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ABSTRACT

A self-regulated pressure control valve such as, for example, a self-regulated pressure reducing valve, comprising, as the principal components, a pressure control valve, a pressure regulating unit, a driving unit for driving the pressure regulating unit, a control unit for controlling the operation of the driving unit, and a pressure setting unit for setting a set pressure. The pressure regulating position of the pressure regulating element of the pressure regulating unit is regulated on the basis of the predetermined functional relation between the pressure regulating position of the pressure regulating element and the controlled pressure so that the pressure regulating element is positioned properly to regulate the controlled pressure to the set pressure. The self-regulated pressure control valve is capable of controlling the controlled pressure at a high response speed.

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SPECIFICATION

SELF-REGULATED PRESSURE CONTROL VALVE

BACKGROUND OF THE INVENTION

Field of the Invention:

The present invention relates to a self-regulated pressure control valve capable of controlling the secondary pressure, namely, the pressure of the associated controlled system, at a predetermined set level through the self-regulation of the pressure setting condition thereof on the basis of a control signal corresponding to the current pressure of the controlled system detected by pressure detecting means.

Description of the Prior Art:

The applicant of the present invention proposed an automatic pressure reducing diaphragm valve in Japanese Patent Application No. 59-207779. This automatic pressure reducing diaphragm valve comprises a pressure reducing diaphragm valve unit, a pressure setting unit including a pressure setting spring, an actuator for operating the pressure setting unit, and a control unit which provides a control signal to actuate the actuator when the pressure deviation of a detected secondary pressure, namely, the controlled pressure, from a target pressure exceeds a predetermined reference deviation so that the pressure deviation is reduced to zero.

This automatic pressure reducing diaphragm valve is capable of stable pressure reducing operation to

stabilize the secondary pressure through mechanical action while the pressure deviation of the secondary pressure is below the reference pressure deviation. However, since the automatic pressure reducing diaphragm valve regulates the secondary pressure on the basis of the result of comparison between the detected pressure deviation and the reference pressure deviation, it takes a long time to stabilize the secondary pressure at the predetermined set pressure.

SUMMARY OF THE INVENTION

Accordingly, it is an object of the present invention to provide a self-regulated pressure control valve capable of rapidly adjusting the secondary pressure to a predetermined set value.

The present invention utilizes the functional relation between the position of pressure regulating means and the secondary pressure of a self-regulated pressure reducing valve including the pressure regulating means and driving means for driving the pressure regulating means.

To achieve the object of the invention, present invention provides a self-regulated pressure control valve comprising: a pressure control valve unit, a detecting unit for detecting the secondary pressure, pressure regulating unit for regulating the secondary pressure of the pressure control valve unit, driving unit for operating the pressure regulating unit, control unit for controlling the driving unit, and pressure setting unit for setting a set pressure.

basis of the functional relation between the position of the pressure regulating unit and the secondary pressure corresponding to the controlled pressure to adjust the secondary pressure to a desired pressure, namely, the set pressure.

In one mode for carrying out the present invention, the control unit comprises a computer including arithmetic means, correcting means and memory means.

According to the present invention, when an optional set pressure is given by means of the pressure setting unit, the operating means of the control unit calculates an appropriate position of the pressure regulating member of the pressure regulating unit on the basis of the functional relation between the secondary pressure and the position of the pressure regulating member, and then the control unit provides a control signal to the driving unit to adjust the position of the pressure regulating member to a calculated appropriate position so that the secondary pressure is regulated to the set pressure.

After the secondary pressure has been thus regulated to the set pressure, the self-regulated valve unit starts mechanical pressure control operation in the conventional manner. When further fine control of the secondary pressure is necessary, it is desirable to provide a secondary pressure detecting means to detect the secondary pressure continuously or periodically and to control the driving unit by a correction signal calculated by the operating means of the control unit

on the basis of the difference between the set pressure and the detected secondary pressure to control the second pressure continuously or periodically.

