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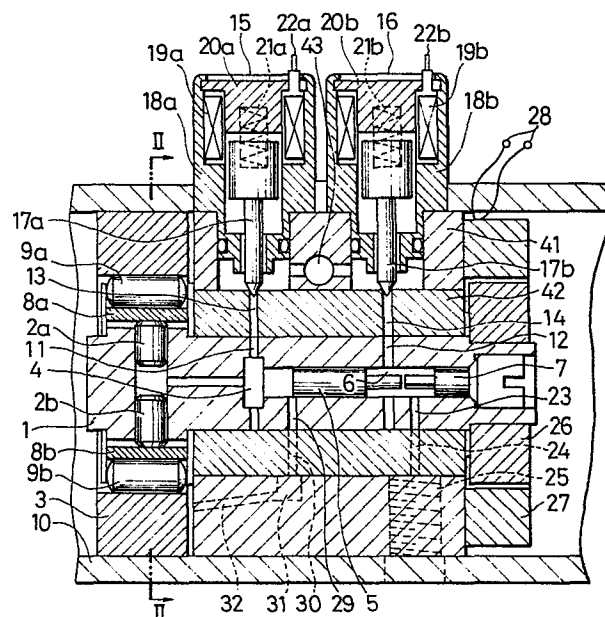
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⑤④ **Fuel injection pump for internal combustion engine having improved excess fuel discharger.**

⑤⑦ Disclosed is a fuel injection pump arranged such that a movable free piston (5) is provided in a high-pressure fuel chamber, and a first compression chamber (4) partitioned by the piston is supplied with fuel for determining the amount of fuel to be injected, while a second compression chamber (6) is supplied with fuel for determining injection timing, then fuel is compressed by means of a rotary compressor mechanism, and the fuel highly compressed in the second compression chamber (6) is supplied to cylinders of an internal combustion engine, wherein the above-mentioned free piston (5) has a valve mechanism which opens when the piston moves toward the second compression chamber (6), thereby to abruptly release the fuel for regulating injection timing compressed in the second compression chamber (6).



# SPECIFICATION

## TITLE OF THE INVENTION

FUEL INJECTION PUMP FOR INTERNAL COMBUSTION

ENGINE HAVING IMPROVED EXCESS FUEL DISCHARGER

## BACKGROUND OF THE INVENTION

### 5 Field of the Invention

The present invention relates to a fuel injection pump used in an internal combustion engine especially a diesel engine and more particularly to a fuel injection pump having an excess fuel  
10 discharger.

### Description of the Prior Art

Because internal combustion engines, particularly diesel engines, generally have a need for supplying fuel under high pressure to their combustion chambers,  
15 fuel injection pumps are employed therefor. A typical conventional fuel injection pump has a mechanical constitution using a governor, a spark advance system and the like in order to control both the amount of fuel to be injected and injection timing.

20 On the other hand, internal combustion engine control systems utilizing a microcomputer have been rapidly developed in recent years. With the development, there has been a demand for a fuel  
25 injection pump capable of electric control.

The relevant prior art literature is listed below:

- (1) U.S. Patent 4,185,779 (issued on Jan. 29, 1980) "Fuel Injector", Assignee: The Bendix Corporation.

This specification discloses an injector adapted to be controlled by means of the output signal from an electronic control unit. The injector is provided to each of cylinders and adapted to inject compressed fuel into the cylinder according to the control signal.

- (2) U.S. Patent 3,704,963 (issued on Dec. 5, 1972) "Fuel Pump", Assignee: Stanadyne, Inc.

This specification discloses a fuel pump, such as abovementioned, using a governor in order to control both the amount of fuel to be injected and injection timing.

#### SUMMARY OF THE INVENTION

An object of the present invention is to provide a fuel injection pump for an internal combustion engine capable of electrically controlling both the amount of fuel to be injected and injection timing and further capable of injecting fuel stably and accurately.

Another object of the present invention is to

provide a fuel injection pump for an internal combustion engine having a compact construction.

To these ends, according to the present invention, there is provided a fuel injection pump  
5 arranges such that a movable free piston is provided in a high-pressure fuel chamber, and a first chamber partitioned by the piston is supplied with fuel related to the amount of fuel to be injected, while a second chamber is supplied with  
10 fuel related to injection timing, wherein the abovementioned free piston is provided with a valve mechanism which opens when the piston moves upon the completion of injection of fuel in order to abruptly release the fuel for injection timing  
15 control in the second chamber.

