder head
pairs have in their common cylinder head a connecting duct between the
compressor cylinder and the work cylinder. The exhaust valve closes early
"enough" in order that a relatively big volume of the exhaust gases remains in the
work cylinder, according to the text 50% or even more. Behind this the aim is to
10 keep the gases in the cylinder and the surfaces of the cylinder and the piston as
hot as possible, in order to have the HC-emission to remain low. The gas
exchange pressure is according to the explanation low, perhaps 1-2 bar. The gas
exchange angle is wide, over 90° and the gas exchange starts quite early, about
90° after the bottom dead centre, according to the explanation.

15

The secondary compression ratio has been limited to be quite low, as the engine
runs with gasoline or similar fuel. The engine is equipped with spark ignition. As
large amount of hot exhaust gas remains in the cylinder, the temperature is
remarkably raised, causing the danger of knock. The connecting duct, having
20 quite a large volume, between the compressor cylinder and the work cylinder limits
also the compression ratio. The delivery ratio of the compressor piston is quite
poor, because of the construction. It is not allowed that the exhaust gases, which
remain in the cylinder and the fresh mixture blend much with each others,
otherwise there is a problem with the ignition.

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3a

Summary of the Invention

According to one aspect of the present invention, there is provided method for obtaining high efficiency in an internal combustion engine having at least one cylinder, having at least one exhaust valve and at least one scavenging valve for the coming new gas and working with a two-stroke principle whereby each cylinder produces power at every rotation of the crankshaft, in which process pressurized air or air/fuel mixture is lead through the at least one scavenging valve during the last quarter of the crankshaft rotation before top dead centre, "BTDC", wherein the at least one scavenging valve is opened for gas inlet at a pressure of 3 to 15 bars at 60 degrees BTDC and kept open during 20 to 30 degrees of the crankshaft rotation, when a piston head already has moved about 90% toward the top dead centre, so that the gas exchange has occurred before the piston head has reached the top dead centre.

According to another aspect of the present invention, there is provided an internal combustion engine having at least one cylinder, at least one exhaust valve and at least one valve for incoming new gas working with a two-stroke principle, whereby each cylinder produces power at every rotation of the crankshaft, wherein the at least one valve for the incoming new gas include means for feeding scavenging air under a pressure of 3 to 15 bars starting at 60 degrees of the crankshaft before top dead centre and lasting 20 to 30 degrees time of the crankshaft rotation, when a piston head already has moved about 90% toward the top dead centre, so that the gas exchange has occurred before the piston head has reached the top dead centre.

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3b

The invention will be described in more detail in the following with reference to the drawings describing one example of an engine according to the present invention.

Figure 1a describes an engine construction
5 according to the present invention as a longitudinal section;

Figure 1b shows the same construction now seen in the direction turned 90 degrees from the one of Fig. 1a;

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Figure 2a is a partly view of that shown in Fig. 1a now showing the connecting rod and partial crankshaft only;

Figure 2b is an illustration of Fig. 2a now turned 90 degrees from that shown in
5 Fig. 2a;

Figure 2c is a complete exemplary illustration of the connecting rods and the crankshaft halves, but also the gears connecting the crankshaft halves;

10 Figures 3a and 3b show the piston system of the engine according to the invention seen in two directions and in two sections A - A and B - B;

Figures 4a - 4e show one embodiment of the working principle according to the present invention; and

15

Figures 5a - 5e show an alternative embodiment of the working principle according to the invention including the internal exhaust gas re-circulation.

First of all it is described the general construction of the engine according to the
20 invention. Reference is made especially to Figures 1 to 3. After that it is described the working principle according to the invention and then reference is made to Figures 4a - 4e and Figures 5a - 5e when an alternative working principle is described.

25 In the preferred embodiment of the invention the engine has e.g. the overall construction shown in Figures 1a and 1b. Even though an engine construction is clear and self-evident for persons having average skills in the field of engines and motors, a detailed description is given for the sake of clarity. So the engine 1 consists of two cylinders 2 and 3 in which a piston having two piston heads 4 and
30 5 is reciprocating.

As clearly shown, Figure 1a and Figure 1b have been shown in sections differing from each other by 90 degrees. Also another difference exists between these figures; in Figure 1a the piston is moving toward its dead centre in either direction,

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but in Figure 1b the piston head 4 is in its uppermost position and accordingly piston head 5 is in its lowest position.

The construction of the piston is described in more detail in Figures 3a and 3b.

5

In a conventional manner the engine 1 has an exhaust valve 6 or valves and an inlet valve 7 or valves and, of course exhaust channel 8 and inlet channel 9. The engine also has a fuel injection nozzle 10. The mechanism for operating the valves has been here referred as number 11 and its construction may be of any conventional type including a camshaft or several camshafts.

10

One of the piston heads, the one designated with reference number 4, is connected, by the aid of two connecting rods 12 and 13 with a crankshaft construction which is described in more detail in Figures 2a to 2c in addition to Figures 1a and 1b. In a conventional manner the connecting rods 12 and 13 have been fastened with bearings to the piston pin at their upper ends and in their lower end the connection has been made to the crankshaft having suitable parts 15 and 16 protruding from the two crankshaft halves 17, 18. A bearing 19, 20 is equipped to make this joint.

15

20

The halves of the crankshaft are rotating in opposite directions. In this way the side forces of the piston are completely cancelled and the power that has been consumed for these forces before can be used now for producing output power from the engine. Also the need for replacing parts as a result of the wearing of the parts is remarkably decreased.

25

As the direction of rotation is opposite on the halves 17 and 18 of the crankshaft, the direction of one of the halves is changed. This can be done by the gears and by an auxiliary shaft. So the crankshaft half 18 has a rigid spur gear 21 around it. This gear is engaged to an intermediate gear 22, which in turn is engaged with a further spur gear 24. The gear 23 is mounted on an accessory shaft 24, on which also a spur gear 25 which engages a spur gear 26 mounted on the other half 17 of the crankshaft, is mounted. This means that, even though the halves of the crankshaft are rotating in opposite directions, the power from these halves can be

30

taken out from one of the crankshaft halves or from the shaft 24. The end of the other half can be used for other purposes.

The above construction is very steady and achieves a construction in which the friction and wearing are at their minimum. This new type of crank mechanism enables at the same time the balancing of the mass forces of first order.

Figures 3a and 3b show the piston of the engine in two directions turned from each other by 90 degrees. It can be readily seen that the piston is only one piston with two heads. In the conventional manner this would be two separate pistons. The piston heads 4 and 5 have piston rings to seal the piston against the cylinder surface. The connecting rods are to be fitted to one of the piston heads 4 in a conventional manner by the aid of a piston pin coming through protrusions 27 in the piston head. The piston rod begins from the head 4 and is, in this embodiment, in the form of a flat plate-like part 28. Anyhow, the form is not critical and may thus be e.g. circular in cross-section. As can be seen in Figure 1, the piston rod will reciprocate and move between the crankshaft halves 17 and 18. The movement is linear.

The piston rod 29 starting from the piston head 5 is preferably of circular cross-section, which is a benefit in the case the piston head is used also as a piston of a compressor as described later. Sealing of a circular rod is much easier than a rod of other cross-section. The channels seen in the rods and piston heads are for transporting lubricating oil.

25

Now the extraordinary and revolutionary new principle of engine is described in two embodiments with reference to Figures 4a to 4e and respectively Figures 5a to 5e.

30 The present engine according to the invention, described in figures 1 to 5 is based on the combination of two- and four-stroke cycles and on an isolated compressor part and on the leading of the new mixture to the cylinder, close at the top dead centre, at every rotation of the crankshaft, during a small crank angle. When the gas exchange occurs according to the enclosed figures 4 - 5, work shall be gained

at every rotation of the crankshaft. This increases the mechanical efficiency of the machine.

First, reference is made to Figures 4a to 4e. For clarity, reference numerals of the main parts have been added only to Figure 4a. The combination of camshaft, valve followers etc. have been designated with only one reference numeral 11.

Figure 4a shows the work phase of the engine. Fuel has been injected through nozzle 10, the compressed fuel/air mixture ignites or is ignited and expansion pushes the piston 4 down and the power will be taken out from the engine as described before. In the opposite cylinder the piston is, as is evident, in its lowest position. Both the exhaust valve 6 and the scavenging valve 7 are closed. The piston 4 moves to its lowest position and starts to return up. The exhaust valve 6 is opened so that the exhaust gases may escape from the cylinder by the aid of the piston returning up. This is shown in Figure 4b.

In Figure 4c the piston has returned quite high and the scavenging valve 7 is opened and pressurized air is directed from a suitable pressurized air reservoir to the cylinder causing gas exchange happen in the upper part of the cylinder. In other words the pressurized air pushes exhaust gases out through the open exhaust valve.

Figure 4d shows the continued process. The exhaust valve is closed, but the scavenging valve is still open and feeding of pressurized air into the cylinder is continued till, as shown in Figure 4e, the scavenging valve is also closed and the secondary compression of the air in the cylinder will happen, in the end of which phase the fuel injection will start the work phase again.

Figures 5a to 5e show the same sequence as described in figures 4a to 4e. However, now there has been made a following change in the procedure. Now the exhaust valve is closed earlier than in Figures 4a to 4e, cf. Figure 4c and 5c. This means that part of the exhaust gases are left in the cylinder to mix with the incoming pressurized gas. This kind of internal re-circulation is favorable to the total process for example in order to lower the Nox output of the engine.

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One of the disadvantages of a conventional two-stroke engine is that a part of the scavenging air shall be lost to the exhaust side. This can be prevented in the engine according to the present invention, by means of the timing of the valves. Also the "internal" re-circulation of the exhaust gas is possible, like described
5 before. The exhaust valve is open about 180° , typically 60° before the bottom dead centre - 120° after the bottom dead centre.