Thus, the self-regulated pressure control valve is capable of rapid response to the variation of the secondary pressure and of instantly regulating the secondary pressure, namely, the controlled pressure, to a set pressure, namely, a target pressure.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and other objects, features and advantages of the present invention will become more apparent from the following description of the preferred embodiments thereof taken in conjunction with the accompanying drawings, in which:

Figure 1 is a fragmentary sectional view of a self-regulated pressure control valve, particularly showing the pressure regulating unit thereof;

Figure 2 is a graph showing the relation between the pressure regulating member of a pressure regulating unit and controlled pressure;

Figure 3 is a block diagram of a self-regulated pressure control valve, in a first embodiment, according to the present invention;

Figure 4 is a block diagram of a self-regulated pressure control valve, in a second embodiment, according to the present invention; and

Figure 5 is a block diagram of a self-regulated pressure control valve, in a third embodiment, according to the present invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

First Embodiment (Figs. 1 and 2);

The first embodiment is the application of the present invention to a pressure reducing valve 1. Referring to Fig. 1, the pressure reducing valve 1 has a pressure setting spring 2 having one end seated on a spring seat 3 and the other end seated on a spring seat 6. The spring seats 3 and 6 are pressed against a diaphragm 4 and against the lower end, as viewed in Fig. 1, of a pressure regulating screw rod 8 through a ball 7, respectively. The secondary pressure of the pressure reducing valve 1 prevails in a pressure chamber 5 covered with the diagphragm 4. The position of the diaphragm 4 is dependent on the pressure balance between the pressure applied thereto by the pressure setting spring 2 and the secondary pressure prevailing within the pressure chamber 5. Since the secondary pressure control function of the diaphragm 4 is well known, the description thereof will be omitted.

An external thread 9 is formed in the lower portion of the pressure regulating screw rod 8. The threaded lower end of the pressure regulating rod 8 is screwed in a fixed member provided with an internal thread 10 in the central portion thereof. An axial bore is formed in the upper portion, as viewed in Fig. 1, of the pressure regulating screw rod 8. A retainer 11 retaining balls 12 is inserted in the axial bore of the pressure regulating screw rod 8. A spline shaft 13 is fitted in the axial bore of the pressure regulating screw rod 8 so as to engage with the

balls 12. The spline shaft 13 is connected through a reduction gear 14 to the output shaft of a motor 15.

Since the pressure regulating screw rod is engaged with the internal thread 10 of the fixed member, the pressure regulating screw rod 8 is rotated through the spline shaft 13 so as to shift downward when the output shaft of the motor 15 rotates in one direction, and thereby the pressure setting spring 2 is compressed through the spring seat 6 by the pressure regulating screw rod 8 to increase the set pressure. On the other hand, when the output shaft of the motor 15 rotates in the opposite direction, the pressure regulating screw rod 8 is rotated in the opposite direction so as to shift upward, and thereby the compression of the pressure setting spring 2 is reduced to reduce the set pressure.

The distance of shift of the lower end of the pressure regulating screw rod 8 from a predetermined reference position (a position where the lower end of the pressure regulating screw rod 8 is in contact with the spring seat 6 through the ball 7 without compressing the pressure regulating spring 8), which will be referred to as "screw rod position", is proportional to the magnitude of compression of the pressure setting spring 2 and hence to set the pressure as shown in Fig. 2. The present invention effectively utilizes such a relation between the distance of shift of the lower end of the pressure regulating screw rod 8 and the set pressure.

Referring to Fig. 2 showing the first embodiment

of the present invention, the self-regulated pressure control valve comprises a pressure reducing valve 1, a pressure regulating unit 50 including the pressure regulating screw rod 8, a driving unit 52 including the motor 15, a pressure detecting unit 54, a signal conversion unit 55, a control unit 56 including a computer storing screw rod position data representing the functional relation between the screw rod position and the controlled pressure, and a pressure setting unit 58. In the first embodiment, the motor 15 is a stepping motor.

The pressure sensor of the pressure detecting unit 54 detects the secondary pressure of the pressure reducing valve 1 and gives a pressure signal representing the secondary pressure to the signal conversion unit 55. Then, the signal conversion unit 55 converts the pressure signal into a corresponding digital pressure signal, and then gives the same to the computer of the control unit 56.

Upon the reception of a set pressure signal representing a set pressure from the pressure setting unit 58, the computer calculates a screw rod position corresponding to the set pressure for the pressure regulating screw rod 8 on the basis of the screw rod position data previously stored therein, and then gives a pulse signal corresponding to the calculated screw rod position to the driving unit 52 to drive the pressure regulating unit 50 so that the pressure regulating screw rod 8 is shifted to the calculated screw rod position; consequently, the secondary

pressure of the pressure reducing valve 1 is adjusted instantly to the set pressure. The angle of rotation of the output shaft of the stepping motor 15 is proportional to the number of pulses of the pulse signal, and hence the position of the pressure regulating screw rod 8 corresponds to the number of pulses of the pulse signal.