#### BRIEF DESCRIPTION OF DRAWINGS

Fig. 1 is a sectional view of a fuel injection pump according to the present invention;

20 Figs. 2 thru 7 are sectional views of the fuel injection pump shown in Fig. 1, illustrating its operation respectively; and

Fig. 8 is a sectional view of the fuel injection pump according to the present invention, particularly illustrating its free piston part.

# DESCRIPTION OF THE PREFERRED EMBODIMENT

Fig. 1 shows a fuel injection pump according to the present invention. The basic constitution thereof is disclosed in the preceding application 5 (U.S. Application filed on September 22, 1981: European Patent Application No. 81107263.6 filed on September 15, 1981).

In Fig. 1, a rotor 1 is rotated by means of a driving shaft (not shown) rotating in synchronism 10 with an engine, while a pair of plungers 2a, 2b are housed in a bore laterally penetrating through the left end part of the rotor 1. Outside the plungers 2a, 2b, roller shoes 8a, 8b and rollers 15 9a, 9b are placed respectively. These plungers 2a, 2b, roller shoes 8a, 8b and rollers 9a, 9b rotate with the rotor 1.

A cam ring 3 on the peripheries of the rollers 9a, 9b is fitted in an outermost housing 20 10. Moreover, the rotor 1 rotates inside a sleeve 42 mounted in a sleeve holder 41 secured to the housing 10.

The inside of the rotor 1 is divided into a first compression chamber 4 and a second 25 compression chamber 6, and a free piston 5 is placed therebetween, the right end of the second

compression chamber 6 being sealed with a stopper

7. In addition, the second compression chamber 6 communicates with a delivery passage 23 formed in the radial direction of the rotor 1, and a second  
5 release passage 12 is provided correspondingly to a second fixed passage 14 in the sleeve 42.

On the other hand, a first release passage 11 communicating with the first compression chamber 4 is provided correspondingly to a first fixed passage  
10 13 in the sleeve 42, and an overflow port 29 is provided in the lower part of the first compression chamber 4, connecting with a discharge passage 32 through overflow passages 30, 31.

The openings of the first and second fixed  
15 passages 13, 14 formed in the sleeve 42 face the tips of valve bodies 17a, 17b of a first solenoid valve 15 and a second solenoid valve 16 respectively, the first and second solenoid valves 15, 16 comprising coils 19a, 19b, fixed magnetic poles 20a, 20b and  
20 springs 21a, 21b housed in cases 18a, 18b respectively. In the central part of the sleeve holder 41, a fuel supply port 43 is formed, and the fuel introduced therefrom fills the chambers housing the valve bodies 17a, 17b of the solenoid  
25 valves 15, 16 respectively and the inside of the

rotor 1.

For further information, reference numerals 22a, 22b designate terminals of the coils 19a, 19b respectively, and reference numerals 24 and 25 denote  
5 an outlet passage and a connection port respectively. Moreover, a reference numeral 27 designates a detector with an annular permanent magnet secured to an end part of the sleeve holder 41, and a pulser 26 mounted on the rotor 1 is inserted  
10 inside the detector 27. The pulser 26 is a magnetic body provided with a projection on its periphery and outputs a rotation signal from detection terminals 28 when a magnetic path is  
15 interrupted through the rotation of the pulser 26 with the rotor 1, thereby allowing the rotation position and speed of the rotor 1 to be detected.

The operation of the thus constituted fuel injection pump will be described hereinunder with  
20 reference to Fig. 2 thru Fig. 7. The left side part (a) of each of these Figs. corresponds to a sectional view of Fig. 1 taken along the line II - II, showing the fuel injection pump in an operating state. On the other hand, the right side part (b) of each  
25 Fig. shows the fuel passage relationship between the rotating rotor 1 and the sleeve 42 housing the

same and the position of the free piston 5.

In Fig. 2, the start of supply of fuel to be injected is shown, and the plungers 2a, 2b are moving outward. In Fig. 2 (a), because the  
5 rollers 9a, 9b have moved from the radially protruded portions to the radially recessed portions of the inner surface of the cam ring 3 and the pressure in the first compression chamber 4 is reduced, the free piston 5 moves in the direction  
10 of an arrow, reducing the pressure in the second compression chamber 6. Consequently, fuel to be injected is sucked through the second release passage 12 and the second fixed passage 14. Because the valve body 17b allows the passage 14  
15 to be opened at this time, the compressed fuel from the fuel injection pump flows into the second compression chamber 6. In other words, this is a step of sucking the fuel to be injected. The amount of fuel to be injected is controlled  
20 according to the opening period of time of the solenoid valve body 17b, i.e., the electric signal applied to the solenoid valve 16.