For the opening time of the gas exchange valve or scavenging valve, meaning the time, during which the main part of the new mixture flows to the cylinder is $20 - 30^\circ$
10 enough, close at the top dead centre of the piston, typically 120° after the bottom dead centre - 30° before the top dead centre. This short opening time, close to the top dead centre of the piston, is enough, because the pressure of the coming gas is quite high, typically 3 - 15 bar, when its volume is small and the needed valves are small and light. The quite low rotating speed, typically 1000 - 4000 r/min, helps
15 in this matter, because the inertia forces of the valve mechanism are proportional to the power of two of the speed of revolution. As a reference, some commercial motorcycles have engines, rotating 15000 18000 r/min, without any problems. After the gas exchange valve is closed, the piston continues its movement toward the top dead centre (the secondary compression), during which the fuel injection
20 starts, and then the self ignition (ignition) and then combustion and expansion.

The fuel ignites or shall be ignited for example with a glow plug, injection of the assistant fuel, spark etc. A typical work cycle appears from the pictures 1 and 4 and 5. If a separate ignition fuel is used, it can be injected to the gas exchange
25 duct, which is equipped with lamella, if needed, parallel with the flow. Also all the fuel can be injected only to gas exchange duct.

In the engine according to the invention, there can be a heat exchanger in the gas flow, between the compressor - flush valve (not seen in the picture). Thus the
30 temperature of the primary compressed gas, which is typically 3 - 15 bar, can be controlled for example from the exhaust gases.

One embodiment of a compressor can be seen in Figure 1a wherein the piston head 5 is working also as a compressor piston. So gas is taken through a channel

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30 to the volume 31 below the piston head 5. When moving to the right (in Fig. 1a) the piston head 5 is compressing the air and the compressed air is fed out through the channel 32. Normally there is a reservoir (not shown) in which the pressurized air is collected and wherefrom it is used for injection through the channel 9.

5

The delivery volume of the compressor can be different from the stroke volume of the work pistons, so thus the expansion can be optimized.

10 In order to achieve a high mechanical efficiency, the expansion pistons and the compressor piston are on the same line; connected to each others, like shown before, when the final net power comes to the crank mechanism. Also a separate compressor, for example a screw compressor, is possible.

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CLAIMS:

1. Method for obtaining high efficiency in an internal combustion engine having at least one cylinder, having at least one exhaust valve and at least one
5 scavenging valve for the coming new gas and working with a two-stroke principle whereby each cylinder produces power at every rotation of the crankshaft, in which process pressurized air or air/fuel mixture is lead through the at least one scavenging valve during the last quarter of the
10 crankshaft rotation before top dead centre, "BTDC", wherein the at least one scavenging valve is opened for gas inlet at a pressure of 3 to 15 bars at 60 degrees BTDC and kept open during 20 to 30 degrees of the crankshaft rotation, when a piston head already has moved about 90% toward the top dead
15 centre, so that the gas exchange has occurred before the piston head has reached the top dead centre.
2. A method according to claim 1, wherein the at least one scavenging valve is closed at approximately 30 degrees BTDC.
- 20 3. A method according to claim 1, wherein the pressure of the incoming gas is 3 to 15 bars.
4. A method according to claim 1, wherein the temperature of the pressurized air or air/fuel mixture is controlled by cooling or heating.
- 25 5. A method according to claim 1, wherein the at least one exhaust valve is opened before bottom dead centre.
6. A method according to claim 1, wherein the at least one exhaust valve is closed before all of the exhaust gases have been driven out by the coming new gas.

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7. A method according to any one of claims 1 to 6, wherein the at least one exhaust valve is kept open approximately up to 60 degrees BTDC.

8. A method according to any one of claims 1 to 7,
5 wherein the piston head is also used as a compressor piston to get pressurized air.

9. A method according to claim 8, wherein the delivery volume of the compressor can be different from the stroke volume of the work pistons, so thus the expansion can
10 be optimized.

10. A method according to any one of claims 1 to 9, wherein a separate compressor is used to develop pressurized air.

11. A method according to claim 10, wherein the
15 separate compressor comprises a screw compressor.

12. A method according to any one of claims 1 to 10, wherein part or all of the fuel is injected into a channel of scavenging air.

13. An internal combustion engine having at least one
20 cylinder, at least one exhaust valve and at least one valve for incoming new gas working with a two-stroke principle, whereby each cylinder produces power at every rotation of the crankshaft, wherein the at least one valve for the incoming new gas include means for feeding scavenging air
25 under a pressure of 3 to 15 bars starting at 60 degrees of the crankshaft before top dead centre and lasting 20 to 30 degrees time of the crankshaft rotation, when a piston head already has moved about 90% toward the top dead centre, so that the gas exchange has occurred before the piston head
30 has reached the top dead centre.

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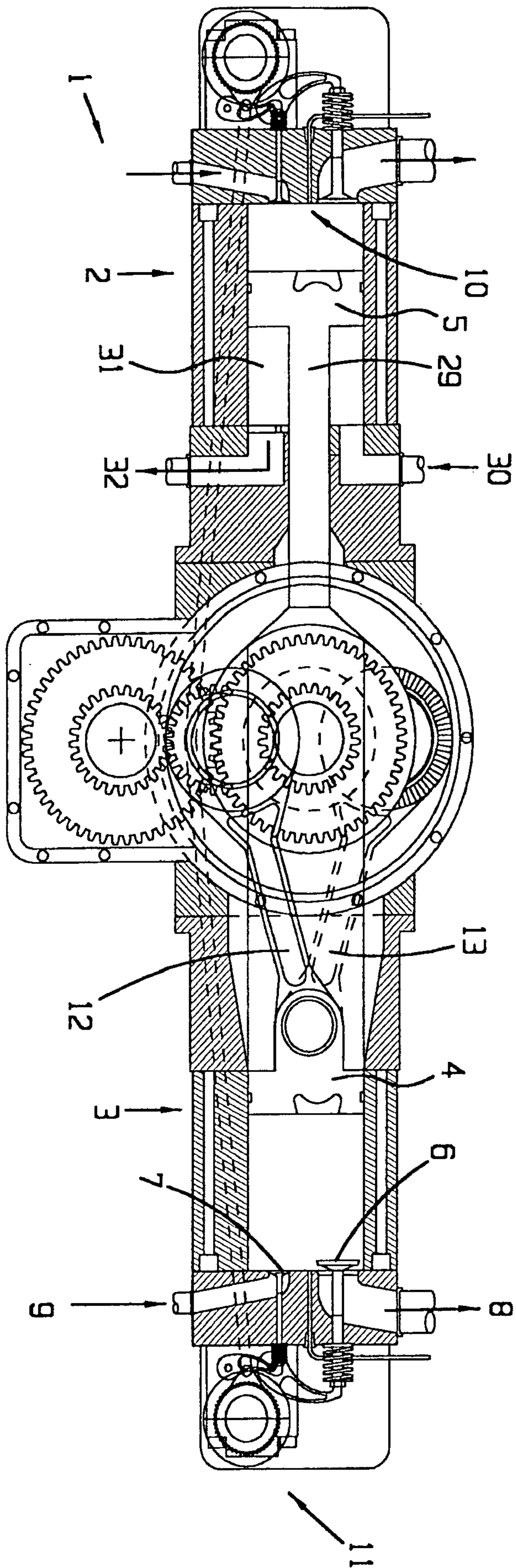
14. Engine according to claim 13, wherein another piston head has been connected with two connecting rods to crankshaft halves rotating in opposite directions.

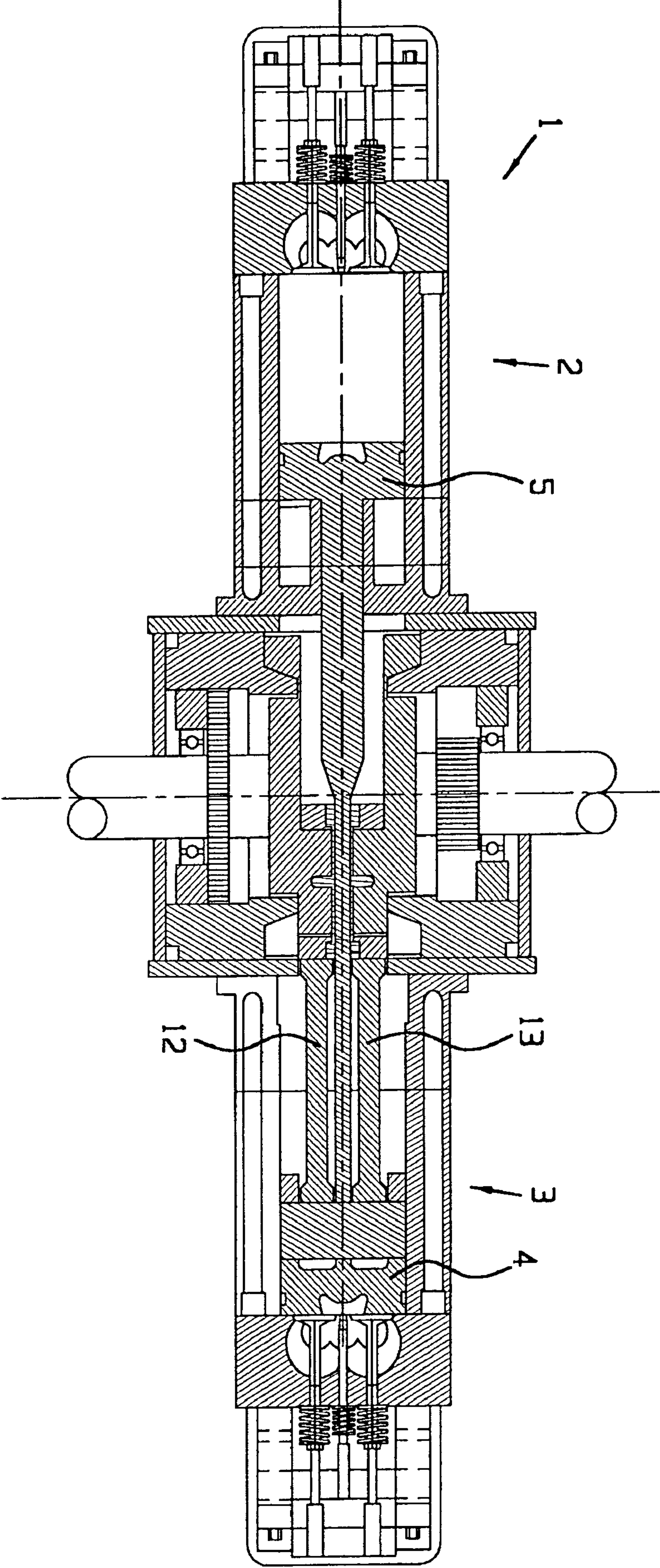
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PATENT AGENTS

