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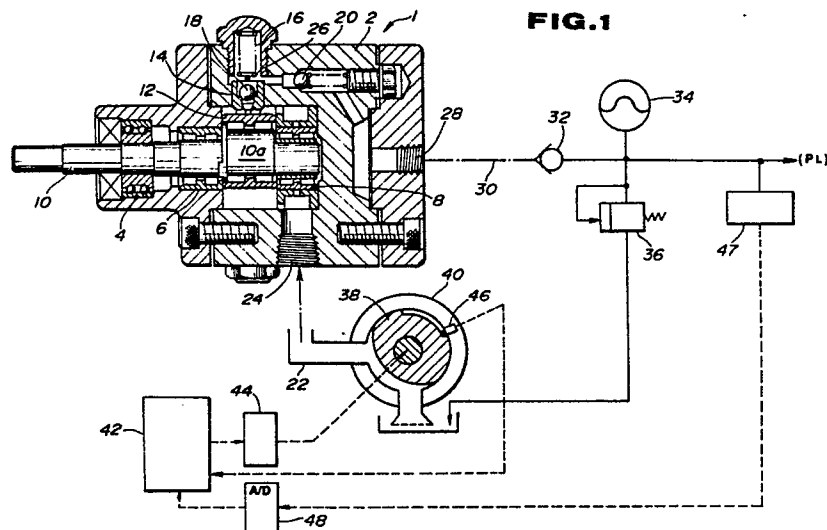
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54 **Fixed cylinder type radial piston pump with volume control apparatus.**

57 A fixed cylinder type radial piston pump with volume control apparatus is disclosed, in which volume control is possible by means of a variable aperture carrying out opening control of a suction passage. For achieving continuous volume control in a large range, the radial piston pump can provide two pump portions separated by an intermediate wall and including a gate valve in the other suction passage. Without installing the intermediate wall, it is also possible to separate the two pump portions from each other by using a suction check valve.



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FIXED CYLINDER TYPE RADIAL PISTON PUMP WITH VOLUME CONTROL APPARATUS

BACKGROUND OF THE INVENTION

1. Field of the Invention

The present invention relates to a volume control apparatus of fixed cylinder type radial piston pump.

2. Description of the Prior Art

As described in "Hydraulic Technique Handbook", p. 257 (Fig. 1 *36) and p. 259 (Fig. 1*39) published by Nikkan Kogyo Shinbunsha Inc., January 30, 1976, in Japan, there are shown two different kinds of radial piston pumps: one being of the rotating cylinder type and the other of the fixed cylinder type.

The rotating cylinder type radial piston pump is constructed such that radially reciprocable pistons are disposed in a cylinder rotated by a pump driving force and are reciprocated as being guided along an inside circumference of an eccentric cam ring to obtain a pump action, so that it is difficult to get a variable volume construction by regulating an eccentric amount of the cam ring. To obtain the rotating cylinder type radial piston pump of the variable volume construction, an eccentricity adjusting mechanism has to be further provided to the cam ring with a large diameter, causing a pump dimension and weight increase and a bad responsibility of volume control.

On the other hand, the fixed cylinder type radial piston pump is constructed such that radially reciprocable pistons are disposed in a fixed cylinder and are reciprocated by an eccentric cam rotated by a pump driving force to obtain a pump action, so that the above-mentioned problem does not arise but pump construction becomes complex to get an eccentric amount of the eccentric cam variable.

Therefore, an object of the present invention is to provide a fixed cylinder type radial piston pump in which volume control is possible without regulating the eccentric amount of the eccentric cam.

A specific object of the present invention is to provide a volume control apparatus of fixed cylinder type radial piston pump.

