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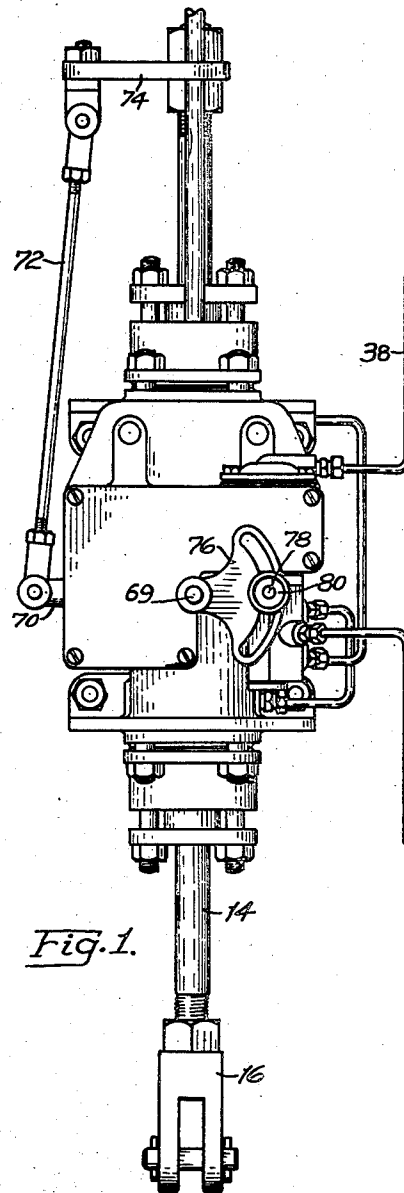
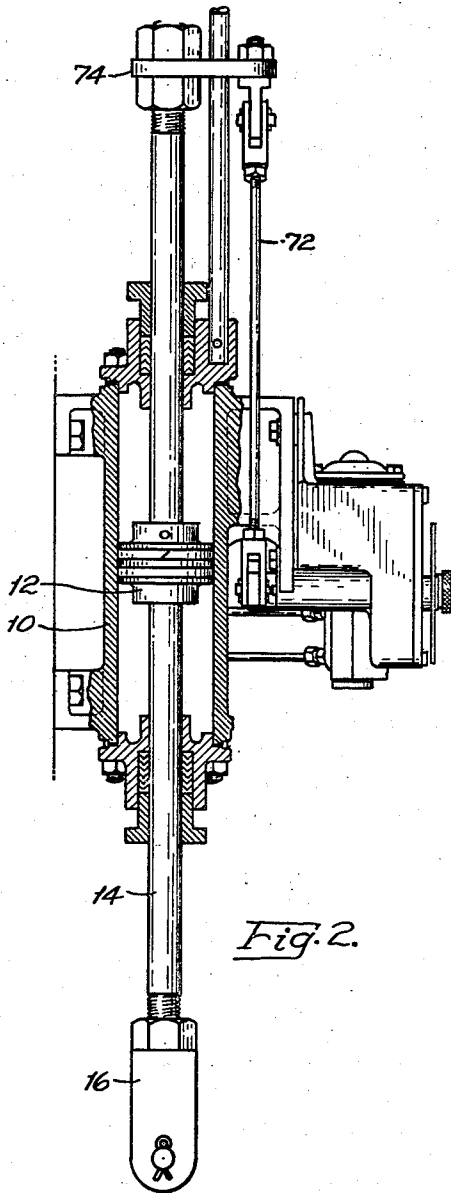
A. F. SPITZGLASS ET AL