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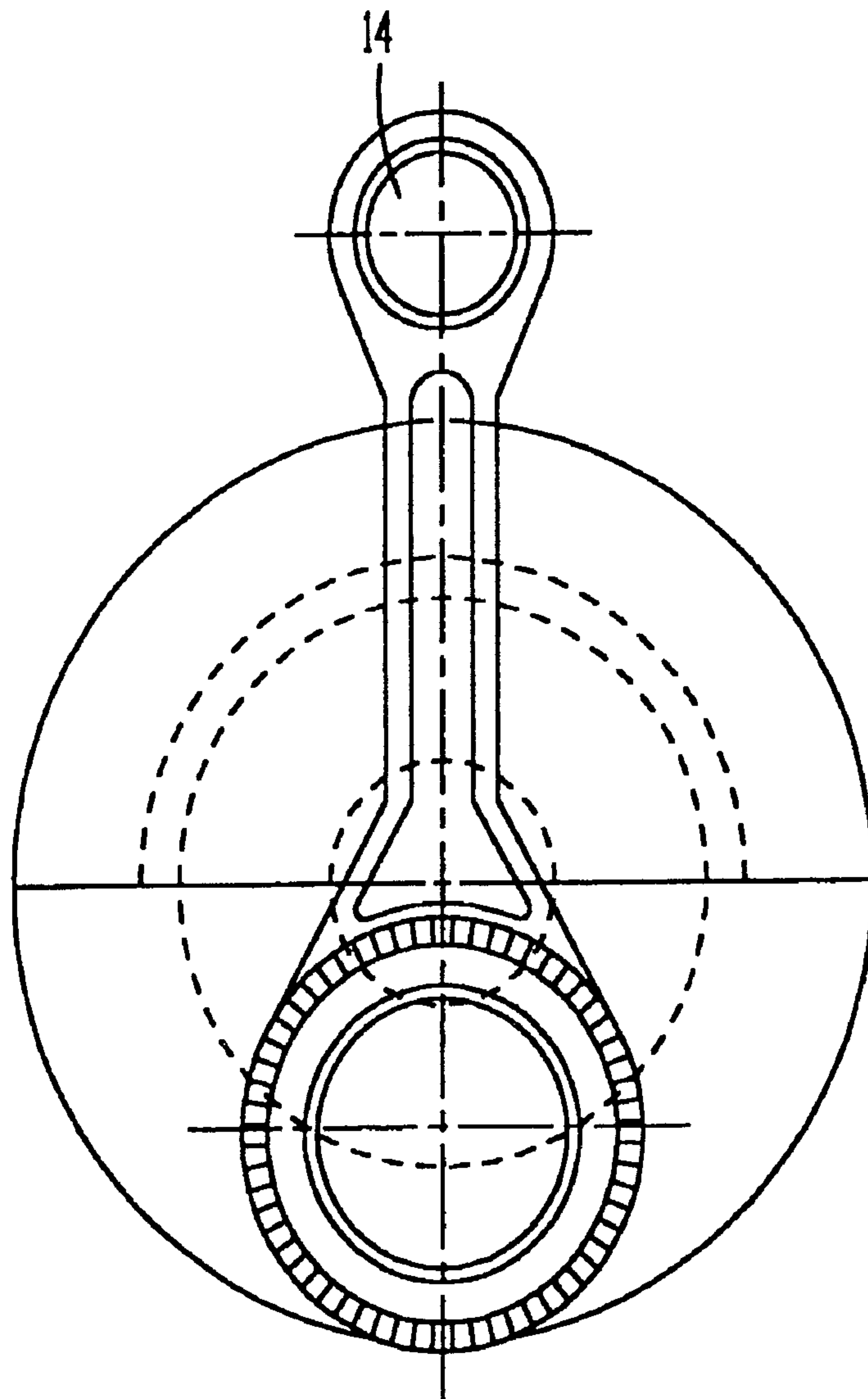


