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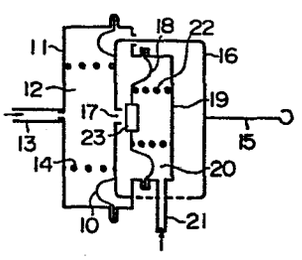
(54) Pressure servomotor and throttle valve opening controller making use of pressure servomotor apparatus.

(57) A pressure servomotor has a driving diaphragm for driving an operation shaft connected to a load. The position of the driving diaphragm is determined by a control position determining means which in turn operates a response to a control signal. When the driving diaphragm has been deflected to the control position determined by the control position determining means, the driving pressure applied to the driving diaphragm is weakened and, when the driving diaphragm is moved apart from the control position, the driving pressure applied to the driving diaphragm is increased. In consequence, the driving diaphragm is set at the control position determined by said control position determining means.

FIG. 1



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PRESSURE SERVOMOTOR AND THROTTLE VALVE OPENING CONTROLLER MAKING USE OF PRESSURE SERVOMOTOR APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates to a pressure servomotor device capable of performing a precise position control, as well as to a throttle valve opening degree control device making use of this pressure servomotor.

United States Patent Specification No. 3,381,771 discloses a typical conventional servomotor, in which a controlling negative pressure is introduced into a negative pressure chamber formed by a diaphragm and a cover so that the diaphragm is deflected by the negative pressure to control the position of an operation shaft fixed to the diaphragm. Namely, the position control is effected by a balance between the load connected to the operation shaft and the load generated by the diaphragm by the action of the control negative pressure introduced into the negative pressure chamber.

Such conventional pressure servomotor, however, gives rise to a problem that accurate position control is failed when there is a difference in the level of load between forward and backward strokes of the diaphragm. Such difference is experienced, for example, in the operation of a throttle valve shaft in carburetors for automotive engines. Namely, there is a

large difference of torque between the opening rotation and closing rotation of the throttle valve shaft. Therefore, when the negative pressure actuated type servomotor is used for the position control of the throttle valve shaft, the negative pressure is not in proportion to the stroke of the diaphragm. Namely, a curve representing the relationship between the negative pressure and the stroke shows a large hysteresis. Thus, this type of servomotor suffers from a serious drawback of inaccuracy in the position control, although it can easily provide a large driving power.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the invention to provide a pressure servomotor device capable of performing a precise position control even if the load level is changed.

To this end, according to the invention, there is provided a pressure servomotor comprising: a driving diaphragm for driving an operation shaft; a driving pressure chamber defined by the driving diaphragm and a cover; a pressure passage through which a driving pressure is communicated to a pressure source so that a driving pressure is introduced into the driving pressure chamber; a control position determining means for determining the position of the operation shaft; and a pressure regulating means adapted to weaken the pressure

in the driving pressure chamber by a cooperation of the control position determining means and the driving diaphragm when the driving diaphragm is deflected to a position determined by the control position determining means.

These and other objects, features and advantages of the invention will become clear from the following description of the preferred embodiment taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a schematic sectional view of a first embodiment of the pressure servomotor in accordance with the invention;

Fig. 2 is a schematic sectional view of a second embodiment of the pressure servomotor in accordance with the invention;

Fig. 3 is a sectional view of a modification of the valve device;

Fig. 4 is a schematic sectional view of a third embodiment of the pressure servomotor in accordance with the invention;

Fig. 5 is a sectional view of a fourth embodiment of the pressure servomotor in accordance with the invention;

Fig. 6 is a diagramatic illustration of a pressure servomotor of the invention applied to the

control of a throttle valve of an internal combustion engine;

Fig. 7 is a partial sectional view of a fifth embodiment of the pressure servomotor in accordance with the invention;

Fig. 8 is a diagramatic illustration of a sixth embodiment of the pressure servomotor of the invention; and

Fig. 9 shows a modification of the valve portion as shown in Fig. 7.

DESCRIPTION OF THE PREFERRED EMBODIMENT

An embodiment of a pressure servomotor in accordance with the invention will be explained hereinunder with reference to the accompanying drawings.