2,220,180

REGULATOR

Filed Nov. 19, 1937

3 Sheets-Sheet 1



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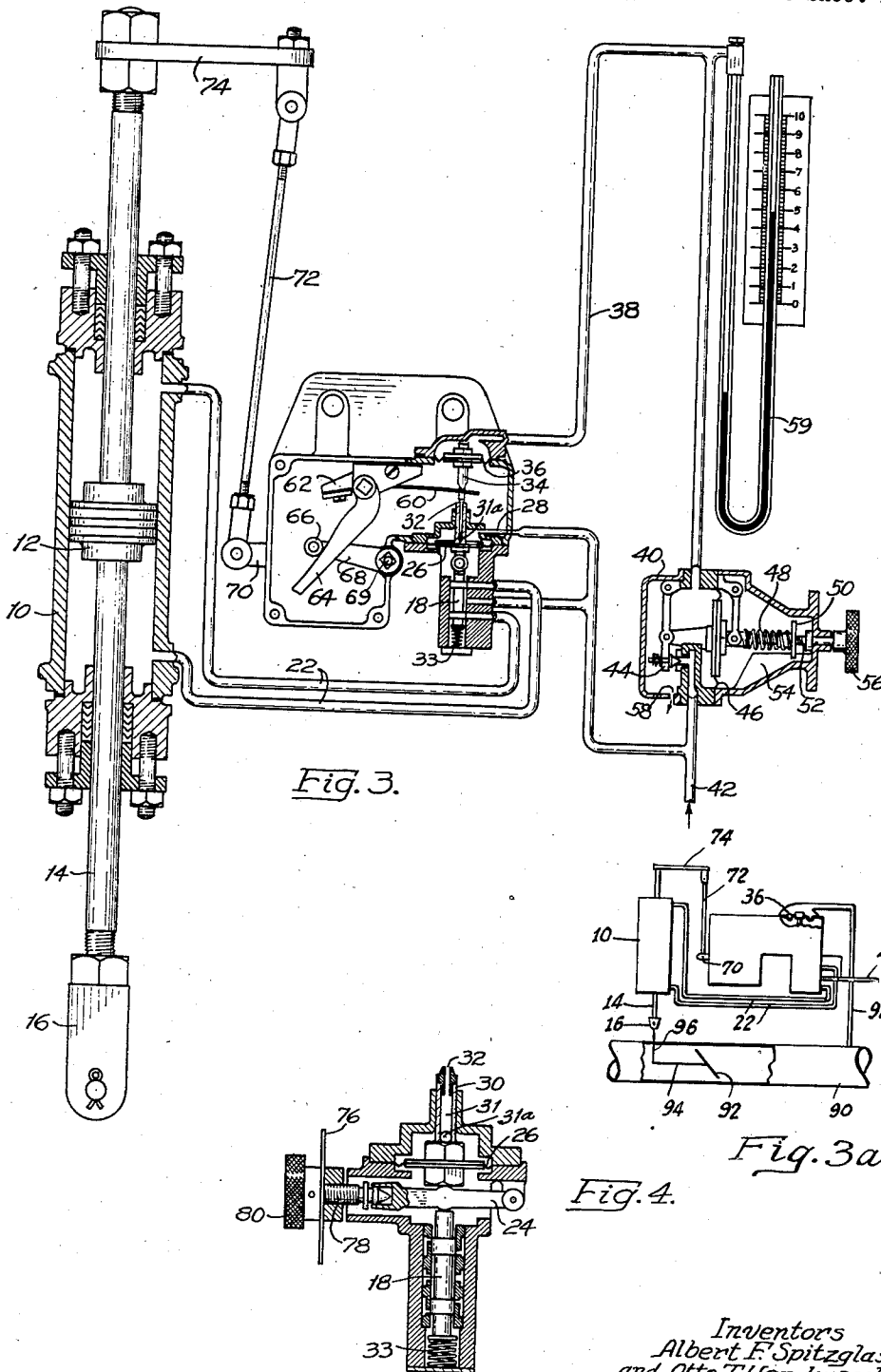
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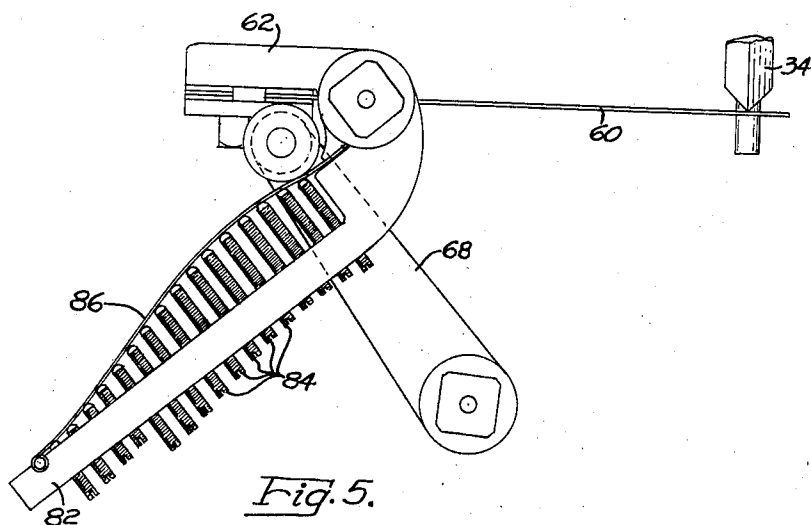
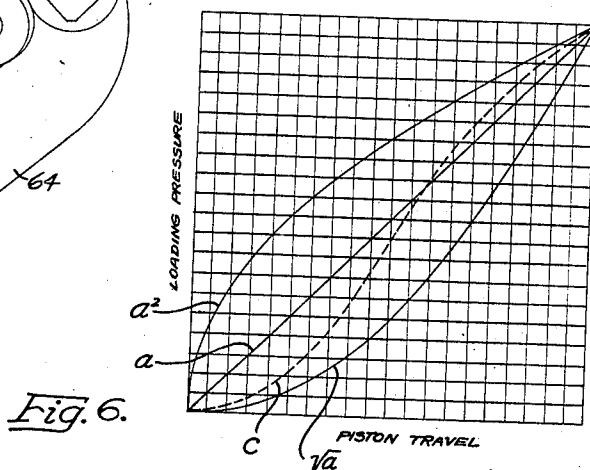
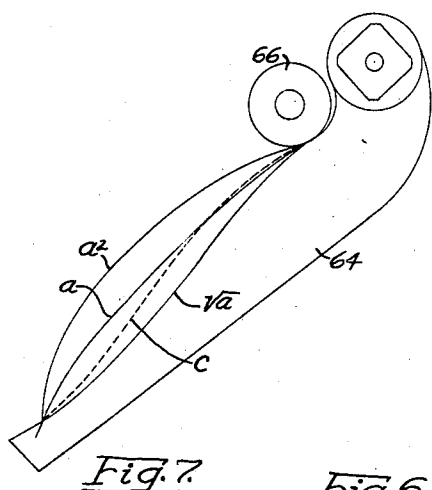
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3 Sheets-Sheet 3