SUMMARY OF THE INVENTION

According to the present invention, there is provided a fixed cylinder type radial piston pump

with volume control apparatus, comprising:

a pump portion including suction and delivery systems, said pump portion carrying out a pump action by pump driving force of a pump drive shaft;

a fixed cylinder provided in said pump portion, in which a plurality of pistons are slidably disposed, said plurality of pistons being radially reciprocable in said fixed cylinder to suck a fluid from a suction passage and discharge said fluid to a delivery passage;

an eccentric cam installed on said pump drive shaft and rotated by a pump driving force of said pump drive shaft, said eccentric cam guiding said plurality of pistons slidably disposed in said fixed cylinder; and

an aperture means for carrying out opening control of said suction passage.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a longitudinal sectional view of an embodiment of a fixed cylinder type radial piston pump with volume control apparatus according to the present invention;

Fig. 2 is a flow chart showing a control program of a microcomputer;

Fig. 3 is a diagram showing an output voltage characteristic of a pressure sensor and a motor drive step number of a variable aperture;

Fig. 4 is a diagram showing a pump discharge characteristic;

Fig. 5 is a longitudinal sectional view showing another embodiment of a fixed cylinder type radial piston pump according to the present invention;

Fig. 6 is a diagram showing a pump discharge characteristic of another embodiment of Fig. 5; and

Fig. 7 is a longitudinal sectional view showing a further embodiment of a fixed cylinder type radial piston pump according to the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Referring now to Fig. 1 there is shown an embodiment of the present invention, in which a fixed cylinder type radial piston pump 1 includes a pump body 2 in which a pump drive shaft 10 is rotatably supported by bearings 4, 6 and 8. An eccentric portion 10a is installed on the pump drive shaft 10 thereby to pivotally support an eccentric cam 12. Around the eccentric cam 12, a plurality of

pistons 14 are disposed each being radially slidable in the pump body 2. Each of the pistons 14 touches an outside circumference of the eccentric cam 12 by force of a spring 16 and incorporates a suction valve 18. In series with respect to the suction valve 18, a delivery valve 20 is provided in the pump body 2.

The radial piston pump 1 thus constructed operates as follows: When the drive shaft 10 is rotated by pump driving force, the eccentric cam 12 radially reciprocates each of the pistons 14. While each of the pistons 14 strokes radially inwardly, the suction valve 18 is opened thereby to suck a fluid from a suction passage 22 and a suction port 24 into a pump chamber 26. While each of the pistons 14 strokes radially outwardly, the suction valve 18 is closed to generate a pressure in the pump chamber 26, thereby to open the delivery valve 20 and discharge the fluid from the chamber 26 to a delivery port 28 and a delivery passage 30 therethrough. A check valve 32, an accumulator 34 and a relief valve 36 are provided in the delivery passage 30. The fluid flowing in the passage 30 comes to the accumulator 34 through the check valve 32, wherein fluid pressure is increased to form a line pressure P_L for controlling a hydraulic apparatus (not shown). If the line pressure P_L is too high, the relief valve 36 is opened to prevent a pump circuit from being damaged. A variable aperture 38 is inserted in the suction passage 22 thereby to permit volume control of the pump 1. The variable aperture 38 is of the rotary type capable of controlling an opening of the suction passage 22 and its rotational position is regulated by a step motor 40. The step motor 40 opens completely the variable aperture 38 at a drive step number 0 and minimally opens it at a drive step number Max. The motor 40 is controlled through an amplifier 44 by a microcomputer 42 to which is input a signal L from a limit switch 46 which is turned on at the minimum opening of the variable aperture 38. Additionally, after converting to a digital signal by an analog-to-digital converter 48, a signal from a pressure sensor 47 for detecting the line pressure P_L is input to the computer 42. The pressure sensor 47 provides a voltage V to the line pressure P_L as shown in Fig. 3, in which P_1 and P_2 denote lower and upper limits of working line pressure and V_1 and V_2 output voltages of the sensor 47 with respect to the lower and upper limits. In Fig. 3, an opening pressure P_3 of the relief valve 36 is also indicated for reference.