FIG. 2A

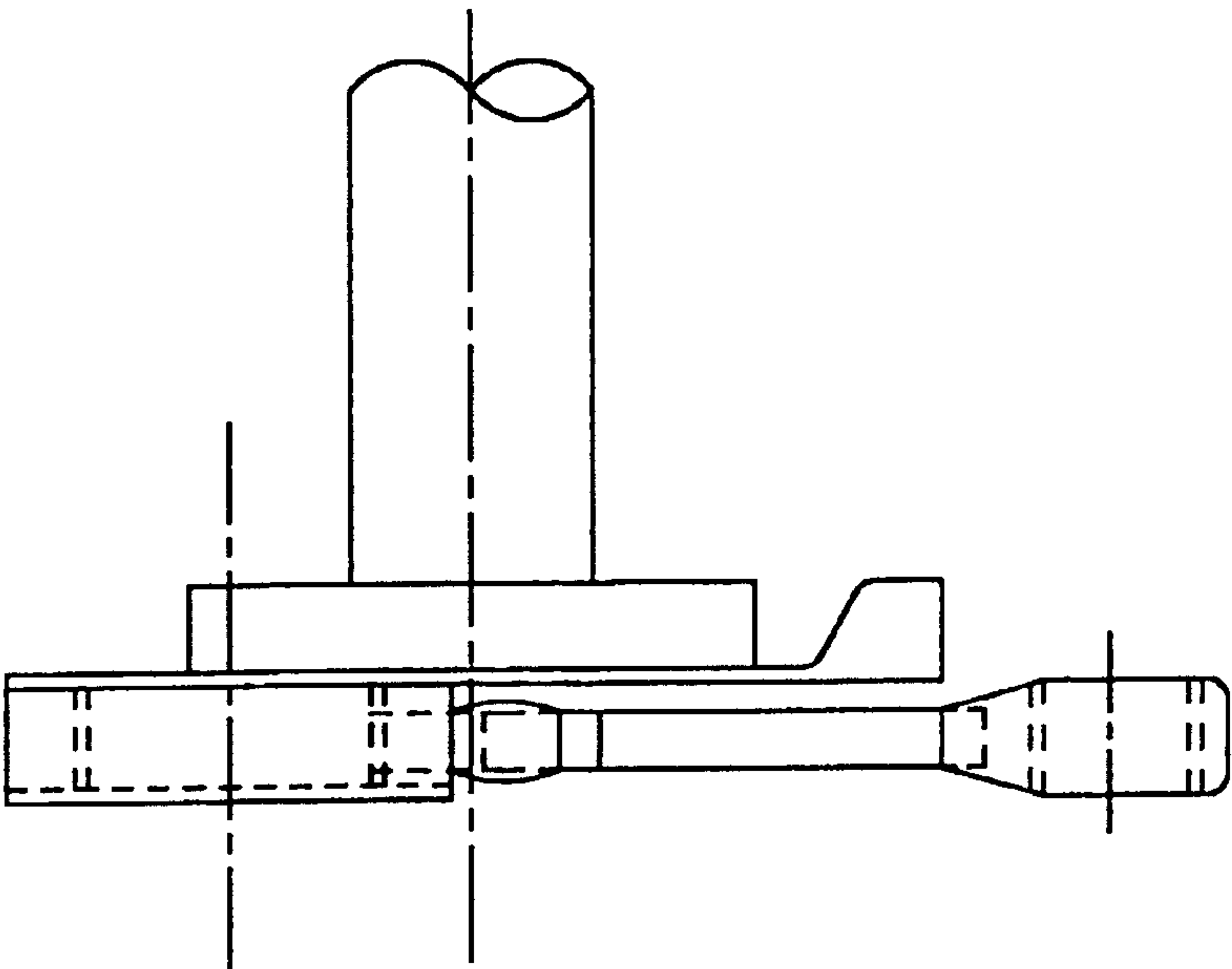


FIG. 2B

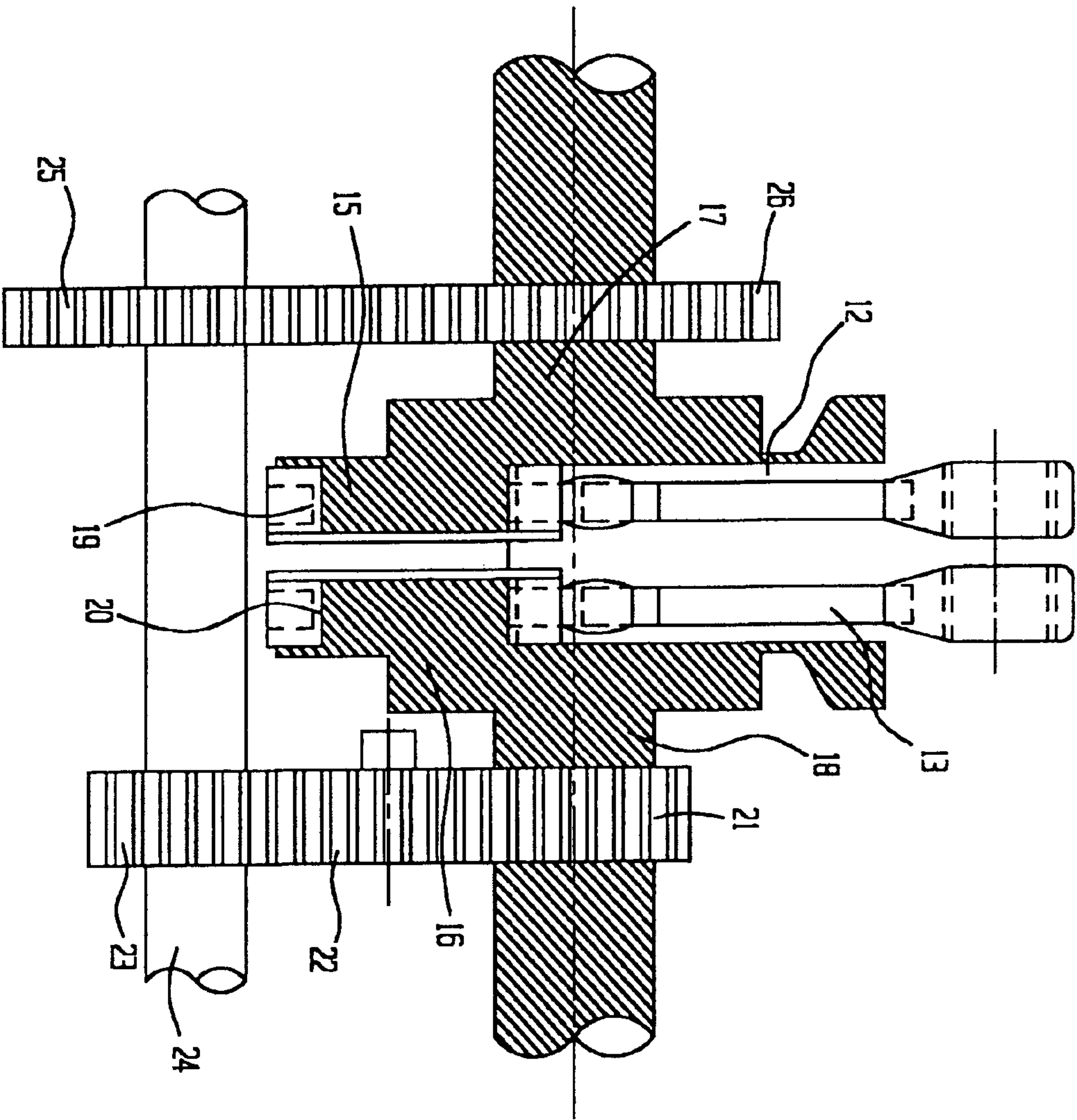


FIG. 2C

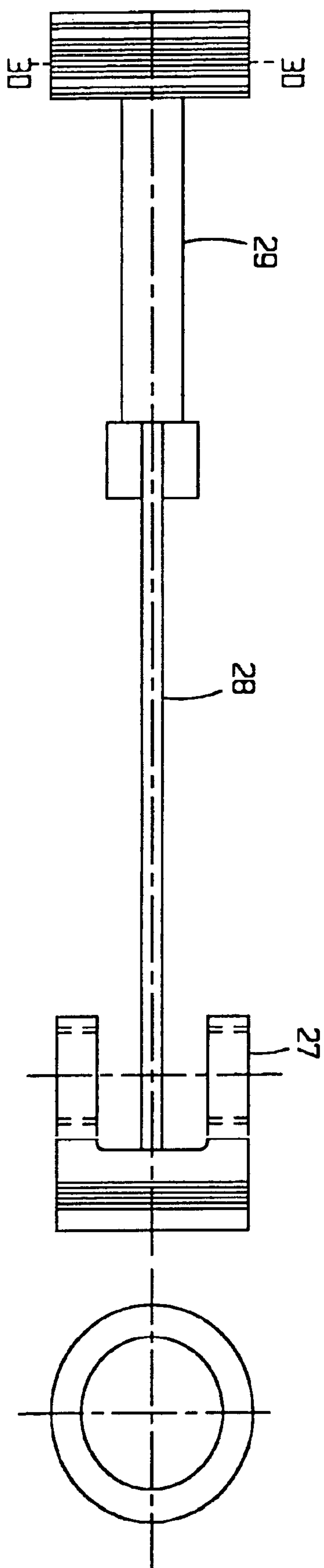
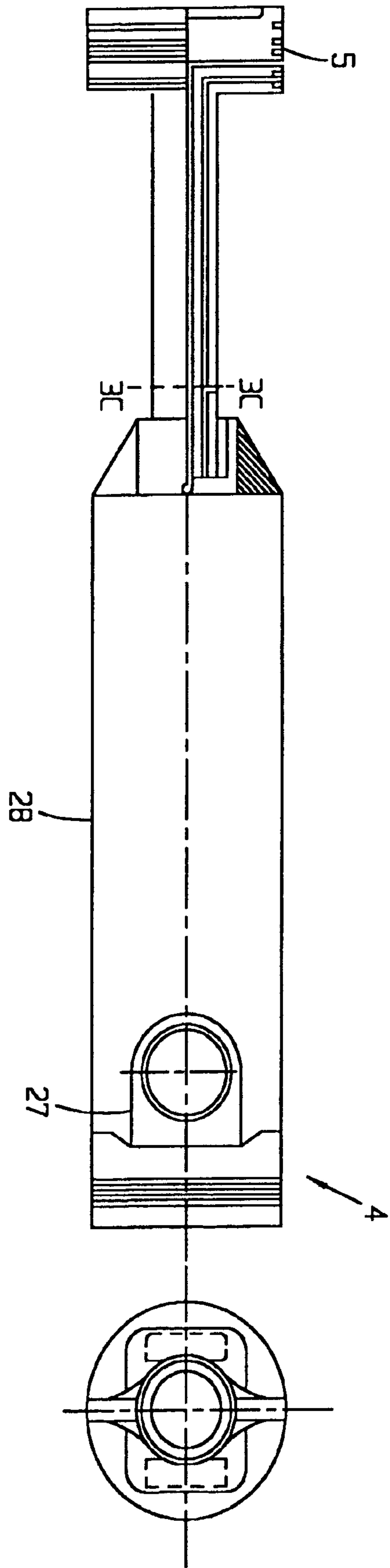