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UNITED STATES PATENT OFFICE

2,220,180

REGULATOR

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Application November 19, 1937, Serial No. 175,448

7 Claims. (Cl. 121-41)

This invention relates to regulators and more particularly to regulators which are adapted to move a control element to positions corresponding to variations in a control force.

One of the objects of the invention is to provide a regulator which is simple and reliable in its construction and operation and which is extremely accurate.

Another object of the invention is to provide a regulator which can readily be locked in any desired position. Preferably this is effected by connecting the motor control mechanism to the motor so that any tendency of the motor to slip or drift will actuate the control mechanism to return it to the desired locked position.

Another object of the invention is to provide a regulator including a novel adjustable cam which greatly facilitates calibration. The adjustable cam may form a permanent part of the regulator or may serve as a pattern for the formation of a permanent cam.

Still another object is to provide a novel method of calibrating a regulator which is simple and quick to carry out and which enables an extremely accurate calibration to be obtained.

Other objects, advantages and novel features of the invention will be apparent from the following description of the accompanying drawings, in which:

Figure 1 is a side view of a regulator embodying the invention;

Figure 2 is a view at right angles to Figure 1 with parts in section;

Figure 3 is a diagrammatic view of the regulator of Figures 1 and 2;

Fig. 3A is a diagrammatic view on reduced scale illustrating one use of the regulator.

Figure 4 is an enlarged partial section of the valve mechanism of Figure 3 in a plane at right angles to that figure;

Figure 5 is a detail view of an adjustable cam; Figure 6 is a diagram; and

Figure 7 is a detail view of the cam illustrating its formation.

The regulator comprises a body portion formed with a power cylinder 10 slidably receiving a piston 12 formed with a piston rod 14 extended through the ends of the power cylinder. At one end the piston rod 14 carries a clevis 16 formed for connection with a control element for varying a condition to be controlled. This control element may be any suitable valve, rheostat or speed varying means for controlling the flow of a fluid, a motor speed, stoker speed or the like.