Fig. 1 schematically shows in section a negative pressure actuated type servomotor which is an embodiment of a pressure servomotor in accordance with the invention. The driving diaphragm mechanism has a driving negative pressure chamber 12 defined by a driving diaphragm 10 and a cover 11, into which driving negative pressure is introduced through a negative pressure introduction pipe 13 provided on the cover 11. The driving negative pressure chamber 12 accomodates a compression spring 14 which acts between the inner surfaces of the driving diaphragm 10 and the cover 11. A frame 16 is secured to the outer surface of the driving

diaphragm 10. An operation shaft 15 is connected at its one end to the frame 16 and at its other end to the load to be actuated. The frame 16 is movable reciprocatingly as a unit with the diaphragm 10. In operation, as negative pressure is introduced into the driving nagative pressure chamber 12, the driving diaphragm is deflected in accordance with the level of the negative pressure thereby to reciprocatingly move the frame 16 and, hence, the operation shaft 15.

In this driving diaphragm mechanism, a leak passage 17 is formed at the center of the driving diaphragm 10 to provide a communication between the driving negative pressure chamber 12 and the atmosphere. The leak passage 17 is adapted to be opened and closed by a signal diaphragm mechanism serving as means for determining the control position. The signal diaphragm mechanism incorporates a signal diaphragm 18 opposing to the driving diaphragm 10. The signal diaphragm 18 cooperates with a cover 19 to define a signal negative pressure chamber 20 therebetween. The cover 19 of the signal diaphragm mechanism is integrally fixed to the cover 11 of the driving diaphragm mechanism. The signal diaphragm 18 is adapted to be actuated by a signal negative pressure introduced through a signal negative pressure introduction pipe 21 provided on the cover 19. The signal negative pressure chamber 20 accomodates a compression spring 22 acting between the inner surfaces

of the signal diaphragm 18 and a cover 19 so that the position of the signal diaphragm 18 is set by the balance between the force produced by the compression spring 22 and the force produced by the signal negative pressure.

The signal diaphragm 18 opposing to the driving diaphragm 10 is provided with a pressure regulating means constituted by a valve body 23 opposing to the leak passage 17 and adapted to open and close the latter in accordance with the operation of the signal diaphragm 18.

The driving negative pressure introduced into the driving negative pressure chamber 12 is maintained at the lowest at the level which provides a force capable of overcoming the load applied to the operation shaft 15. At the same time, a negative pressure of a level necessary for balancingly holding the signal diaphragm 18 at the desired position is introduced to the signal negative pressure chamber 20. A load to be controlled is imposed on the operation shaft 15.

The negative pressure actuated servomotor having the described construction operates in a manner explained hereinunder.

Namely, the servomotor operates in the following manner from the equilibrium state in response to a change in the load or to a change in the signal negative pressure serving as the control signal.

(1) As the load is increased, the driving diaphragm 10 is moved to the right as viewed in Fig. 1, so that the leak passage 17 and the valve body 23 are spaced away from to reduce an amount of air flowing into the driving negative pressure chamber 12 to raise a level of negative pressure in the negative pressure driving chamber 12. Consequently, the driving diaphragm 10 is pulled to the left as viewed in Fig. 1 against the force of the compression spring 14 to be held at the set position.

(2) To the contrary, as the load is decreased, the driving diaphragm 10 is moved to the left as viewed in Fig. 1, so that the leak passage 17 and the valve body 23 are spaced away from each other to increase an amount of air into the driving negative pressure chamber 12 to reduce the level of negative pressure in the latter. Consequently, the driving diaphragm 10 is forced back to the right as viewed in the drawing by the force exerted by the compression spring 14.

(3) Subsequently, as the level of the signal negative pressure is lowered, the signal diaphragm 18 is moved to the left as viewed in Fig. 1, so that the leak passage 17 and the valve member 23 come near to each other to reduce an amount of air flowing into the driving negative pressure chamber 12 ot increase the negative pressure in the latter. Consequently, the driving diaphragm 10 is moved to the left as viewed in

Fig. 1, against the force of the compression spring 14.

(4) On the other hand, as the signal negative pressure is increased, the signal diaphragm 18 is moved to the right as viewed in Fig. 1 to pull apart the leak passage 17 and the valve member 23 thereby to decrease the negative pressure in the driving negative pressure chamber 12. Consequently, the driving diaphragm 10 is moved to the right as viewed in Fig. 1 by the force of the compression spring 14 to be held at the set position.