The pressure detecting unit 54 detects the secondary pressure continuously or periodically and the signal conversion unit 55 gives digital signals accordingly to the control unit 56. The computer of the control unit 56 compares the detected secondary pressure with the set pressure. When the deviation of the detected secondary pressure from the set pressure is within a predetermined range of deviation, the control unit does not provide any signal to actuate the driving unit 52. When the deviation of the detected secondary pressure from the set pressure is greater than the limit value of the predetermined range of deviation, the computer calculates a correction distance by which the pressure regulating screw rod 8 needs to be shifted to correct the deviation, on the basis of the difference between the detected secondary pressure and the set pressure and the screw rod position data stored therein, and then provides a control signal representing the calculated correction distance for secondary pressure correction to actuate the driving unit for shifting the pressure regulating screw rod 8 for the fine adjustment of the secondary pressure.

For example, when the set pressure is 5 kg/cm^2, the reference range of deviation is ± 0.1 kg/cm^2, and the detected secondary pressure is 4.5 kg/cm^2, the computer calculates a correction distance corresponding to the pressure deviation of 0.5 kg/cm^2 on the basis of the screw rod position data to shift the pressure regulating screw rod 8 accordingly.

For the further advanced pressure control, digital data representing the functional relation between the set pressure and the screw rod position, for example, a predetermined correlation between the set pressure and the screw rod position represented by set pressures of 1 kg/cm^2 intervals and the corresponding screw rod positions, is stored in the table of the memory means of the computer, and the conrol operation and the correcting operation are executed on the basis of the digital data according to the predetermined correlation. When a correction is made, the digital data representing the previous screw rod position is replaced with the corrected data representing the new screw rod position to update the table of the memory means.

For example, suppose that screw rod positions S4 and S5 stored in the memory means of the computer correspond to set pressures, more specifically, set secondary pressures, 4 and 5 kg/cm^2, respectively. When the valve is set for the set pressure 5 kg/cm^2 by means of the pressure setting means, the motor drives the pressure regulating screw rod to the corresponding screw rod position S5. When a reference deviation

range is $\pm$0.1 kg/cm^2, the motor remains stopped while the deviation of the actual secondary pressure from the set pressure is within the reference deviation range.

Suppose that the set pressure is 5 kg/cm^2, the reference deviation range is $\pm$0.1 kg/cm^2, and the current secondary pressure is 4.5 kg/cm^2. Then the computer calculates a screw rod position correcting displacement ΔS corresponding to the deviation: 5.0 - 4.5 = 0.5 kg/cm^2 by using an equation:

$$\Delta S = (S5 - S4) \times 0.5/(5-4)$$

Then, the motor drives the pressure regulating screw rod by the calculated screw rod position correcting displacement ΔS to increase the secondary pressure from 4.5 kg/cm^2 to 5.0 kg/cm^2. Then, the initial screw rod position S5 stored in the memory means is replaced with S5 + ΔS.

When the same set pressure is given to the control unit to regulate the controlled pressure to the same target pressure after the pressure regulating screw rod 8 has been shifted from the previous screw position to change the set pressure, the computer calculates a true screw position to regulate the secondary pressure instantly to the target pressure.

When the pressure control system of the self-regulated pressure control valve is thus constituted, the pressure control system generates an ideal control data even when the operating condition of the pressure reducing valve is varied, so that the self-regulated pressure control valve is able to operate at a high response speed.

Second Embodiment (Figs. 1 and 4):

Basically, the second embodiment is the same as the first embodiment in constitution and function. The second embodiment employs a rotary potentiometer for detecting the position of the pressure regulating screw rod 8, and a reversible motor instead of the stepping motor, for driving the pressure regulating screw rod 8.

Referring to Fig. 4, the second embodiment comprises a pressure reducing valve 1, a pressure regulating unit 50, a driving unit 52, a pressure detector 54, a signal converter 55, a control unit 56, a pressure setting unit 58, a reduction gear 14, and a rotary potentiometer 20.