Admission of actuating fluid to the opposite

ends of the cylinder 10 is controlled by a control member shown as a spool valve 18 having a central inlet pipe 20 for fluid under pressure and a pair of outlet pipes 22 leading to the opposite ends of the cylinder 10. The valve is so arranged that when it is in its central position both pipes 22 are closed and movement of the valve one way or the other from center opens one or the other of the pipes 22 to the inlet pipe 20.

The upper end of the valve engages a lever 24 (Figure 4) pivoted on the valve housing and which in turn engages a flexible diaphragm 26, the upper surface of which is connected through a restricted orifice 28 with the source of fluid pressure. The diaphragm carries a hollow stem 30 having a bore 31 projecting upwardly through the diaphragm housing and formed at its upper end with a bleed port 32. A passage 31a connects the bore 31 with the space above the diaphragm 26. A suitable compression spring 33 acts on the lower end of the valve and tends to balance the downward force of the diaphragm 26.

The bleed port 32 is controlled by means sensitive to a controlling force shown as consisting of a valve stem 34 rigidly connected to a diaphragm 36, the upper surface of which is subject to the pressure in a pipe 38. As the valve stem 34 moves down to restrict the bleed port 32, pressure on the upper surface of the diaphragm 36 over-balances the spring 33 and moves the valve 18 downwardly. If the valve stem moves away from the bleed port to decrease the restriction thereof, the spring 33 will urge the valve 18 upwardly.

The diaphragm 36 is adapted to be loaded by a controlling pressure which may be responsive to a result to be produced, as for example the steam pressure in a boiler or the like. As shown in Figure 3, the loading pressure is manually controlled so that the regulator can be set by hand from a remote point to produce any desired setting of the control element. The means illustrated for so controlling the loading pressure includes a housing 40 connected to the pipe 38 and to a fluid pressure supply pipe 42. Admission of fluid from the pipe 42 to the housing is controlled by valve 44 connected to a flexible diaphragm 46 which tends to urge the valve onto its seat. The diaphragm is opposed by a compression spring 48 engageable at one end with a collar on the diaphragm and at its opposite end with a collar 50. The collar 50 is screw threaded on a rod 52 and is held from rotation by a flange 54 engaging a suitable notch therein. The rod 52 may be turned by a hand wheel 56 to move

the collar 50, thereby to adjust the tension of spring 48. Since the spring 48 must be balanced by diaphragm 46, this arrangement serves to control the pressure in the chamber 40, which acts on the diaphragm 36. Preferably the chamber 40 is provided with a small bleed opening 58 to enable escape of fluid therefrom. A manometer gage 59 is preferably connected to the pipe 38 to indicate the loading pressure. The supply pipe 42 is shown connected directly to the central inlet pipe 20 and to the orifice 28.

Loading pressure on the diaphragm 36 is balanced according to the present invention by yielding means shown as a leaf spring 60 carried by a pivotally mounted carriage 62, as more particularly described and claimed in the copending application of Otto T. Handwerk, Serial No. 162502, filed September 4, 1937, and issued as Patent No. 2,156,496 on May 2, 1939. The carriage 62 has secured thereto a cam lever 64 engageable with a roller 66 on a pivoted arm 68. The arm 68 is mounted on a cross shaft 69 which carries a second arm 70 connected through a link 72 with a bracket 74 which is rigidly secured to the piston rod 14.

In operation, the hand wheel 56 is adjusted to produce the desired loading pressure, as indicated on gage 59, this loading pressure acting on diaphragm 46 to urge the valve stem 34 downwardly. If the position of the piston 12 is such as to tension spring 60 an amount equal to the loading force on diaphragm 36, no movement will be produced. However, if the tension on spring 60 is not enough to balance the loading force, the valve stem 34 will move downwardly to restrict the bleed port 32, thereby increasing the downward pressure on the diaphragm 26. This will cause the valve 18 to move downwardly, connecting inlet pipe 20 to the lower outlet pipe 22 and admitting fluid pressure to the upper end of cylinder 10 above the piston 12. The piston 12 will now move downwardly, changing the setting of the control element and at the same time rocking levers 70 and 68 counterclockwise. Through engagement of the roller 66 with the cam lever 64, the carriage 62 will be rocked counterclockwise, thereby increasing the tension on spring 60 sufficiently to balance the loading force on the diaphragm 36. The valve stem 34 will then move upwardly to its normal position, relieving the constriction on bleed port 32 and permitting valve 18 to return to its central position under the influence of the spring 33. Thus the piston 12 and the control element will always occupy a position which corresponds to the loading pressure in the chamber 40.