Thus, in the described embodiment of the invention, the arrangement is such that the driving diaphragm 10 is moved in the direction for negating disturbance or noise if any. Therefore, the driving diaphragm 10 is always held at the predetermined position where the balance of force is obtained and is made to follow up the movement of the signal diaphragm 18. It is, therefore, possible to move the object exactly to the aimed position without being affected by the change in the load, by a suitable control of the signal negative pressure.

Fig. 2 shows a second embodiment of the invention in which a push rod 24 extending through the driving negative pressure chamber 12 and the cover 11 is used in place of the operation shaft 15 and the frame 16 used in the first embodiment, so as to produce a thrust force as the driving power. To this end, a seal 25 is provided

between the cover 11 and the push rod 24 and a bearing 26 is used to hold the portion of the push rod 24 extending outwardly of the cover 11. This embodiment is adapted for use particularly in such a case the installation space for the servomotor is limited, because the driving power is derived as a thrust force.

In the first and second embodiments described hereinbefore, there is a possibility that a stable parallel relationship can not be established between the axis of the leak passage 17 and the axis of the valve member 23 for openig and closing the latter. To avoid this problem, it is advisable to attach a needle valve 27 to the driving diaphragm 10 and to hold the needle valve 27 in contact with the valve body 23 so that the leak passage 17 is opened and closed by the needle valve 27.

Fig. 4 shows a negative pressure actuated type servomotor as a third embodiment of the invention in which the signal diaphragm mechanism is mounted on the outer surface of the cover 11 of the driving diaphragm mechanism, and a valve device is separately mounted on the driving diaphragm 10. A push rod 28 attached to the signal diaphragm 18 is movable through the cover 11 into contact with the valve body 23. The valve device is provided with a valve spring 29 which biases the valve body 23 so as to normally close the leak passage 17. This embodiment is adantageous in that the signal

diaphragm mechanism serving as an actuator is extremely easily mounted.

Fig. 5 shows a fourth embodiment of the invention in which a valve device similar to that in the third embodiment is attached to the signal diaphragm 18 and the operation shaft 15 attached to the driving diaphragm 10 serves also as a rod for opening and closing the valve body 23 of the valve device. To this end, a valve mounting sleeve 30 extending through the cover 11 of the driving diaphragm mechanism is secured to the signal diaphragm 18, and a vent hole 31 for communication with the exterior is formed in the valve mounting sleeve 30. This embodiment offers an advantage in prevention of contamination by foreign matters introduced from the outside.

Fig. 6 shows a negative pressure actuated servomotor embodying the present invention, applied to a system for controlling a throttle valve 34 of an internal combustion engine. In this system, the intake negative pressure available in the intake pipe 35 is utilized as the driving negative pressure. On the other hand, a negative pressure serving as a control signal is produced by means of a duty control type solenoid valve 33 from a constant pressure which is obtained through a constant pressure valve 32 from the intake valve. In this application, it is easy to form a system which can ensure an accurate control of the engine speed

regardless of a change in the load.

In the embodiments described hereinbefore, a signal diaphragm mechanism is used as the means for determining the control position. This, however, is not exclusive and the same advantage is obtained when other type of actuator, such as a pulse motor, D.C. motor or the like is used in place of the signal diaphragm mechanism.

In the first to fourth embodiments explained hereinbefore, the position of the driving diaphragm is determined by relieving the driving negative pressure to the atmosphere. An explanation will be made hreinunder as to another embodiment in which the driving negative pressure itself is controlled to vary the force generated by the driving diaphragm.

Referring to Fig. 7, a fifth embodiment of the pressure servomotor in accordance with the invention has a driving diaphragm 10, cover 11, compression spring 14, driving negative pressure chamber 12, operation shaft 15, leak passage 17, valve body 23 and a valve spring all of which are identical to those shown in Fig. 4. A reference numeral 36 designates a housing of a pulse motor 37 which is fixed to the rear side of the cover 11, while numerals 38 and 39 designate feed coils of a pulse motor 37. Ball bearings 40 and 41 are mounted on the housing 36 and rotatably carries a shaft 42 carrying a permanent magnet 43. A rod 44 is

threadedly engaged by the shaft 43. A rod guide 45 as a part of the housing 36 fits in a bore formed in the rod 44 so as to permit the latter to move in the axial direction but not to rotate. Thus, with the arrangement, the rod 44 is moved in the axial direction as the shaft 42 is rotated. A reference numeral 46 designates a negative pressure pipe for introducing a driving negative pressure, while numeral 47 denotes a passage for introducing the negative pressure to the driving negative pressure chamber 12. A reference numeral 48 denotes a leak orifice which allows the negative pressure in the actuation negative pressure chamber to leak to the atmosphere.

