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CONTROL APPARATUS

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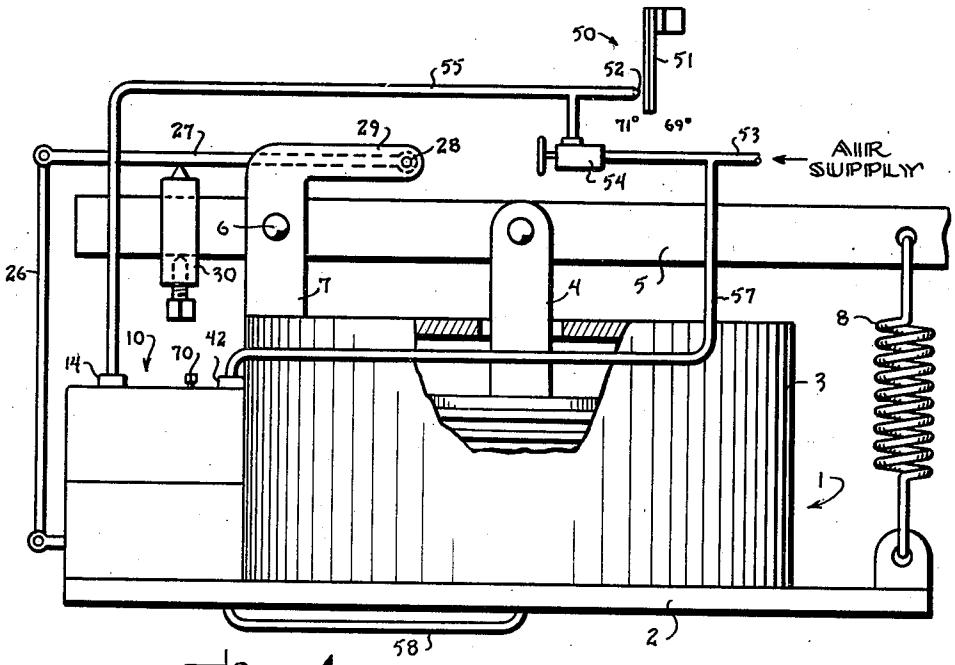


Fig. 1

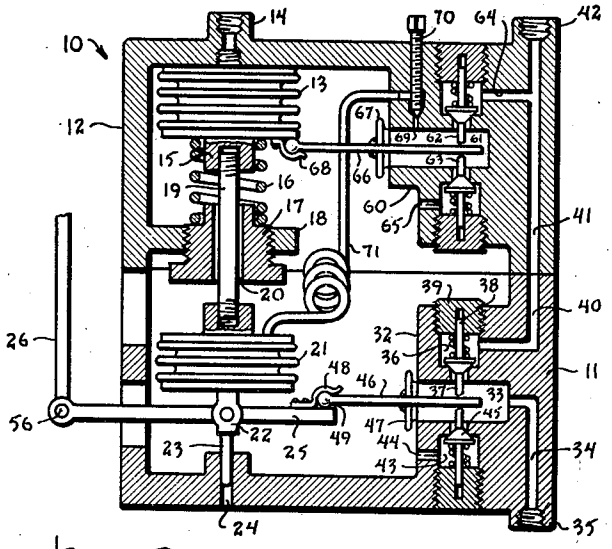


Fig. 2

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CONTROL APPARATUS

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10 Claims. (Cl. 236—82)

This invention relates in general to automatic controls and more particularly to automatic controls of the pneumatic or pressure actuated type.

It is an object of this invention to provide a control device for a pneumatic or pressure actuated motor which is simple and sturdy in construction, which provides for positive proportionate positioning of the motor in accordance with changes in condition of its controller, and which further provides for load compensation to thereby maintain the condition being controlled at the control point of the controller irrespective of the actual load upon the system being controlled.

More specifically, it is an object of this invention to provide a follow-up control arrangement for a pneumatic motor which includes a load compensating device associated with the elements of the follow-up mechanism for varying the motor position in a manner to compensate for changes in process load.