Referring to Fig. 1, the rotary potentiometer 20 is operatively interlocked with one of the gears, not shown, of the reduction gear 14. The output voltage of the potentiometer 20 is proportional to the distance of shift of the pressure regulating screw rod 8 from the reference position (a position where the pressure regulating screw rod is in engagement with the pressure setting spring 2 without compressing the latter), namely, the screw rod position. Accordingly, the output voltage of the rotary potentiometer 20 represents the screw rod position, hence the secondary pressure, namely, the controlled pressure. In the second embodiment, screw rod position data representing the functional relation between the screw rod position represented by the output voltage of the rotary potentiometer 20 and the secondary pressure is stored in the computer.

The rotary potentiometer 20 may be substituted by a linear potentiometer or a differential transformer. When a linear potentiometer is employed, the arm of the linear potentiometer is arranged so as to move linearly together with the pressure regulating screw rod 8. When a differential transformer is employed, the core of the differential transformer is arranged so as to move linearly together with the pressure regulating screw rod 8.

The control unit 56 gives a signal continuously to the driving unit 52 until the output signal of the rotary potentiometer 20, namely, the screw rod position signal, coincides with a signal given to the control unit 56 by means of the pressure setting unit 58. Since the rest of the functions are the same as those of the first embodiment, the description thereof will be omitted to avoid duplication.

Third Embodiment (Fig. 5):

Referring to Fig. 5, the third embodiment comprises a pressure reducing valve 1, a reduction gear 14, a rotary potentiometer 20, a pressure regulating unit 50, a driving unit 52, a control unit 70, and a pressure setting unit 72 including a potentiometer.

The control unit 72 does not include any computer. The third embodiment is capable of most simply controlling the secondary pressure on the basis of the relation between the screw rod position and the secondary pressure, namely, the controlled pressure. The rotary potentiometer 20 operatively connected to the reduction gear 14 gives a voltage signal

representing a screw rod position corresponding to the secondary pressure to the control unit 70, while the potentiometer of the pressure setting unit 72 gives a voltage signal representing a set pressure to the control unit 72. The control unit 72 compares the voltage signal representing the screw rod position and the voltage signal representing the set pressure, and then gives a control signal to the driving unit 52 to shift the pressure regulating screw rod until the voltage signal provided by the rotary potentiometer 20 coincides with the voltage signal representing the set pressure.

The rotary potentiometer 20 may be substituted by a linear potentiometer or a differential transformer as mentioned in the description of the second embodiment.

Although the invention has been described with reference to the preferred embodiments thereof with a certain degree of particularity, it is to be understood to those skilled in the art that many changes and variations are possible in the invention without departing from the scope and spirit thereof.

What is claimed is:

1. A self-regulated pressure control valve comprising:

a pressure control valve;

a pressure setting means for setting a set pressure.

a pressure regulating means for regulating the controlled pressure of said pressure control valve;

a driving means for driving said pressure regulating means;

a control means for controlling the operation of said driving means on the basis of a set pressure set by said pressure setting means and the predetermined functional relation between the position of the pressure regulating element of said pressure regulating element of said pressure regulating means and the controlled pressure so that the pressure regulating element of said pressure regulating means is shifted to a position to regulate the controlled pressure to the set pressure.

2. A self-regulated pressure control valve as recited in Claim 1, wherein said control means includes a computer which stores control data representing said predetermined functional relation between the position of the pressure regulating element of said pressure regulating means and the controlled pressure, calculates a position where said pressure regulating element is to be positioned on the basis of said control data and a set pressure signal provided by said pressure setting means, the position of said pressure regulating element is detected by means of a position detecting means such as a potentiometer, and said control means controls the operation of said driving means so as to drive said pressure regulating means until the detection signal of said position detecting means coincides with a signal representing the position

calculated by the computer of said control means on the basis of the control data and the signal representing the set pressure.

3. A self-regulated pressure control valve as recited in Claim 1, wherein said control means includes computer which stores control data representing the predetermined functional relation between the position of the pressure regulating element of said pressure regulating means and the controlled pressure, said driving means includes a stepping motor, said computer calculates, on the basis of a set pressure signal given thereto from said pressure setting means, a pulse signal having pulses of a number corresponding to a position where said pressure regulating element is to be positioned, and then gives the pulse signal to the stepping motor to regulate the controlled pressure to the set pressure.