In operation, a negative pressure of level sufficient to pull the load on the operation shaft is applied to the negative pressure pipe 46, so that the negative pressure in the driving negative pressure chamber 12 is increased to deflect the diaphragm 10 to the left. In consequence, the diaphragm 10 is moved to the left so that the valve body 23 comes into contact with the opening in the rod 44 to cut off the negative pressure. As a result, the negative pressure level in the driving negative pressure chamber 12 is lowered by a small amount of air coming through the leak orifice 48. The reduction of negative pressure in the driving negative pressure chamber 12 in turn causes the diaphragm 10 to be moved to the right by the force of the compression

spring 14 so that the valve body 23 is moved away from the opening of the rod 44 to raise again the level of negative pressure in the driving negative pressure chamber 12. As this operation is repeated, the diaphragm 10 remains in the close proximity of the opening in the rod 44. The same operation is made also in response to an increase or decrease of the load imposed on the operation shaft, as well as to a change in the level of the negative pressure applied to the negative pressure pipe 46, although the distance between the valve body 23 and the rod 44 is changed slightly. As the pulse motor 37 is operated in accordance with a control signal, the rod 44 is moved to the left and right to cause a change in the distance between the valve member 23 and the opening of the rod 44, so that the position of the diaphragm 10 is changed as if the valve body 23 follows up the opening of the rod 44, due to the principle as explained hereinbefore. As will be understood from the foregoing description, according to this embodiment, it is possible to accurately move the object without being influenced by turbulence or noise such as a change in the load. Needless to say, a pulse motor having a very small capacity can satisfactorily operate in this embodiment.

Fig. 8 shows a sixth embodiment of the invention, which is materially identical to the embodiment shown in Fig. 7 except that a negative pressure type

actuator having a diaphragm 49 and a control negative pressure chamber 50 is used in place of the pulse motor as the actuator for producing the position signal, that the position of the actuator with respect to the diaphragm 10 is reversed and that the actuating power is derived as a thrust force instead of the pulling force. As the signal diaphragm 49 similar to that in Fig. 4 is moved to the left, it pushes the rod end 52 of the needle valve 51 so that a valve seat orifice 53 and a needle valve 51 are moved apart from each other to permit the driving negative pressure to be introduced into the driving negative pressure chamber 12 through the negative pressure pipe 46. As a result, the diaphragm 10 also is moved to the left.

In this state, the needle valve 51 is held in contact with the valve seat orifice 53 so that the negative pressure level in the driving negative pressure chamber 12 is lowered by the atmospheric air introduced through the leak orifice 48. In consequence, the valve seat orifice 53 is moved away from the needle valve 51 to increase again the negative pressure level in the driving negative pressure chamber 12. This operation is repeated to hold the diaphragm 10 at the predetermined position.

In the embodiment shown in Fig. 7, the reduction of the negative pressure level in the driving negative pressure chamber 12 is caused by the air flowing

only through the leak orifice 48. A higher response speed of the actuator, however, can be obtained by providing the driving diaphragm 10 with a second leak orifice 54 to increase the rate of drop of the negative pressure in the negative pressure chamber 12 as in the modification shown in Fig. 9.

Although the invention has been described through specific terms, it is to be noted here that the described embodiments are not exclusive and various changes and modifications may be imparted thereto without departing from the scope of the invention which is limited solely by the appended claims.

WHAT IS CLAIMED IS:

1. A pressure servomotor comprising:

(a) a driving diaphragm for driving an operation shaft;

(b) a driving pressure chamber defined by said driving diaphragm and a cover;

(c) a pressure passage through which a driving pressure is connected to a pressure source so that a driving pressure is introduced into said driving pressure chamber;

(d) a control position determining means for determining the position of said operation shaft; and

(e) a pressure regulating means adapted to weaken the pressure in said driving pressure chamber through a cooperation between the control position determining means and said driving diaphragm when said driving diaphragm is deflected to a position determined by said control position determining means.