Referring to Fig. 2, the microcomputer 42 performs a control program on input informations as mentioned above, thereby to carry out opening control of the suction passage 22, i.e. volume control of the pump 1 by means of the step motor 40. At step 50, upon starting the step motor 40, the

drive step number STEP of the motor 40 is initialized and the variable aperture 38 completely opens the suction passage 22 to set the pump 1 in the maximum discharge (maximum capacity). Thus, upon starting the motor 40, the maximum amount of fluid is discharged in the passage 30, allowing rapid increase of the line pressure P_L . At step 51, an output voltage V of the pressure sensor 47 is read to detect a current value of the line pressure P_L . At step 52, an aimed drive step number STEP (A) of the step motor 40 is looked up from a table data corresponding to Fig. 3 obtained from the current value of the line pressure P_L . The table data of the aimed drive step number STEP (A) is such that: If the line pressure P_L is less than the lower limit P_1 , the variable aperture 38 is completely opened to maximize the pump discharge; if the line pressure P_L is more than the upper limit P_2 , the aperture 38 is minimally opened to minimize the pump discharge; and if the line pressure P_L falls in a practical range from P_1 to P_2 , the aperture 38 is set to a predetermined opening to appropriately control the pump discharge, thereby for keeping the line pressure P_L in the practical range. At step 53, if it is judged that the limit switch 46 is turned on, the program proceeds to step 54 at which the step number STEP is set to the maximum STEP (Max) thereby to avoid integrating an error of the step number STEP. At step 55, the current step number STEP is compared with the aimed step number STEP (A). If both are of the same value, the program proceeds to step 56 at which a signal for driving the step motor 40 is provided to keep the variable aperture 38 at a current opening. If the current step number STEP is less than the aimed step number STEP (A) or STEP is more than STEP (A), the program proceeds to step 57 or 58 at which the step number STEP is increased or decreased by one to set it to the aimed step number STEP (A). And at step 56, a signal for driving the step motor 40 is provided as described above.

The step motor 40 may carry out opening control of the variable aperture 38 to keep the line pressure P_L in the practical range from P_1 to P_2 and allows an appropriate selection of a pump capacity resulting in an energy-saving. In this connection, when the variable aperture 38 is completely opened, the pump discharge is indicated by a fully-drawn line in Fig. 4. As the aperture 38 is less opened, the discharge is reduced as indicated by an one-dot-chain line in Fig. 4 because of decreased opening period of time of the suction valve 18.

Referring to Fig. 5, there is shown another embodiment of the present invention, in which another eccentric portion 10b is installed on the pump drive shaft 10 to rotatably support an eccentric cam

12', and a pump portion comprising a piston 14', a spring 16', a suction valve 18' and a delivery valve 20' is added to include two pump portions displaced by a half phase each other. The two pump portions have a delivery port 28 and a delivery passage 30 in common and two suction systems separated by an intermediate wall 60. One suction system includes, as described above, the suction passage 22 with the variable aperture 38 and the suction port 24 and another a suction passage 22' and a suction port 24'. As aperture means, a gate valve 62 is provided in the suction passage 22'.

With such construction, if the gate valve 62 is kept opened, the discharge of a pump portion related to the valve 62 is increased, e.g. the maximum pump discharge can be increased from a characteristic value indicated by a fully-drawn line in Fig. 6 equivalent to that in Fig. 4 to a characteristic value indicated by a one-dot-chain line in Fig. 6. Additionally, it can be continuously decreased up to a characteristic value indicated by a three-dot-chain line by carrying out opening control of the variable aperture 38 with the gate valve 62 opened. On the other hand, pump discharge characteristic similar to Fig. 4 can be obtained by carrying out opening control of the variable aperture 38 with the gate valve 62 closed. That is, the pump discharge also can be reduced from a characteristic value indicated by the fully-drawn line to that indicated by a two-dot-chain line in Fig. 6 by performing opening control of the variable aperture 38 with the gate valve 62 closed. After all, the pump discharge is capable of being continuously controlled from the characteristic value indicated by the one-dot-chain line to that indicated by the two-dot-chain line so that control range is greatly enlarged.