FIG. 3B

FIG. 3D

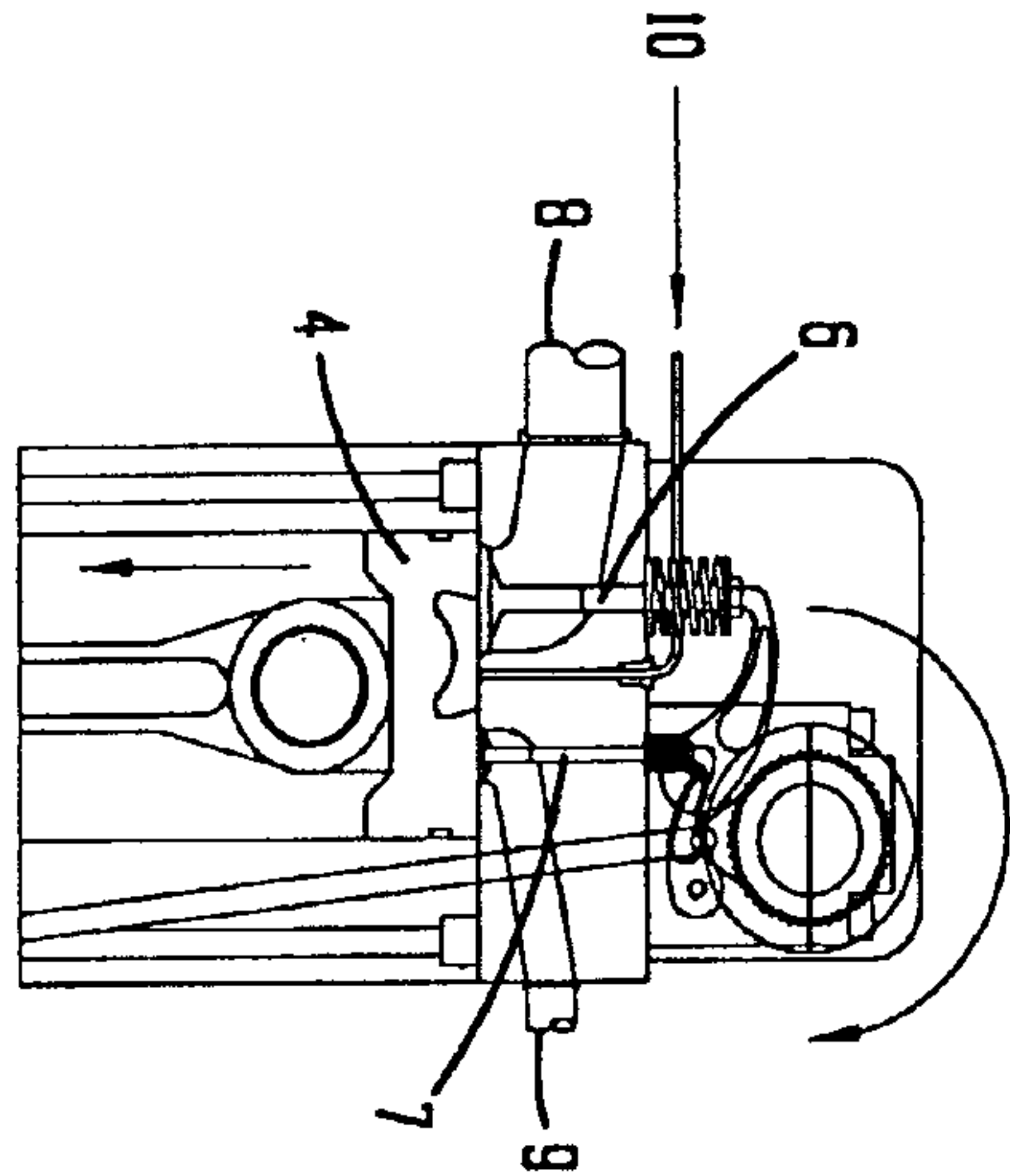


FIG. 4A

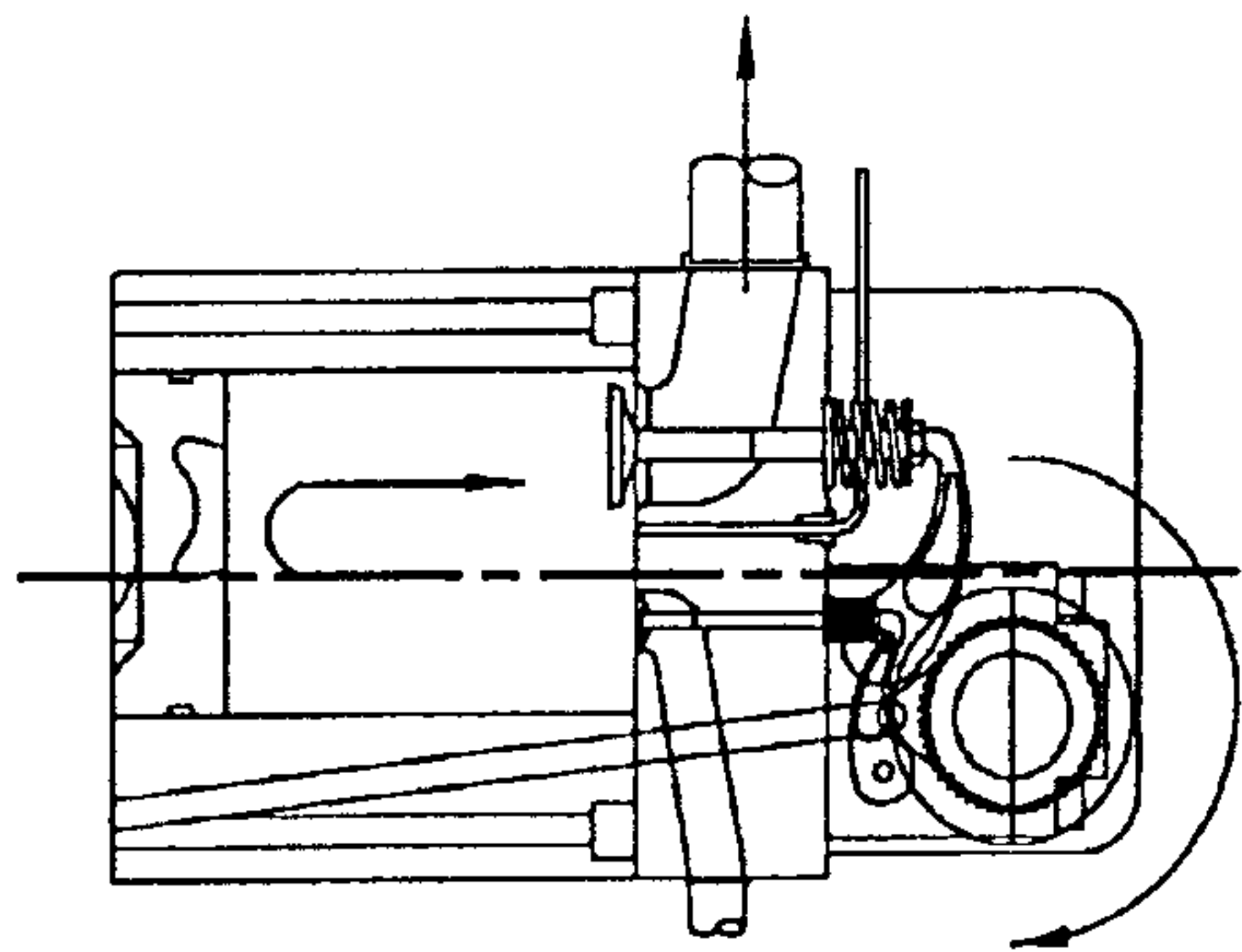


FIG. 4B

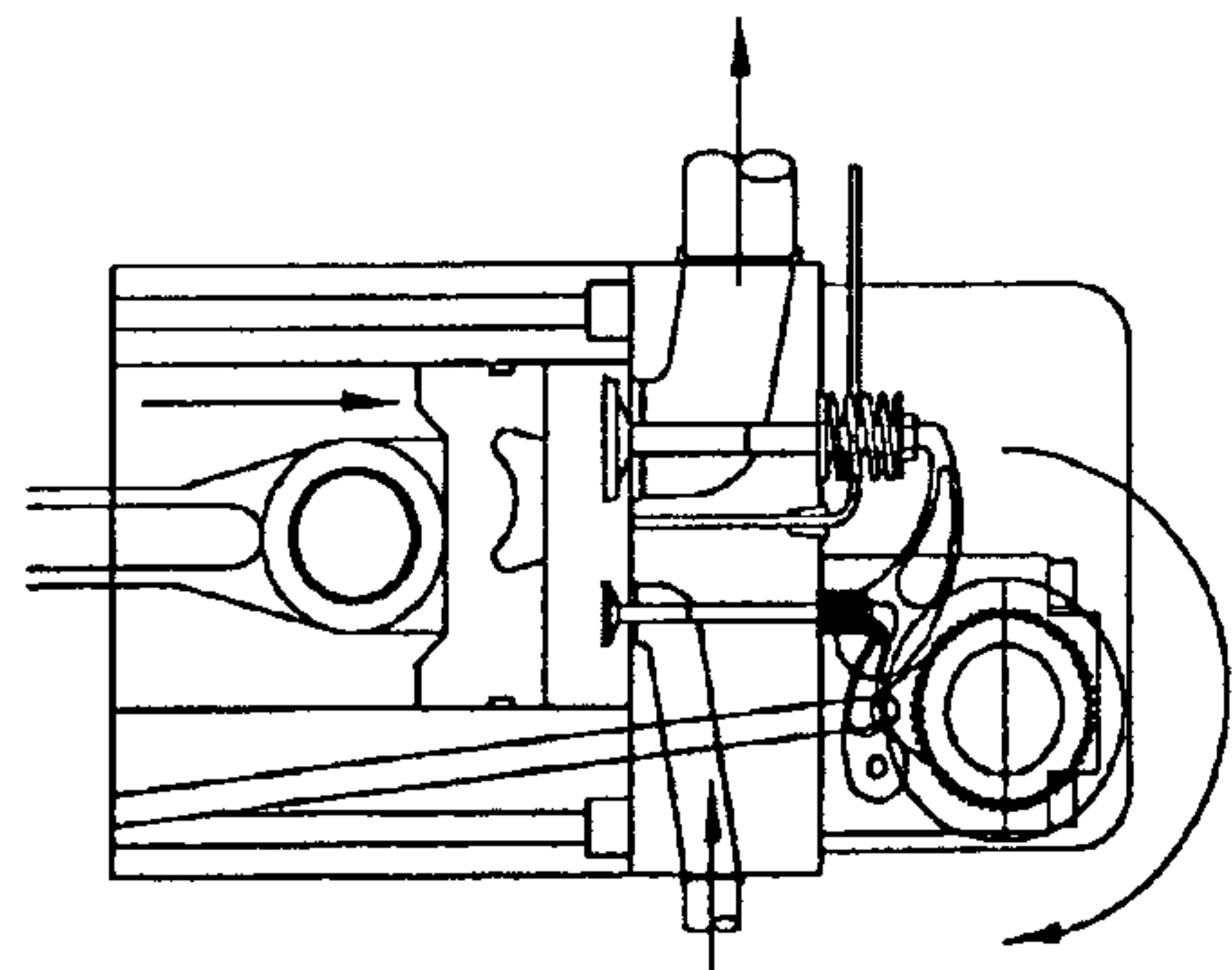