Fig. 3A illustrates an application of the invention to the automatic regulation of pressure in a conduit. As shown, a conduit 90 through which fluid under pressure is adapted to flow is provided with a butterfly valve 92 having an arm 94 connected through a link 96 to the clevis 16 on the piston rod 14. The upper side of the control diaphragm 36 is connected through a pipe 98 to the conduit 90 anterior to the valve 92.

In operation if the pressure in the conduit 90 rises above the desired point, the diaphragm 36 will be depressed to restrict the bleed opening 32 and move the valve 18 downwardly. This will admit fluid pressure to the upper side of the power piston 12 to move the rod 14 downwardly thereby opening the valve 92. When the valve 92 is opened, flow through the conduit 90 will increase to reduce the pressure therein. Upon

a drop of pressure in the conduit 90 below the desired valve, the above action will be reversed to effect a further closing of the valve 92.

According to an important feature of the invention, means are provided for locking the regulator in any desired position, as for instance during calibration or when it is desired for some other reason that the control element remain stationary. This may be affected by providing a plate 76 on the shaft 69 which carries levers 68 and 70. The plate is formed with an arcuate slot in which a bolt 78 is normally slidable. The bolt 78 carries a thumb piece 80 by which it may be tightened into clamping engagement with the plate 76, and has its end engaging a socket in the free end of the lever 24.

Normally the plate 76 may slide freely relatively to the bolt 78, and there is no connection between the plate and the lever 24. However, when the thumb piece 80 is screwed up, the bolt 78 is rigidly locked to the plate and the plate and lever 24 are rigidly connected. This will prevent any movement of valve 18, and if there should be any tendency for the piston 12 to shift or drift, valve 18 will be moved thereby in a direction to return the piston to the desired position. For example, if the piston 12 should move downwardly, the valve 18 will be moved up to admit fluid pressure to the bottom end of the cylinder 10 and move the piston up until the valve is again centered.

Figure 5 illustrates an adjustable cam which may be used as a permanent part of the regulator, but which is preferably employed to obtain accurate adjustment and is thereafter replaced by a permanent cam. As shown, the cam includes an arm 82 secured to the spring carriage 62 and carrying a plurality of screws 84 spaced along its length. A flexible strip 86 is carried by the arm and overlies the ends of the screws 84. It will be apparent that by proper adjustment of the screws 84, substantially any desired shape of the strip 86 can be obtained to give the regulator any desired characteristic.

Figure 6 is a diagram in which piston travel is plotted horizontally against loading pressure vertically. It is normally desirable to obtain a straight line relationship between the loading pressure and the condition being controlled, but this is not always possible if the loading pressure and piston travel are directly proportional since the control element may not have a straight line characteristic. On the diagram of Figure 6 the straight line a represents the necessary cam shape for a direct proportional relationship between loading pressure and piston travel, while the upper curve a^2 represents the necessary cam shape for a condition in which the loading pressure is proportional to the square of the piston travel and the lower curve $\sqrt{a}$ represents the cam shape necessary if the loading pressure is proportional to the square root of the piston travel. Normally some cam shape intermediate the two outer curves is required for the particular control element, and there has been illustrated by way of example one such cam shape shown by the dotted line c . This cam shape roughly approximates a sine curve and illustrates the approximate cam shape required for a butterfly type control valve to maintain area opening controlled by the valve proportionately to the load pressure.

Figure 7 illustrates these same curves laid out on a cam arm similar to the cam arm 64 of Figure 3. It will be noted that the curve a be-

comes generally arcuate and that the cam shape approaches more nearly a straight line than in the form shown in Figure 6. This is due to the movement of the cam lever and of the roller 56 in relation thereto.