If the suction system related to a suction port 24' is associated with a pump chamber 26' through a suction check valve 64 as shown in Fig. 7, suction systems of two pump portions can be separated without the intermediate wall 60 as shown in Fig. 5, resulting in reduction of the total length of the pump.

Claims

1. A fixed cylinder type radial piston pump with volume control apparatus, comprising:
a pump portion including suction and delivery systems, said pump portion carrying out a pump action by pump driving force of a pump drive shaft;
a fixed cylinder provided in said pump portion, in which a plurality of pistons are slidably disposed, said plurality of pistons being radially reciprocable in said fixed cylinder to suck a fluid from a suction passage and discharge said fluid to a delivery

passage;
an eccentric cam installed on said pump drive shaft and rotated by a pump driving force of said pump drive shaft, said eccentric cam guiding said plurality of pistons slidably disposed in said fixed cylinder; and
an aperture means for carrying out opening control of said suction passage.

2. A fixed cylinder type radial piston pump with volume control apparatus as defined in claim 1, wherein there provide another pump portion and another eccentric cam.

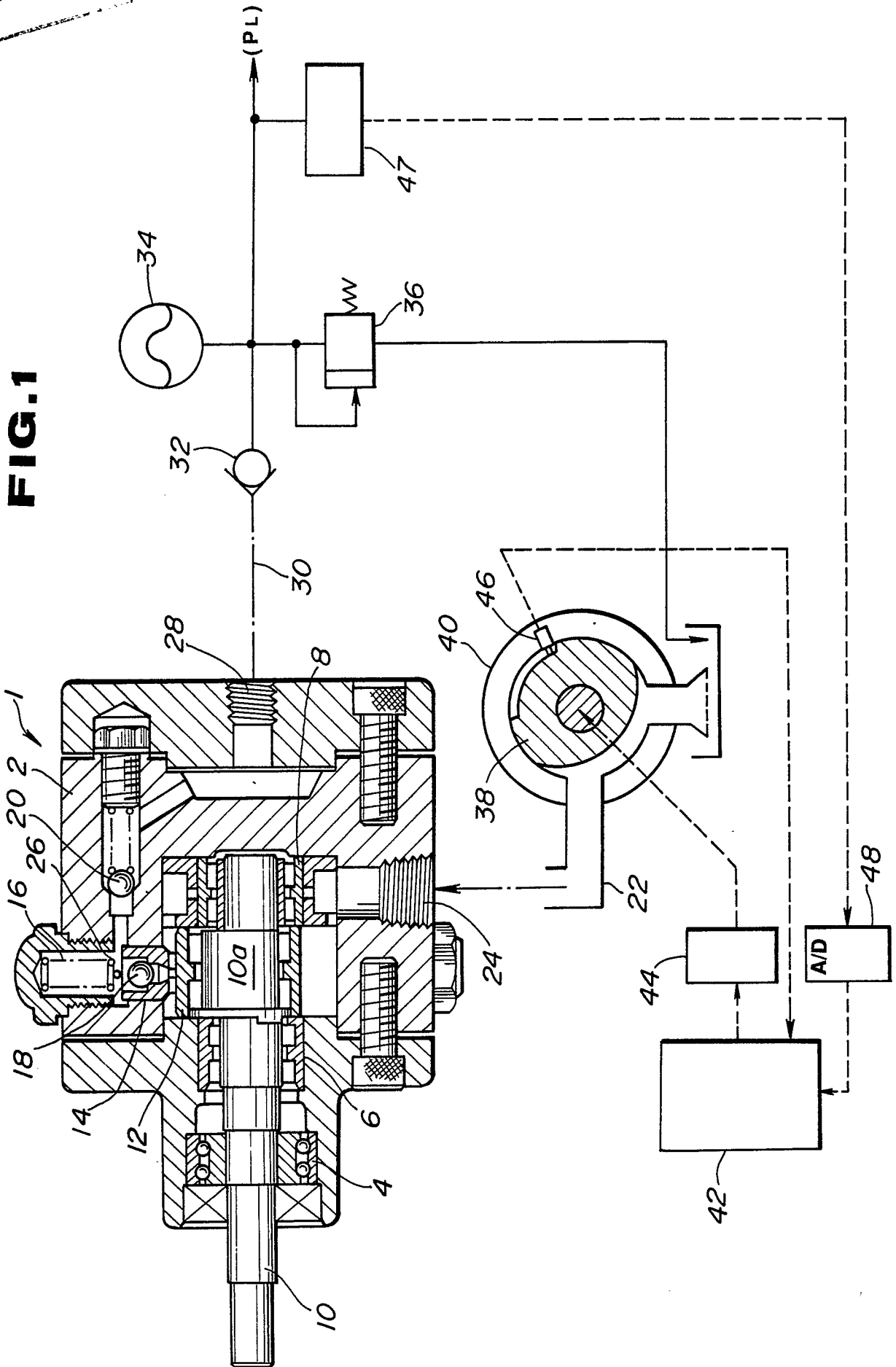
3. A fixed cylinder type radial piston pump with volume control apparatus as defined in claim 2, wherein an intermediate wall means is disposed for forming the suction system of said another pump portion.