2. A negative pressure servomotor comprising:

(a) a driving diaphragm for driving an operation shaft;

(b) a driving negative pressure chamber defined by said driving diaphragm and a cover;

(c) a negative pressure passage through which a driving negative pressure is communicated to a negative pressure source so that a driving negative pressure is introduced into said driving negative pressure chamber;

(d) a control position determining means for determining the position of said operation shaft; and

(e) a pressure regulating means adapted to introduce the atmospheric pressure into said driving negative pressure chamber by the operation of said control position determining means when said driving diaphragm is deflected to a position determined by said control position determining means.

3. A pressure servomotor according to claim 2, wherein said control position determining means is a diaphragm type position determining means adapted to be actuated by a control negative pressure signal and to take a position determined by the level of said control negative pressure signal.

4. A pressure servomotor according to claim 3, wherein said pressure regulating means includes a valve body adapted to open and close a leak port formed in said driving diaphragm and provide a communication between said driving negative pressure chamber and the atmosphere, and a rod fixed to said diaphragm type position determining means for moving said valve body to open and close said leak port.

5. A pressure servomotor according to claim 3, wherein said pressure regulating means includes a valve body adapted to open and close a leak port formed in said diaphragm type position determining means and provide a communication between said driving negative pressure

chamber and the atmosphere, and a rod fixed to said driving diaphragm for moving said valve body to open and close said leak port.

6. A pressure servomotor according to claim 3, wherein said pressure regulating means includes a leak port formed in said driving diaphragm for providing a communication between said driving negative pressure chamber and the atmosphere, and a valve body provided on said diaphragm type position determining means for opening and closing said leak port.

7. A negative pressure servomotor comprising:

(a) a driving diaphragm for driving an operation shaft;

(b) a driving negative pressure chamber defined by said driving diaphragm and a cover and provided therein with a leak port communicating with the atmosphere;

(c) a negative pressure passage through which a driving negative pressure is communicated to a negative pressure source so that a driving negative pressure is introduced into said driving negative pressure chamber;

(d) a control position determining means for determining the position of said operation shaft; and

(e) a pressure regulating means adapted to cut off the driving negative presure introduced into said driving negative pressure chamber by the operation of said control position determining means when said driving diaphragm is deflected to a position determined

by said control position determining means.

8. A pressure servomotor according to claim 7, wherein said control position determining means is an electric position determining means adapted to be operated by a control electric signal and to be held at a position determined by the level of the electric signal.

9. A pressure servomotor according to claim 8, wherein said pressure regulating means includes a rod adapted to be actuated by said electric position determining means and having said negative pressure passage formed therein, and a valve body provided on said driving diaphragm and adapted to open and close said negative pressure passage.

10. A pressure servomotor according to claim 7, wherein said control position determining means is a diaphragm type position determining means adapted to be operated by said control negative pressure signal and to take a position determined by the level of said control negative pressure signal.

11. A pressure servomotor according to claim 10, wherein said pressure regulating means includes a valve seat orifice provided in said driving diaphragm and providing a communication between said driving negative pressure chamber and said negative pressure passage, and a valve body adapted to be actuated by said diaphragm type position determining means so as to open and close

said valve seat orifice.

12. A throttle valve opening control means making use of a pressure servomotor comprising:

(a) A throttle valve disposed in an intake pipe;

(b) a driving diaphragm drivingly connected through an operation shaft to said throttle valve to drive said throttle valve;

(c) a driving negative pressure chamber defined by said driving diaphragm and a cover;

(d) a negative pressure passage providing a communication between said driving negative pressure chamber and a portion of said intake pipe downstream from said throttle valve so as to introduce a driving negative pressure into said driving negative pressure chamber;

(e) a control position determining means for determining the position of said throttle valve; and

(f) a pressure regulating means adapted to weaken the negative pressure in said driving negative pressure chamber by a cooperation between said control position determining means and said driving diaphragm when said driving diaphragm is deflected to the position determined by said control position determining means.