Fig. 3 shows the start of supply of the fuel for regulating injection timing after the completion  
25 of suction of the fuel to be injected. At this



time, the free piston 5 is suspended and the valve body 17a is in an opening state. As shown in Fig. 3 (a), because the rollers 9a, 9b rotate in the recessed portions of the cam ring 3, respectively, during this time, the plungers 2a, 2b further reduce the pressure in the first compression chamber 4, so that the fuel for regulating injection timing is sucked through the first fixed passage 13 and the first release passage 11. The amount of the fuel is also controlled by means of the valve body 17a of the solenoid valve 15 controlled electrically. It is also possible to make the valve bodies 17a, 17b simultaneously open their corresponding passages for introducing fuel.

Fig. 4 shows the completion of supply of the fuel for regulating injection timing. The plungers 2a, 2b and the free piston 5 are suspended, and both the valve bodies 17a, 17b are in a closing state.

Fig. 5 shows the start of injection of fuel. Because the rollers 9a, 9b are led to the protruded portions of the cam ring 3 respectively, at this time, the plungers 2a, 2b start approaching to each other. Consequently, the free piston 5 moves in the direction of an arrow, i.e., rightward, pumping the fuel in the second compression chamber 6 to the connection

port 25 in Fig. 1 through the delivery passage 23 and the outlet passage 24. Because the pipe attached to the connection port 25 communicates with a cylinder of an internal combustion engine, a given amount  
5 of fuel is supplied thereto.

Fig. 6 shows the start of discharge of excess fuel after the completion of injection of fuel. Because when the free piston 5 has moved to the right limit the overflow port 29 is exposed, the  
10 compressed excess fuel for regulating injection timing flows out through the overflow passage 30. The fuel flows out to the low-pressure portion inside the housing 10 through the overflow passage 31 in the sleeve holder 41 shown in Fig. 1, which  
15 exactly shows this state.

Fig. 7 shows the completion of discharge of the excess fuel. Although suspending, the free piston 5 is about to move into the state shown in Fig. 2 to suck the fuel to be injected. It may  
20 be understood from the above description that a series of fuel suction and injection operations are performed during a 90-degree turn of the rotor 1. Because the engine in this case has four cylinders, fuel is injected into all the cylinders  
25 during one full turn of the rotor 1. In case of

a three-cylinder engine, the fuel injection pump is arranged such that all the three cylinders are supplied with fuel during one full turn of the rotor 1. In addition, the fuel sucked into the  
5 first compression chamber 4 is fuel for regulating what is called injection timing. Therefore, the fuel sucked into the second compression chamber 6 is actually injected.

Fig. 8 is a sectional view of an essential  
10 part of the fuel injection pump according to the present invention, particularly showing the free piston 5 thereof. The same parts in Fig. 1 and Fig. 8 have the same symbols respectively.

Although a movable valve body 51 is housed in the  
15 free piston 50 in this preferred embodiment, the valve body 51 and the free piston 50 are hermetically fitted to each other. Therefore, no fuel moves from the first compression chamber 4 to the second compression chamber 6. Moreover, being pressed  
20 by a spring 53 retained by a ring 54, the collar portion of the valve body 51 housed in the free piston 50 closely contacts with the valve seat, preventing the fuel in the first compression chamber 4 from flowing out through a discharge port 52,  
25 the overflow port 29 and the overflow passage 30.

When the free piston 50 moves rightward and the step of the excess fuel discharge is reached after the completion of injection, however, the projected end of the valve body 51 contacts with the tip of the stopper 7, causing the collar of the valve body 51 separates from the valve seat.

Consequently, the excess fuel in the first compression chamber 4 flows out into the overflow passage 30 from the discharge port 52. Because the overflow port 29 and the overflow passage 30 are made larger in diameter than those in Fig. 1 in this case, the excess fuel can be made to rapidly flow out therethrough.

When the diameter of the seat portion with which the collar of the valve body 51 contacts is 4 mm and the clearance between the valve body 51 and the seat portion is 0.1 mm, for example, the cross-sectional area of the passage through which fuel flows is  $1.26 \text{ mm}^2$ . Moreover, the fuel passing through the passage can be easily and speedily discharged through the discharge port 52, the overflow port 29 and the overflow passage 30, which have cross-sectional areas larger than this.