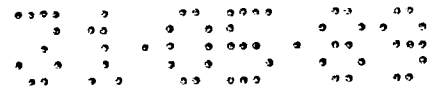
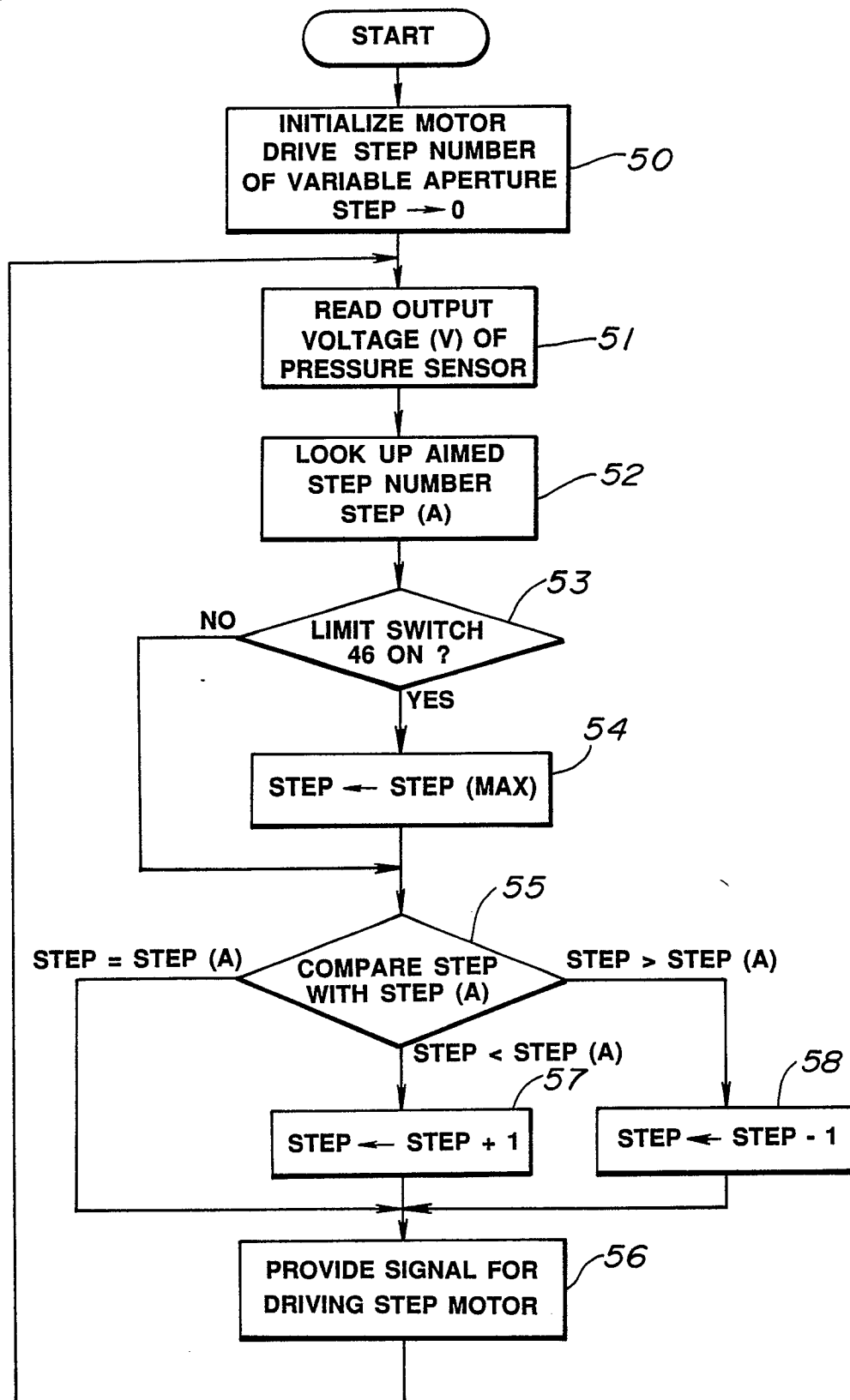
4. A fixed cylinder type radial piston pump with volume control apparatus as defined in claim 2, wherein the aperture means disposed in the suction system of said another pump portion is a gate valve.