13. A throttle valve opening control device making use of a pressure servomotor according to claim 12, wherein said control position determining means includes a constant pressure valve for changing the negative

pressure in said intake pipe into a constant pressure, a duty control valve for converting said constant pressure into a control negative pressure signal, and a diaphragm type position determining means adapted to take a position determined by said control signal.

14. A throttle opening control device making use of a pressure servomotor according to claim 13, wherein said pressure regulating means includes a leak port providing a communication between said driving negative pressure chamber and the atmosphere, and a valve body adapted to be operated by said diaphragm type position determining means so as to open and close said leak port.

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FIG. 1

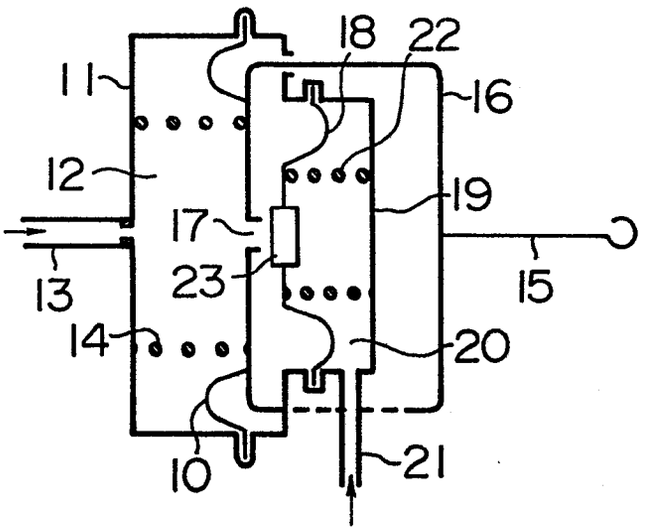
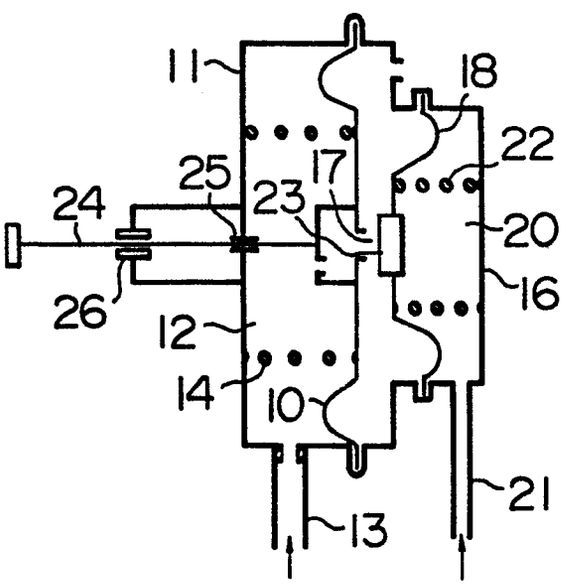


FIG. 2



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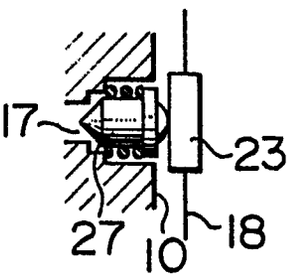

FIG. 4

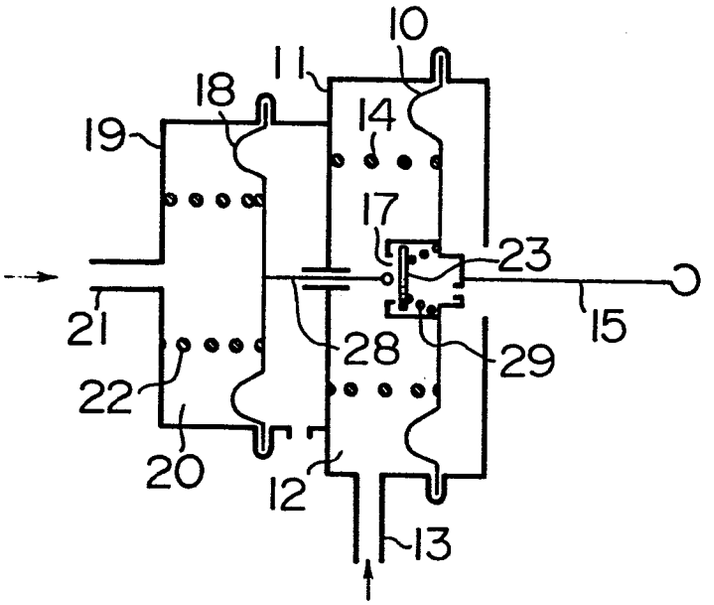
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FIG. 5