On the other hand, in the free piston 5 shown in Fig. 1, even if the diameter of the overflow port 29 is 3 mm and the free piston 5 moves by 0.6 mm

to define an overflow part, only an area of  $0.998 \text{ mm}^2$  is obtained.

In other words, in case of the preferred embodiment of the present invention, a slight  
5 movement of the free piston 50 makes it possible to speedily discharge the excess fuel. Because the injection end is taken place at a fixed position of the free piston 50, it is easy to set the discharge port 52 so as to face to the  
10 overflow port 29.

The fuel injection pump according to the present invention is arranged such that the valve body 51 with the collar is placed inside the free piston 50 thereof, and the projected end of the  
15 valve body contacts with the stopper 7 at a maximum movement of the free piston 50, so that even when the collar is slightly separated from the seat portion, it is possible to discharge a relatively large amount of the excess fuel in the first  
20 compression chamber 4 in a short period of time. Accordingly, it is also possible to improve the accuracy in controlling the amount of the fuel injected from the second compression chamber 6. In addition, because there is an increase in the  
25 area of the free piston 50 receiving pressure

rightward around when the delivery passage 23 is  
opened, the free piston 50 is restrained from  
vibrating when the excess fuel is discharged, and  
because the pressure in a high-pressure pipe  
5 leading to an injection valve is speedily lowered  
and stabilized, it is useful for preventing undesired  
injection when no fuel is needed, i.e., the secondary  
injection or the like. Accordingly, it is possible  
to obtain such an advantageous effect as to improve  
10 the stability in injection of fuel.

WHAT I CLAIM IS:

1. A fuel injection pump for delivering liquid fuel under high pressure to cylinders of an internal combustion engine at controlled timing with the rotating operation thereof, comprising:

a housing (10);

a sleeve (42) disposed within said housing (10) and including first (11) and second (12) fuel supply passages and excess and output fuel outlets;

first and second solenoid valves (17a, 17b) for controlling the amount of fuel supplied through the first (11) and second (12) passages;

a rotor (1) rotatably received by said sleeve (42) and driven in synchronism with the rotating operation of the engine, and including,

a cylindric space formed within said rotor (1), a free piston (5) positioned in the cylindric space and defining first (4) and second (6) compression chambers therewith,

a rotary compressor mechanism connected to the first compression chamber (4) and for compressing fuel supplied to the first compression chamber (4) in timed relationship to the rotation of said rotor (1), thereby transferring the pressure through the free piston (5) to fuel filled within the second chamber (6), and

a plurality of conduits formed in said rotor (1), each of which aligns with the corresponding passage and outlets in timed relationship to the rotation of said rotor (1), thereby fuel under high pressure within the second chamber (6) is injected to the cylinders of the internal combustion engine, wherein said free piston (5) includes a valve mechanism (17a, 17b) which opens to abruptly release fuel

compressed within the first chamber (4) after the completion of injection of fuel into the cylinders.

2. A fuel injection pump claimed in claim 1,  
5 wherein the valve mechanism(17a, 17b) of said free piston (5) includes a valve body with a projection which projects in the second compression chamber (6), thereby the valve opens when the free piston (5) is pushed into the second chamber (6).

10

3. A fuel injection pump claimed in claim 2, wherein a cylindric bore is formed, within which the valve is slidably received.