In shaping the cam in actual practice the loading pressure is set at a predetermined value, for example one-fourth maximum, and the cam is adjusted to give the piston a position such that the condition will be given a corresponding value; i. e. one-fourth maximum. In the case of a flow control valve this means that the valve will be so set that the flow is one-fourth of the maximum regardless of whether the valve is more or less than one-fourth open. By selecting other values and adjusting the cam to give the desired relationship the cam shape can readily be determined. Another and perhaps preferable way is to set the control element and piston in a predetermined position such as to give for example one-fourth maximum flow and lock the regulator by tightening the nut 80. The loading pressure may then be adjusted to a corresponding value; i. e. one-fourth maximum, and the cam adjusted until the diaphragm 36 is balanced.

The present invention also provides a novel method for calibrating the regulator through the use of a cam of the type illustrated in Figure 5 in conjunction with the novel locking mechanism 76 to 80. According to this method the piston 12 is adjusted to a position to give a known value of the condition to be controlled and the loading pressure is set to a corresponding value. The regulator is locked in this position and the set screws 84 on the adjustable cam are moved until the spring 80 balances the loading force on diaphragm 36. This operation is repeated for a number of positions and values until the strip 86 on the adjustable cam is given a shape which will produce the desired control on the control element. The adjustable cam is then removed from the regulator and is replaced by a permanent cam having exactly the same configuration. In this way a very accurate calibration of the regulator is obtained quickly and easily so that the loading pressure will always be proportional to the value of the condition as regulated by the particular control element.

While only one embodiment of the invention has been shown and described in detail, it is not intended that the scope of this invention be limited to the form shown or otherwise than by the terms of the appended claims.

What is claimed is:

1. A regulator comprising a motor having a part moved by power and adapted to move a control element, a movable member for controlling the motor, a sensitive element for controlling said member, and means for connecting said member rigidly to said part to lock the regulator regardless of operation of the sensitive element.

2. A regulator comprising a motor having a part moved by power and adapted to move a

control element, a movable member for controlling the motor, a sensitive element urged in one direction by a control force for controlling said member, yielding means connected to said part for urging said sensitive element in the other direction, and means operable at will for rigidly connecting said member to said part to lock the regulator.

3. A regulator comprising a motor cylinder, a piston slidable in said cylinder and adapted to be connected to a control element, a valve for controlling admission of pressure fluid to said cylinder, a sensitive element urged in one direction by a control force and controlling the valve, yielding means connected to the piston for urging the sensitive element in the other direction, and means for rigidly connecting the valve to the piston for locking the regulator.

4. A regulator comprising a motor cylinder, a piston slidable in said cylinder and adapted to be connected to a control element, a valve for controlling admission of pressure fluid to said cylinder, a sensitive element urged in one direction by a control force and controlling the valve, a pivoted arm connected to the piston to be moved thereby, yielding means controlled by said arm for urging the sensitive element in the other direction, and means for connecting said arm to the valve to lock the regulator.

5. A regulator comprising a motor cylinder, a piston slidable in said cylinder and adapted to be connected to a control element, a valve for controlling admission of pressure fluid to said cylinder, a sensitive element urged in one direction by a control force and controlling the valve, a pivoted arm connected to the piston to be moved thereby, a pivotally mounted spring engaging the sensitive element, and cam means connecting the arm and the spring.

6. A regulator comprising a motor cylinder, a piston slidable in said cylinder and adapted to be connected to a control element, a valve for controlling admission of pressure fluid to said cylinder, a diaphragm connected to said valve, means for conducting pressure fluid to one side of the diaphragm for urging the valve in one direction, means providing a bleed port from said one side of the diaphragm, resilient means urging the valve in the other direction, a second diaphragm responsive to a control force urging it in one direction, means carried by the second diaphragm for controlling said bleed port, spring means urging the second diaphragm in the other direction, and cam means operated by the piston for controlling the spring means.

7. A regulator comprising a motor, a valve controlling the motor, sensitive means controlling the valve, a spring balancing the sensitive means, a pivoted arm connected to the motor for resetting said spring as the motor moves to different positions, and means for connecting said arm rigidly to the valve to lock the regulator.

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OTTO T. HANDWERK.