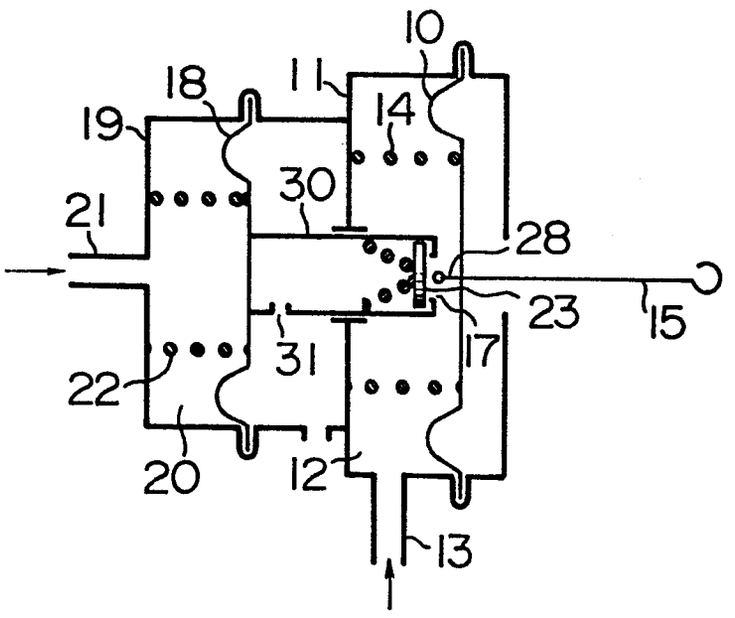
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FIG. 6

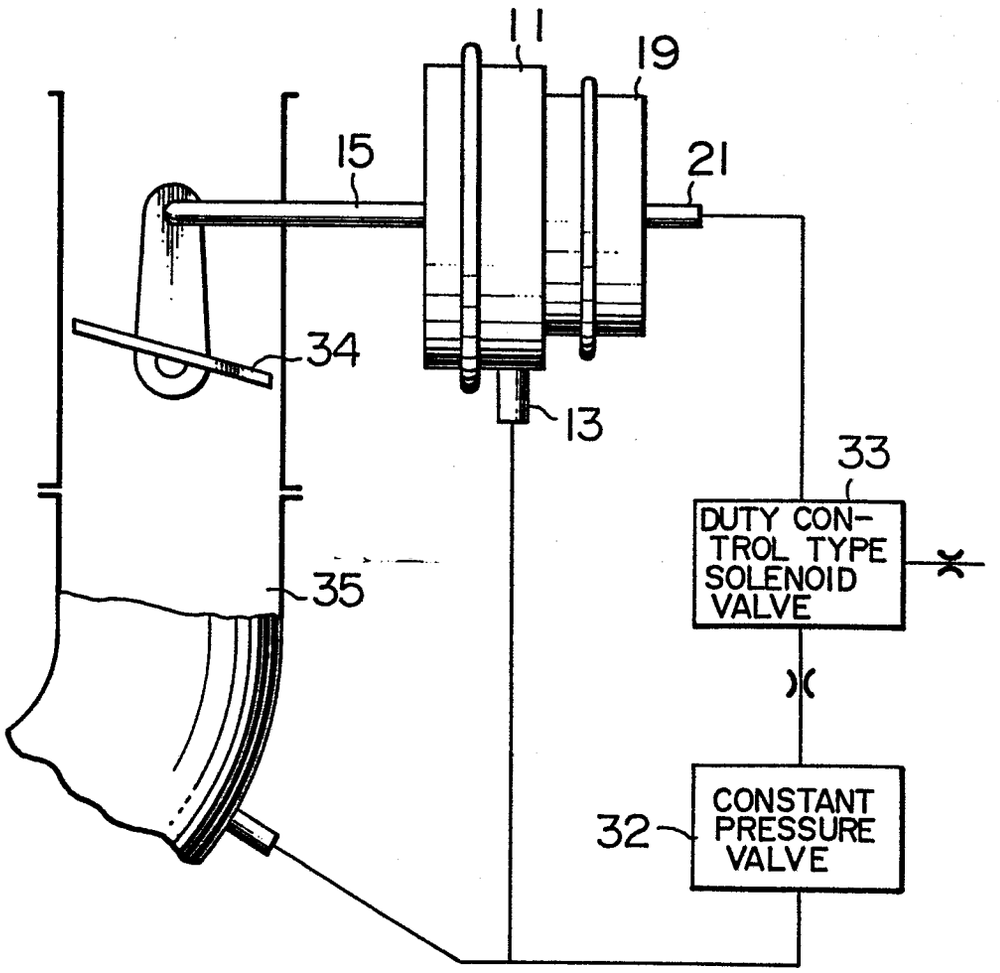
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FIG. 7