FIG. 4C

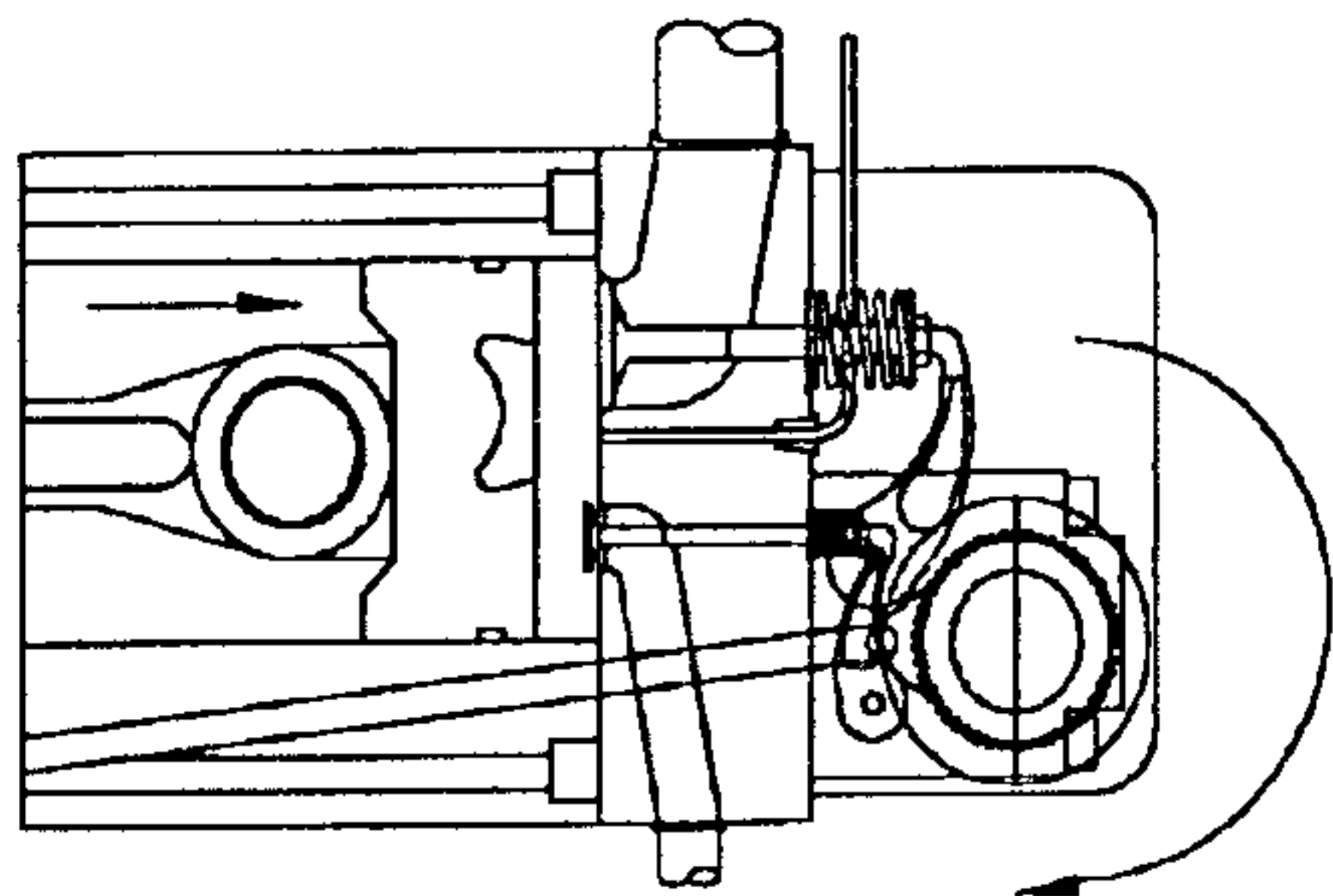


FIG. 4D

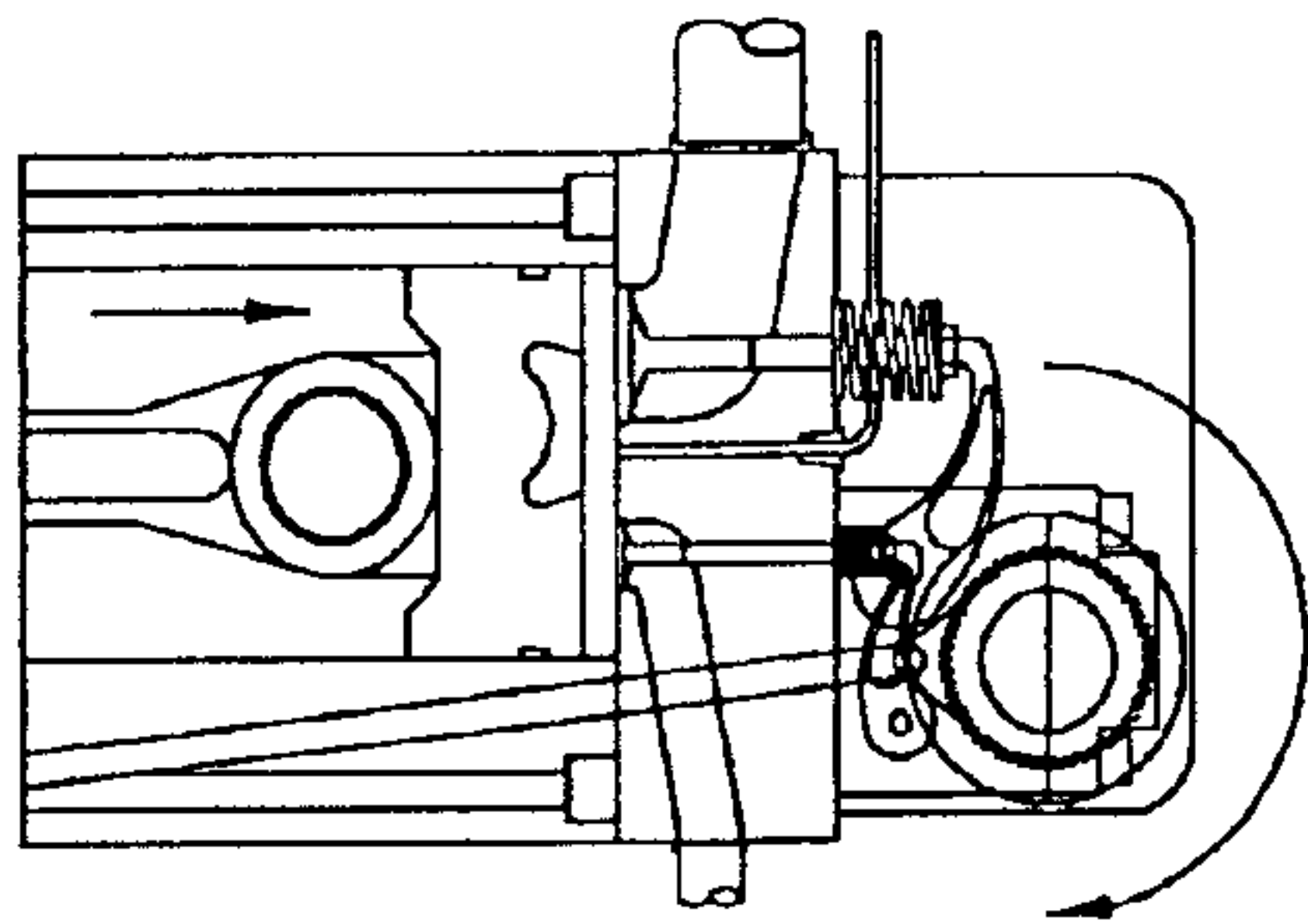


FIG. 4E

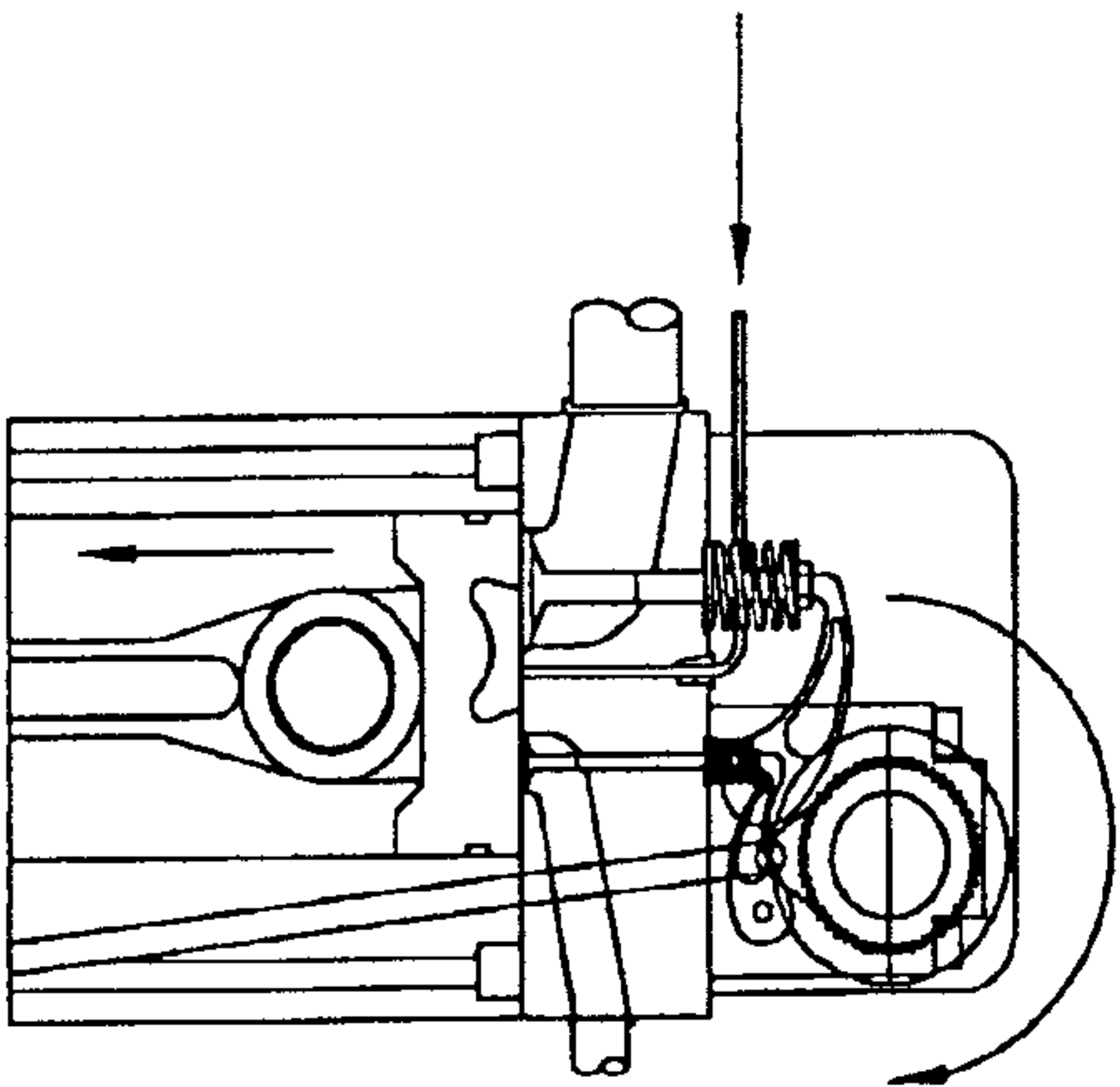