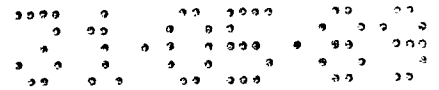
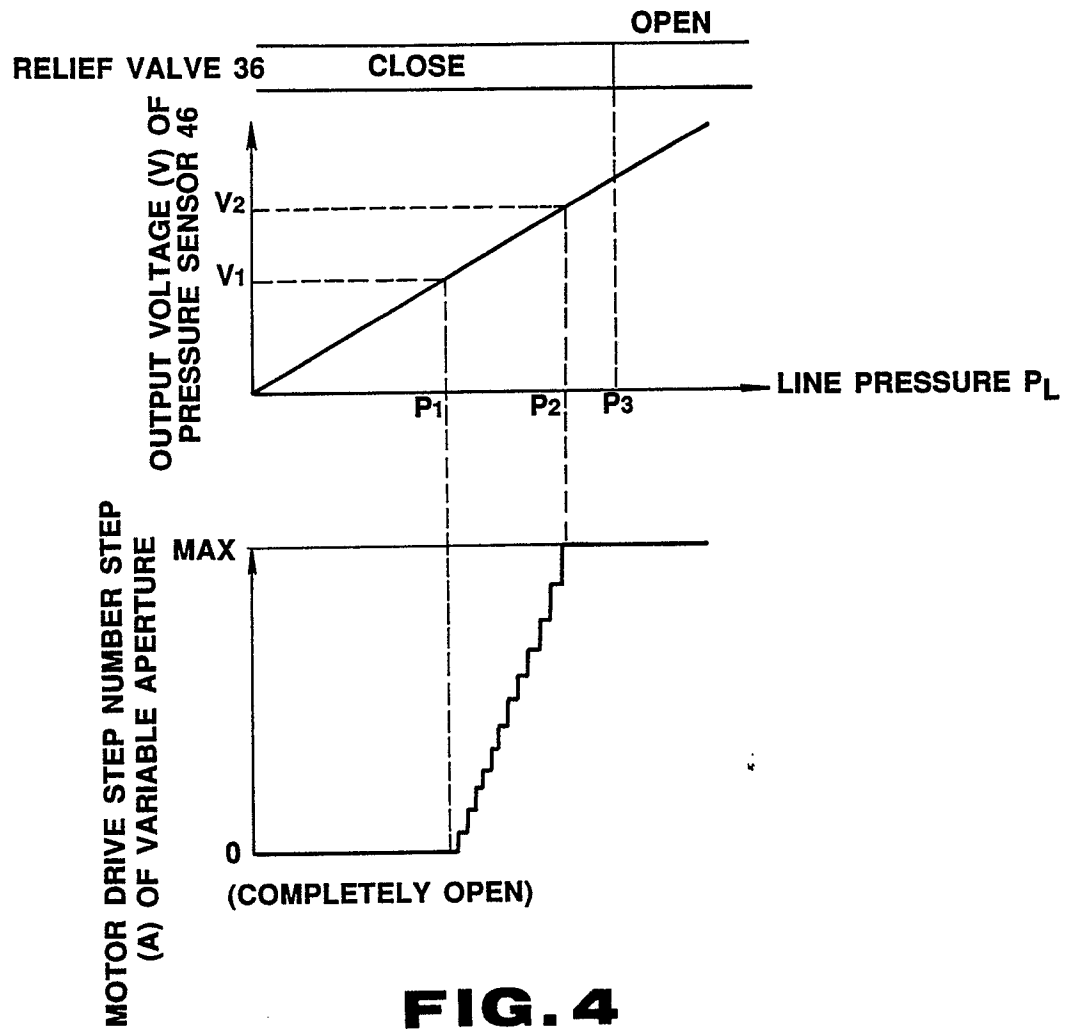
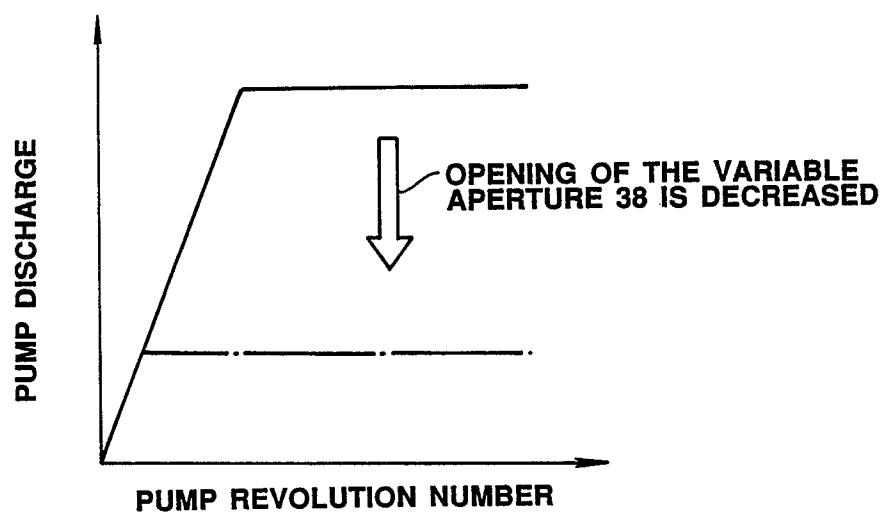
5. A fixed cylinder type radial piston pump with volume control apparatus as defined in claim 2, wherein the aperture means disposed in the suction system of said another pump portion is a suction check valve.