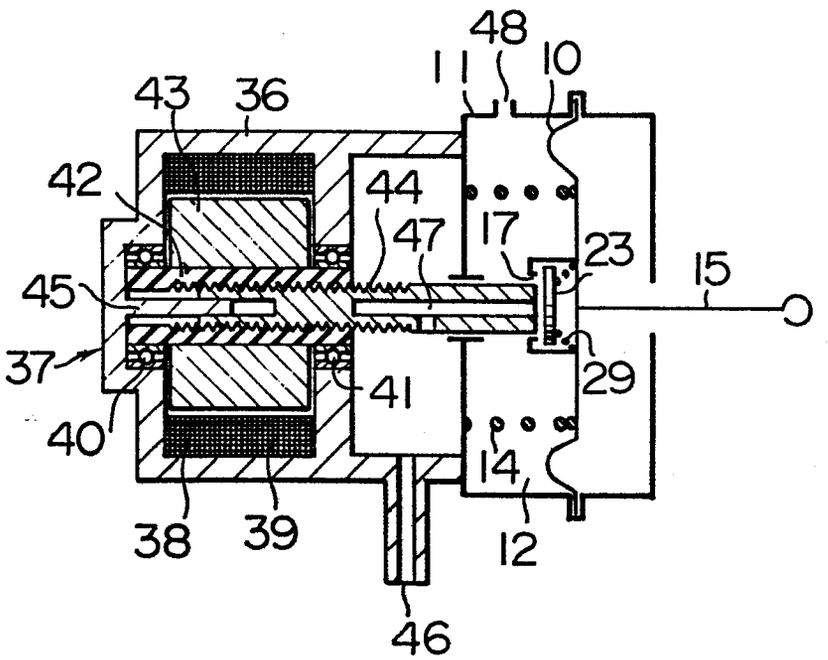

FIG. 8

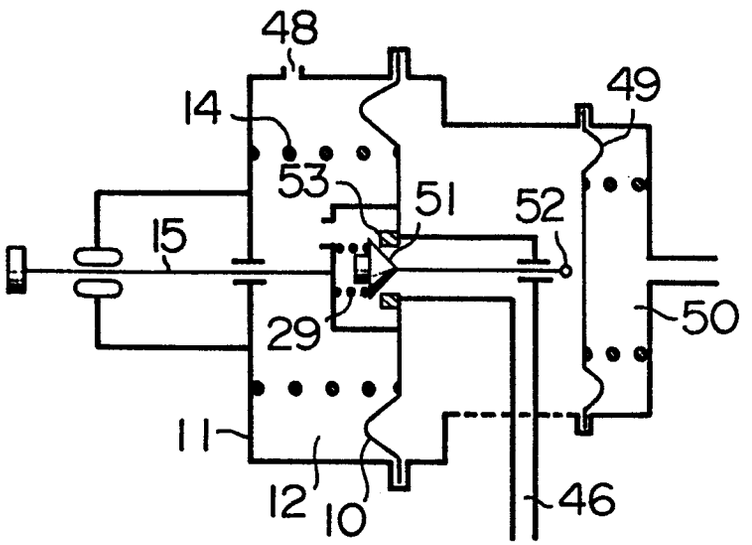

FIG. 9