4. A self-regulated pressure control valve as recited in Claim 2 or 3 further comprising a controlled pressure detecting means for detecting the controlled pressure, wherein the detection signal provided by said controlled pressure detecting means and the set pressure signal provided by said pressure setting means are compared continuously or periodically by said control means to determine the deviation of the controlled pressure from the set pressure, if there is any significant deviation of the controlled pressure from the set pressure, the computer calculates a correction distance by which the pressure regulating element of said pressure regulating means needs to be

shifted from the current position on the basis of the deviation and the control data stored in the computer to correct the controlled pressure so that the controlled pressure coincides with the set pressure.

5. A self-regulated pressure control valve as recited in Claim 4, wherein the position of the pressure regulating element of said pressure regulating means determined by said control unit through the operation of the difference between the controlled pressure signal representing the detected controlled pressure and the set pressure signal representing the set pressure is stored in the computer as a new correct position of the pressure regulating element of said pressure regulating means.

6. A self-regulated pressure control valve as recited in Claim 1, wherein said control means controls said driving means so as to operate until the detection signal corresponding the position of the pressure regulating element of said pressure regulating means detected by the potentiometer or the like of said position detecting means coincides with the set pressure signal representing a set pressure provided by a potentiometer or the like of said pressure setting means.

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FIG. 1

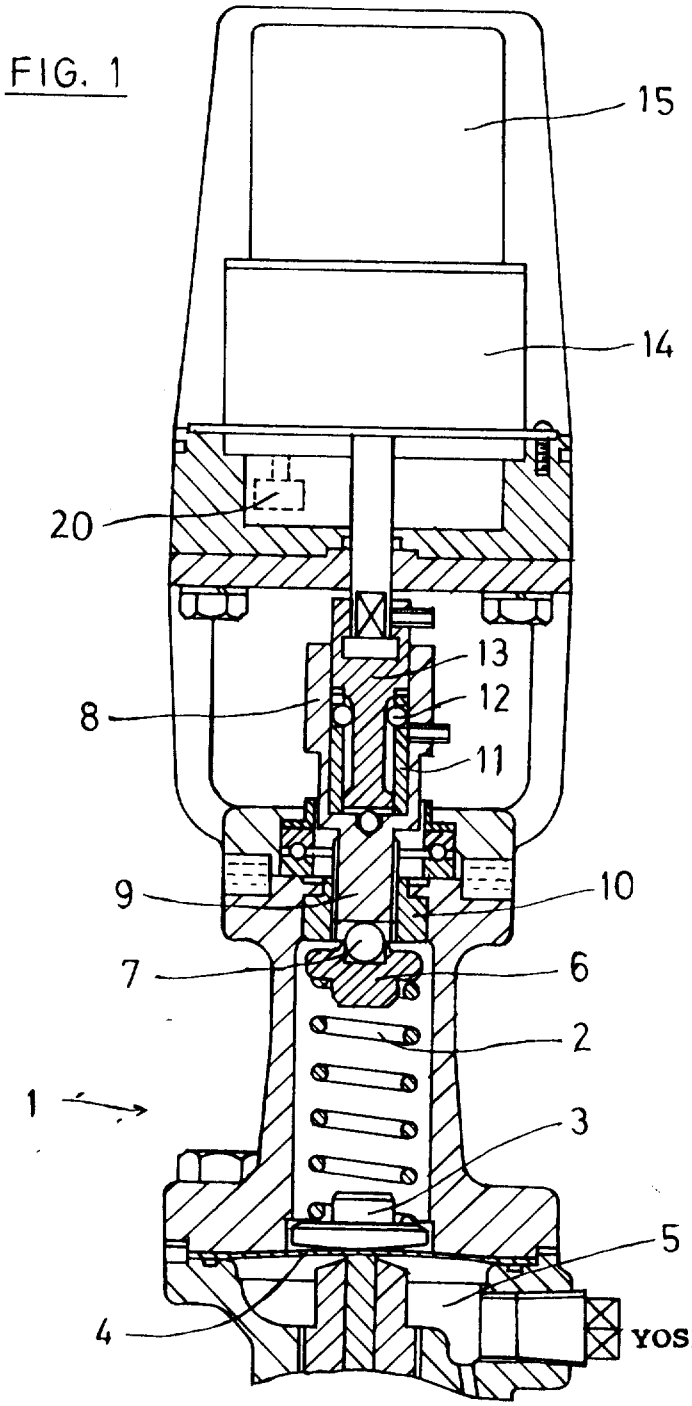

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FIG. 2

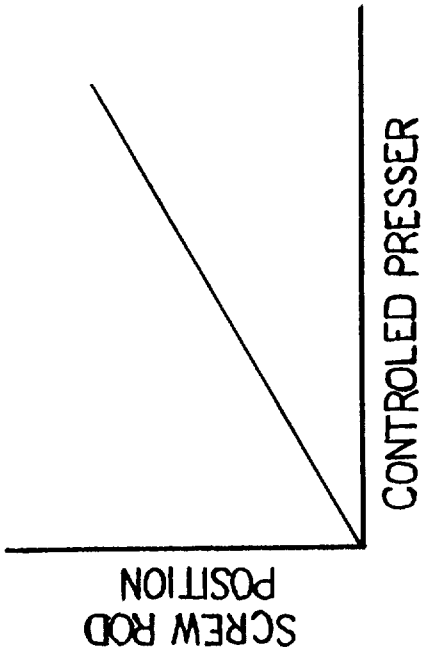

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FIG. 3

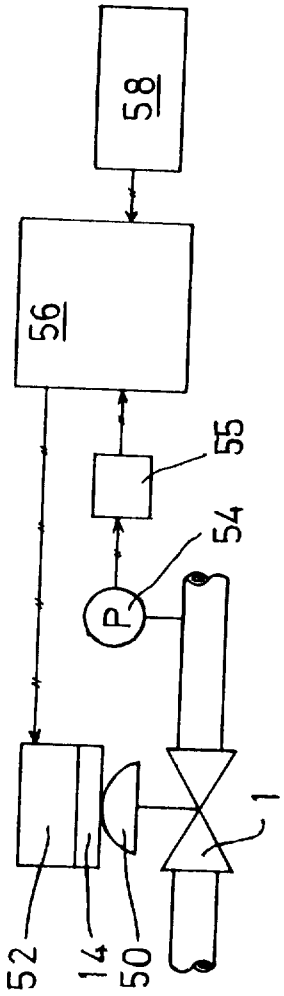

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FIG. 4

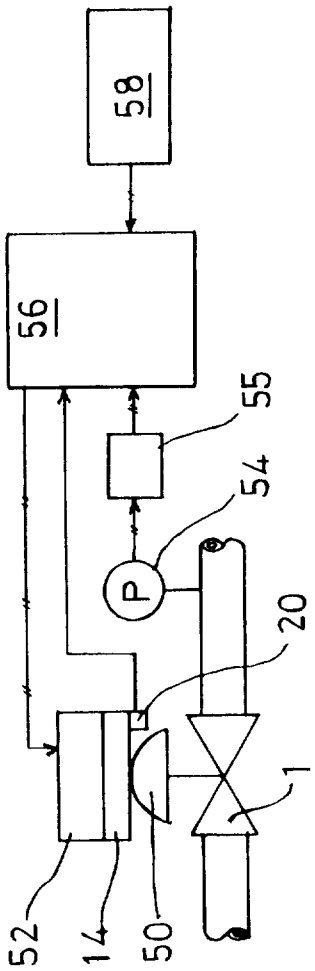

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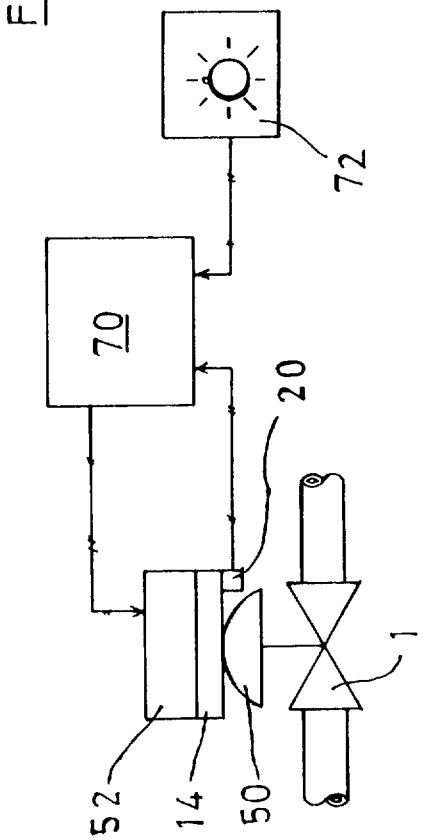
FIG. 5



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