15

4. A fuel injection pump claimed in claim 3, wherein the valve is inclined not to open normally.



FIG. 1

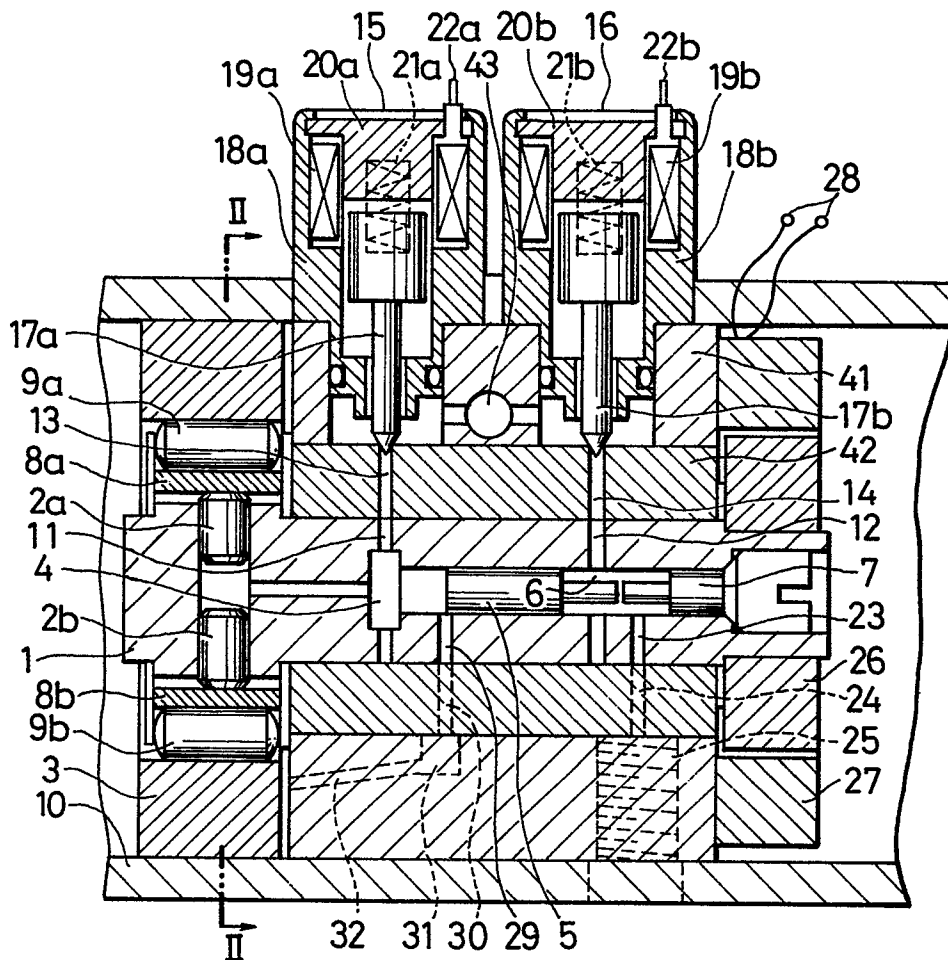
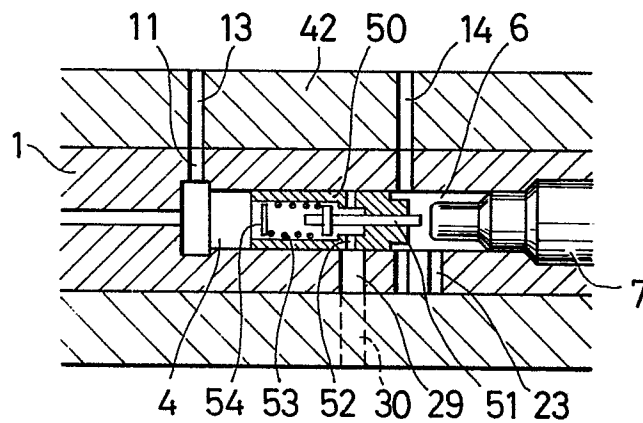
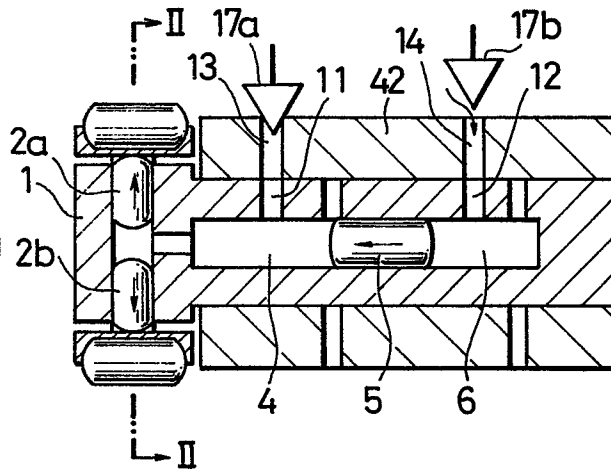