FIG. 5A

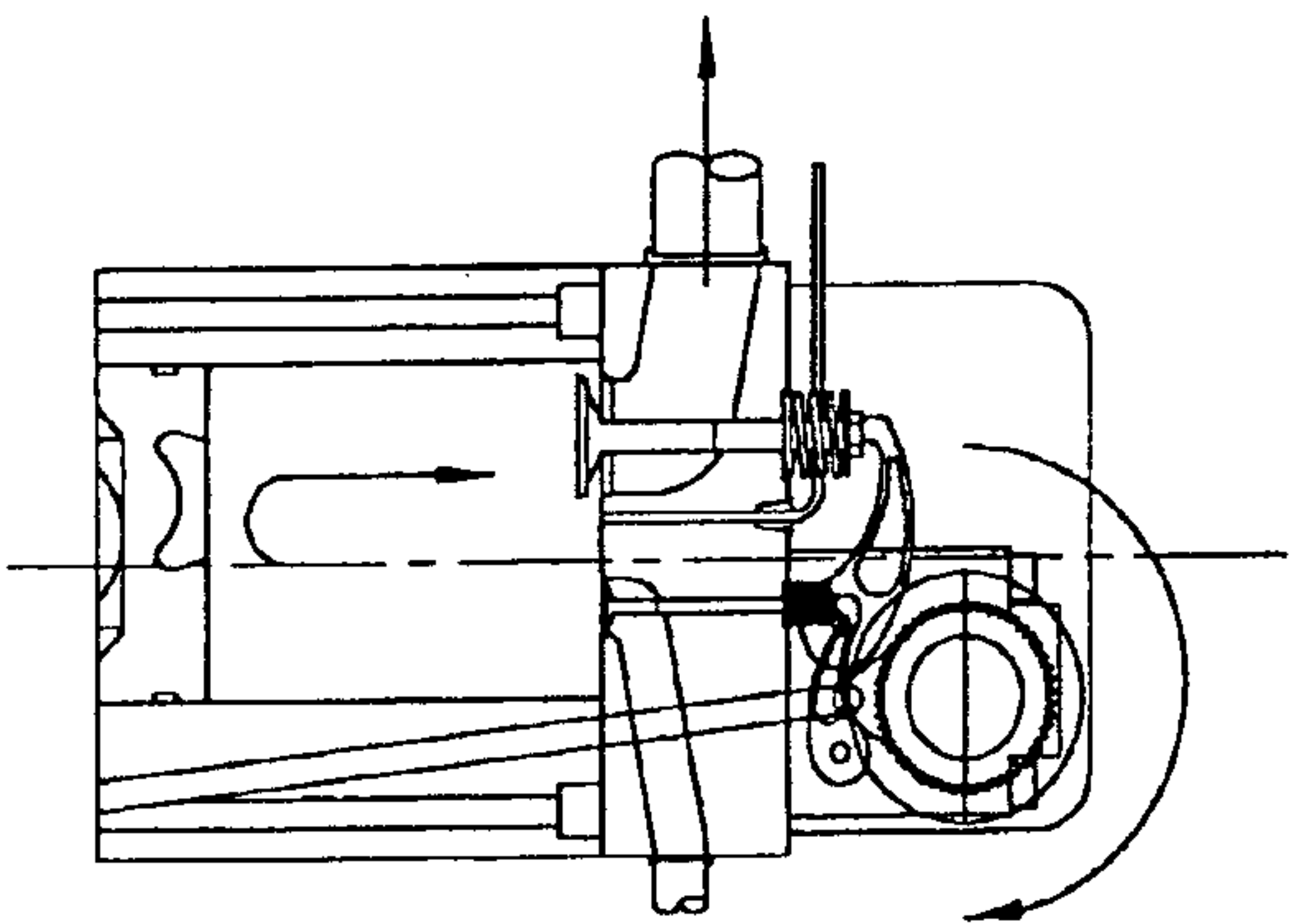


FIG. 5B

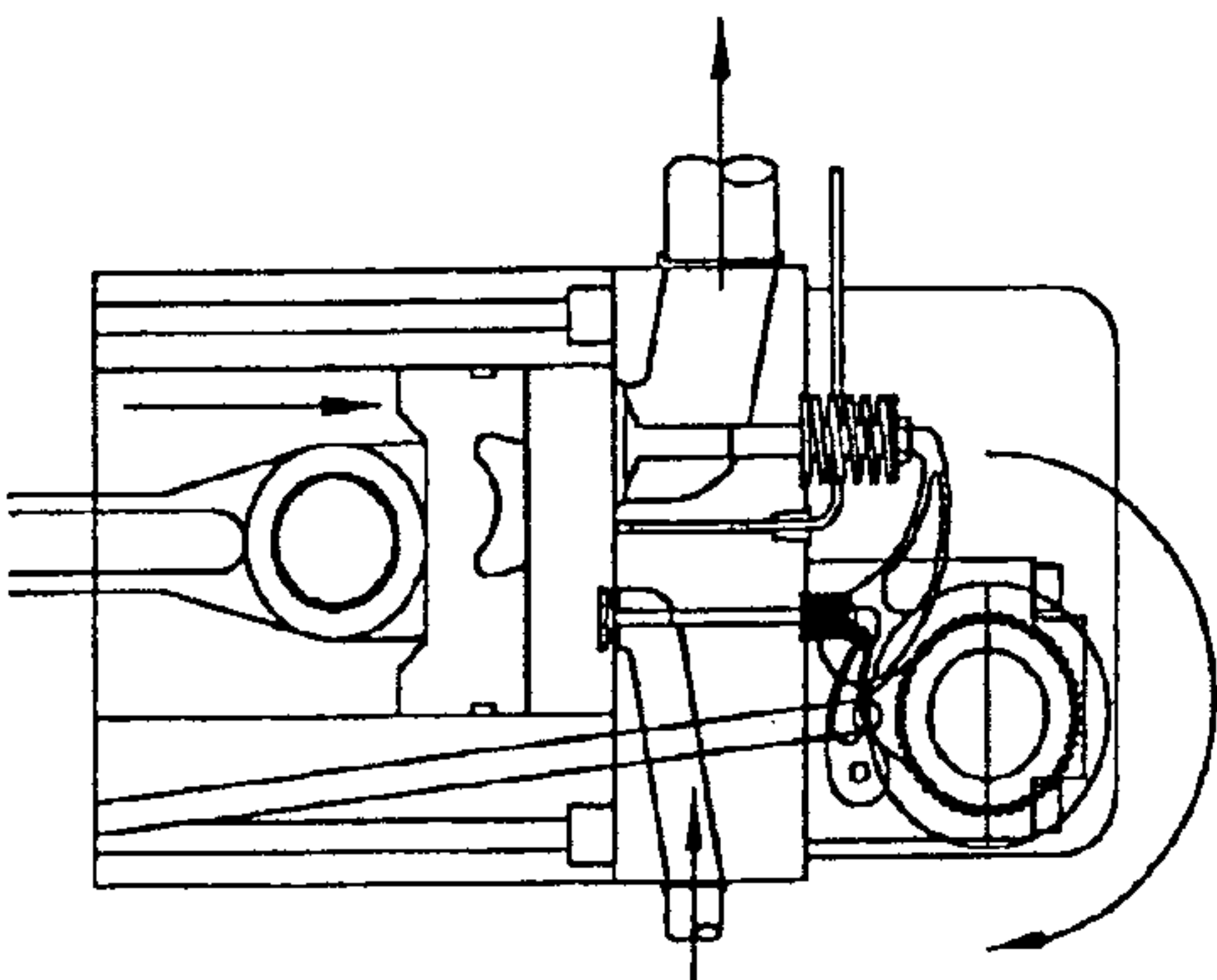


FIG. 5C

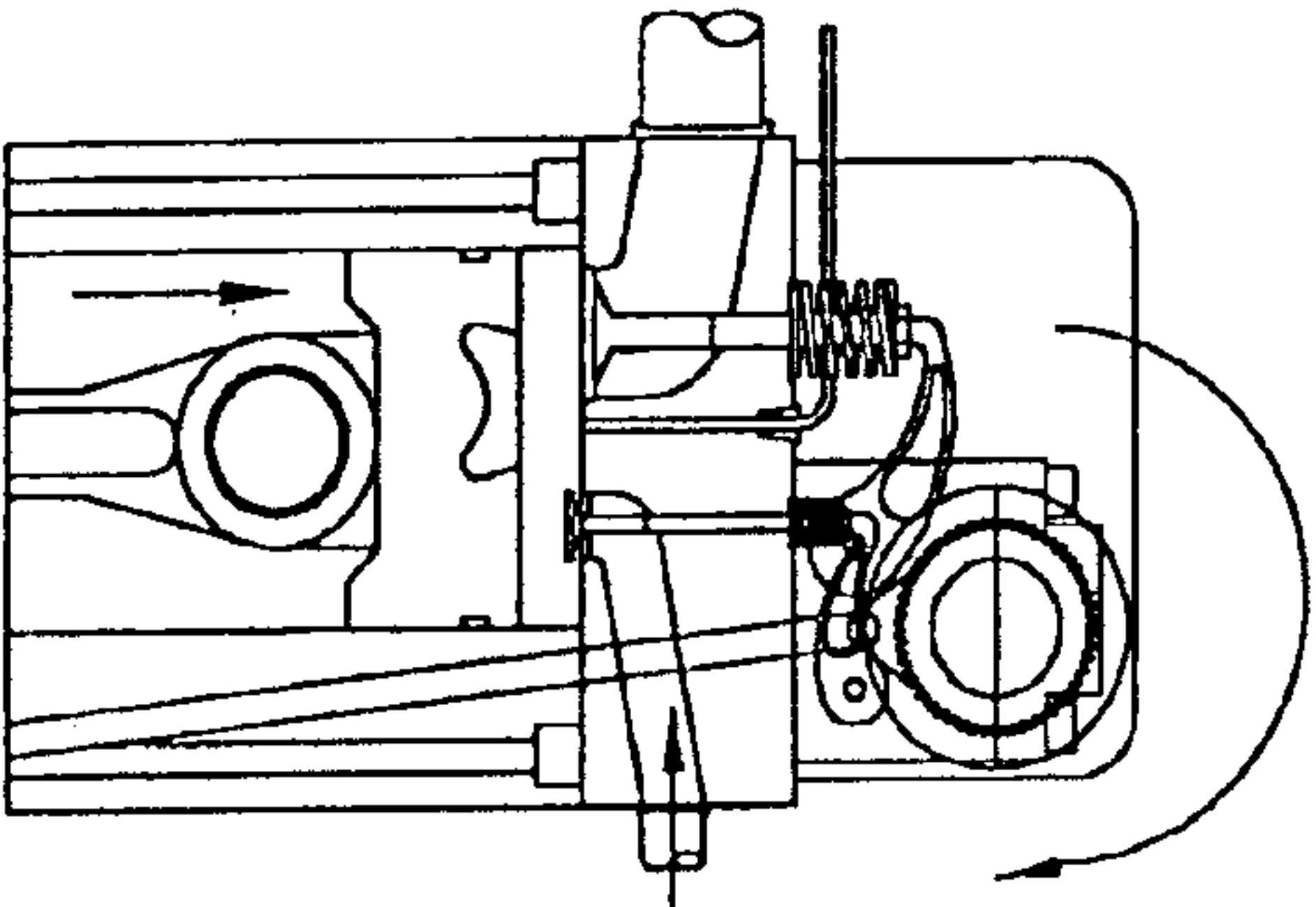