A further object of this invention is the provision of a proportioning control system for a pneumatic motor with a compensating device consisting of an expansible cell, the pressure in which is slowly changed in either direction in response to the condition being controlled deviating from the control point of the controller, and which maintains the pressure in the compensating cell constant when the condition being controlled is at the control point of the controller.

Other objects will appear from the following description and the appended claims.

For a full disclosure of this invention, reference is made to the following detailed description and to the accompanying drawing, in which

Figure 1 shows a pneumatic damper motor having my invention applied thereto, and in which

Figure 2 is a cross sectional view of the combined positive positioner and load compensating device.

Referring to Figure 1, reference character 1 indicates a damper motor of a construction well known in the art. This motor consists of a base 2 upon which is mounted a cylindrical housing member 3 which contains an expansible and contractible diaphragm for actuating a member 4 extending through the top of this housing. The member 4 is connected to the usual lever arm 5 which is pivoted at 6 upon a bracket member 7 attached to the top of the housing. Also attached to the lever arm 5 is a tension spring 8, the lower end of which is attached to a suitable bracket formed on the base member 2. The spring 8 thus urges rotation of the lever arm 5 downwardly about its pivot 6 thereby biasing the member 4 against the diaphragm located in housing member 3. It will be apparent that upon increasing the air or other fluid pressure within the diaphragm, the lever arm 5 will be urged upwardly against the action of spring 8, while upon decrease in such pressure the spring 8 will cause downward movement of the lever arm. The lever arm 5 may actuate valves or dampers for controlling whatever medium is desired to be controlled.

Mounted upon an extension of the base member 2 is the combined positive positioning and load compensating device 10. Referring to Figure 2, this device 10 is shown as being formed of a lower housing member 11 and an upper housing member 12. Located in the upper housing member 12 is a diaphragm or bellows 13, this bellows being sealed to the upper wall of member 12 and being in communication with a pipe connection 14. The lower wall of the diaphragm 13 is provided with a projection 15 which forms a retainer for a spring 16 the lower end of which is supported upon an adjusting nut 17 mounted in a web 18. The projection 15 is also attached to a stem 19 which extends through an opening 20 in the adjusting nut and which is attached to a compensating diaphragm or bellows 21. The lower end of the compensating diaphragm 21 is connected to a clevis 22 which is provided with a guide stem 23 fitting into an opening 24 in the lower housing member 11. Pivoted into the clevis 22 is a floating lever 25, the left-hand end of which is attached to a link 26 which in turn is pivoted to a lever 27 fulcrumed at 28 in an extension 29 of the bracket member 7. The lever 27 is actuated in unison with the motor lever arm 5 by means of an abutment member 30 which may be adjustably positioned upon the lever arm 5.

The lower housing member 11 is also provided with a boss 32 provided with a central chamber 33 which communicates through a passage 34 with a pipe connection 35. The boss 32 also contains a valve chamber 36 containing a valve member 37 which is urged against its seat by means of a spring as shown. This valve member is provided with a guide stem 38 received in a plug 39. The valve chamber 36 is in communication with an air passage 40 in the lower housing member 11. This passage 40 coincides with a passage 41 in the upper housing member 12 which communicates with a pipe connection 42 provided on this housing member. The boss 32 also contains a vent valve chamber 43 which communicates with atmosphere through a vent 44 and which

contains a valve member 45 which is identical in arrangement to the valve member 37. The valves 37 and 45 are actuated by means of a valve lever 46 which is pivotally mounted in a diaphragm 47 which seals the open end of the chamber 33. This valve lever is attached to the floating lever 25 by means of a spring clip 48 receiving the end of the lever 46 which is formed as a ball.