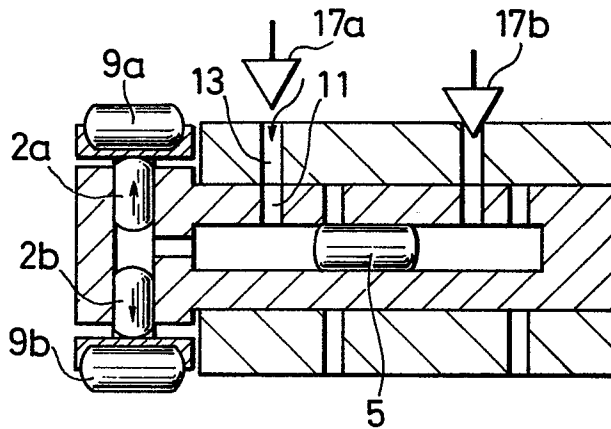
FIG. 8



**FIG. 2(b)**



**FIG. 3(b)**



**FIG. 4(b)**

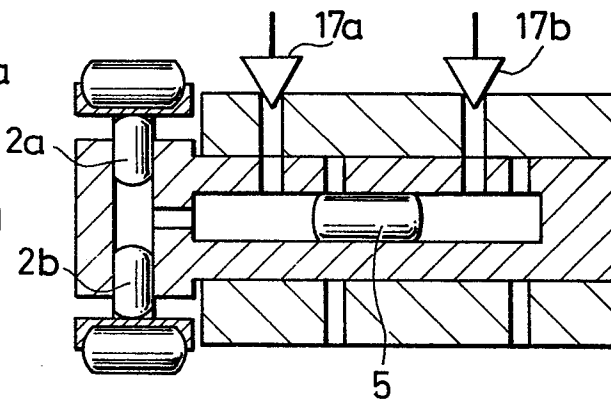


FIG. 5(a)

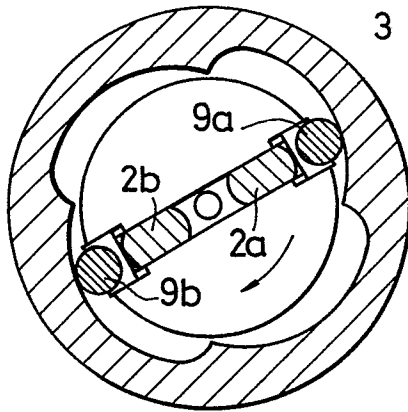


FIG. 5(b)

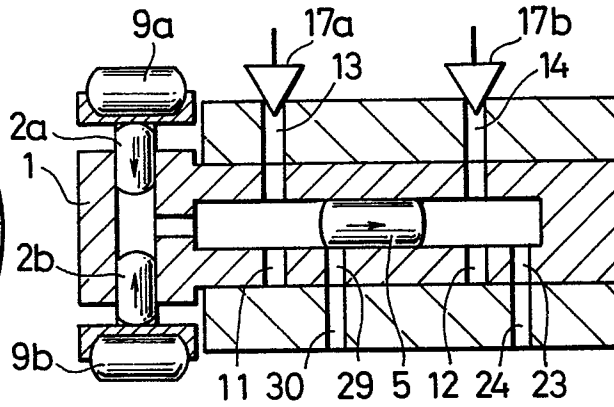


FIG. 6(a)

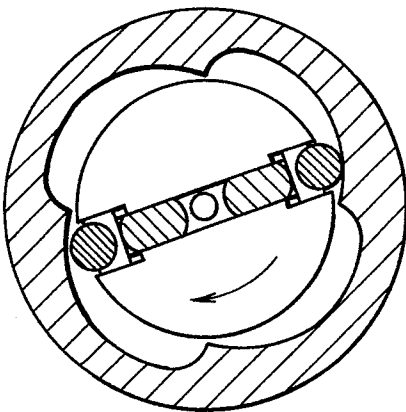


FIG. 6(b)

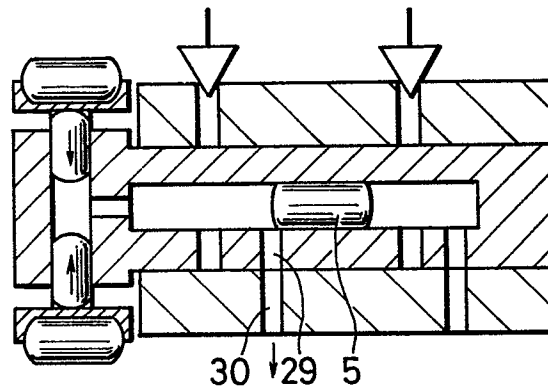


FIG. 7(a)

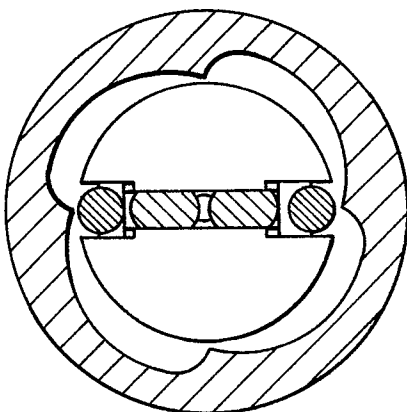


FIG. 7(b)