FIG. 5D

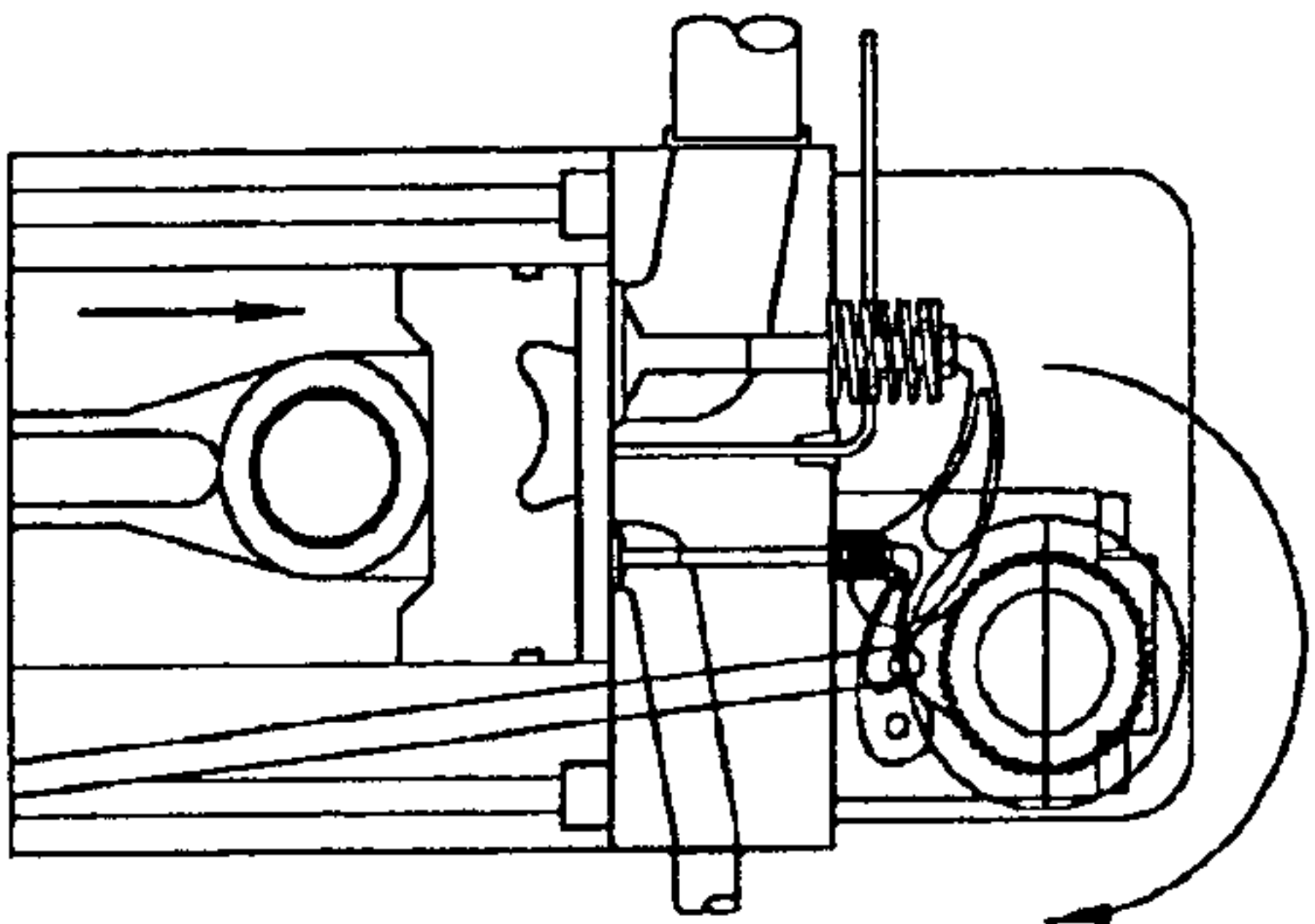
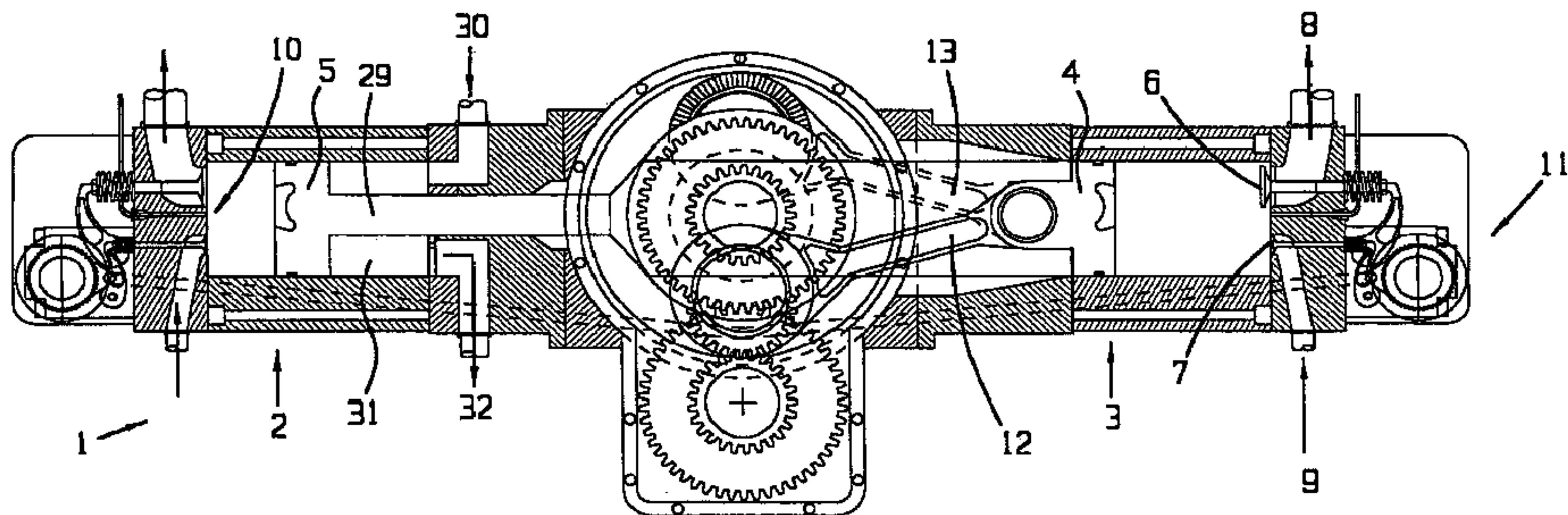
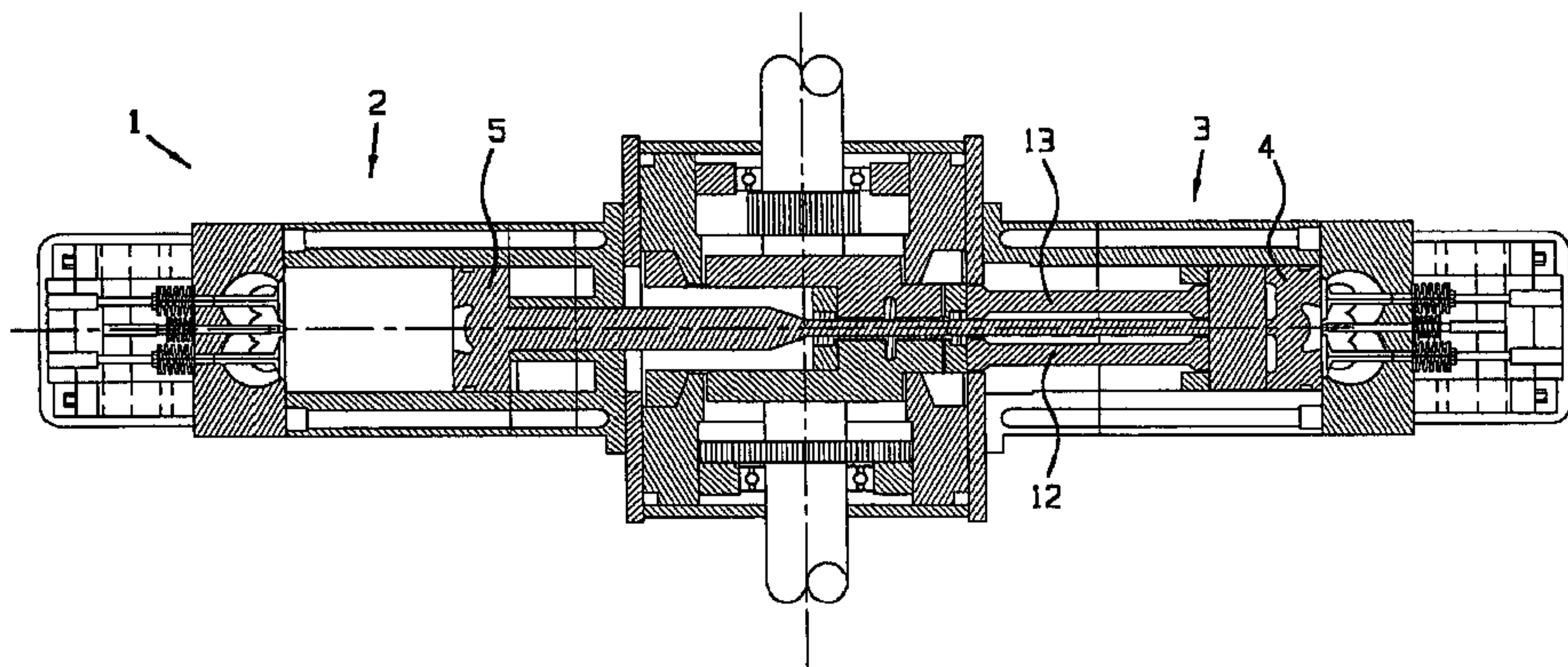


FIG. 5E



A



B