6. A fixed cylinder type radial piston pump with volume control apparatus as defined in claim 1, wherein the aperture means is of the rotary type.

FIG.1



**FIG. 2**

**FIG. 3****FIG. 4**

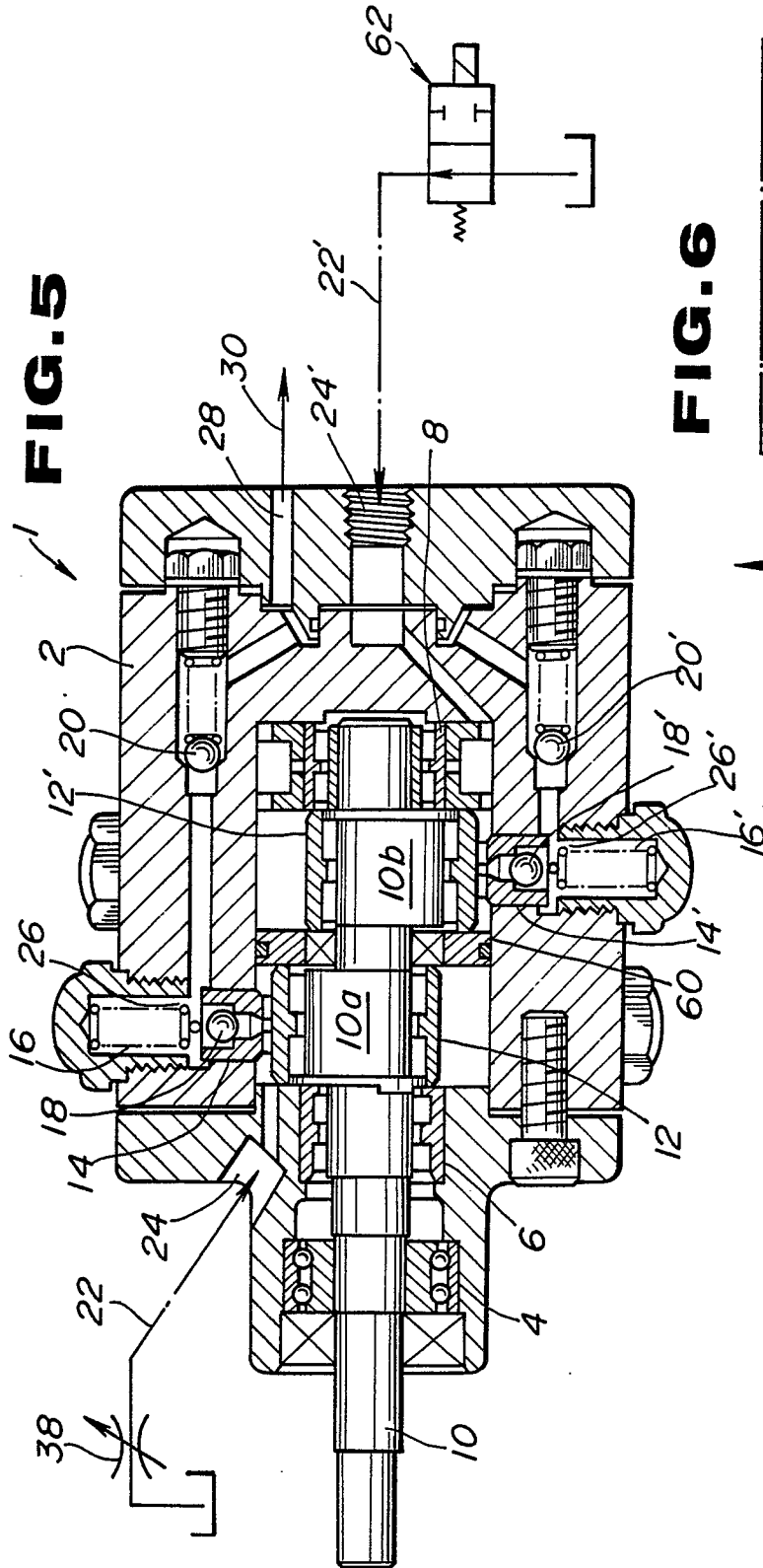


FIG. 5

FIG. 6