For illustrative purposes the motor is shown as being controlled by a thermostat generally indicated as 50. This thermostat is shown as consisting of a bimetallic element 51 cooperating with a leak port 52. The leak port 52 is connected to an air supply pipe 53 through a restriction 54 and is also connected by pipe 55 to the pipe connection 14 of the device 10. Air may be supplied at 15 lbs. per square inch pressure through the pipe 53, and the thermostat 50 operates to vary the pressure in pipe 55 and consequently in the diaphragm 13 of the positioning device 10 in accordance with variations in temperature at this thermostat. Assuming that the damper motor controls the supply of heat to a space and that the thermostat 50 is responsive to the space temperature, this thermostat may be arranged so as to cause complete closure of the leak port 52 when space temperature rises to 71° F. This will cause a pressure of 15 lbs. per square inch to be applied to the diaphragm 13. This thermostat 50 may be also arranged to cause the leak port 52 to be wide open when the space temperature falls to 69° F. Thus for this value of space temperature zero pressure will be applied to the diaphragm 13 of the positioning device 10. It will therefore be apparent that the pressure in the diaphragm 13 is varied in accordance with the temperature at thermostat 50. As this diaphragm 13 is biased by the spring 16 it will be apparent that the position of the stem 19 will vary in accordance with the pressure in diaphragm 13 and therefore in accordance with the temperature at thermostat 50. Thus when the bimetallic element 51 is at an intermediate position for applying 7½ lbs. per square inch pressure to the diaphragm 13, this diaphragm will assume the intermediate position shown, while expanding upon temperature rise and contracting upon temperature fall.

With the parts in the positions shown, the space temperature is approximately 70° which has caused a pressure of 7½ lbs. pressure to be applied to the diaphragm 13. This has caused the lever arm 5 to assume midposition for thus causing the damper or valve being controlled to be half open. If the space temperature should increase, the thermostat 50 will increase the pressure applied to the bellows 13 which will cause downward movement of the stem 19 to a position in which the tension of spring 16 just balances the increased pressure within diaphragm 13. This downward movement of the stem 19 will shift bodily the compensating diaphragm 21 downwardly thereby causing rotation of the floating lever arm 25 about pivot 56. This will cause counter-clockwise rotation of the valve lever 46 about its pivot formed in diaphragm 47 thereby opening the valve 37. Opening of valve 37 will permit a flow of air under pressure from the supply pipe 53 through pipe 57, passages 41 and 40, into the valve chamber 36 and through the valve port into chamber 33 from which it flows through passage 34 and pipe 58 into the motor diaphragm. This flow of air under pressure into the motor diaphragm will cause it to expand for rotating the lever arm 5 upwardly against the action of spring 8 which will cause shifting of the device being controlled in a manner to decrease the supply of heat to the space. As the lever arm 5 is rotated upwardly, the left-hand extension thereof will rotate downwardly which will permit downward movement of the lever 27 and thus causes counter-clockwise rotation of the floating lever 25 about the pivot in clevis 22. This in turn will cause clockwise rotation of the valve lever 46 for thus shifting the supply valve 37 towards closed position. When the motor movement corresponds to the downward movement of the stem 19 due to change in pressure in the diaphragm 13, the valve 37 will be returned to complete closed position and consequently the motor will remain stationary.

Assuming a decrease in temperature at the thermostat 50, this thermostat will increase the air flow through leak port 52 thereby decreasing the pressure in the diaphragm 13 which will cause contraction of this diaphragm until the decrease in tension of spring 16 corresponds to the decrease in pressure in diaphragm 13. This will cause upward movement of the stem 19, diaphragm 21 and clevis 22, for thus rotating the floating lever 25 upwardly about pivot 56 which in turn rotates the valve lever 46 in a direction for opening valve 45. This opening of valve 45 will permit air to flow from the motor through the vent 44 to atmosphere, which will permit the spring 8 to rotate the lever arm 5 in a clockwise direction about its pivot 6 for increasing the supply of heat to the space. This clockwise rotation of the lever 5 will cause upward movement of lever 27 about its pivot 28 thereby rotating the floating lever 25 clockwise about the pivot in clevis 22. This will rotate the valve lever 46 counter-clockwise for moving the valve 45 towards closed position. It will be apparent that when the motor movement corresponds to the decrease in pressure in diaphragm 13, the lever 46 will have moved just far enough to close the vent valve 45 for retaining the motor stationary.

From the description thus far it will be apparent that the device described provides for causing the motor to assume the position demanded by the thermostat 50 and that the motor diaphragm is either supplied with full line pressure or is vented until it reaches the proper position. One defect in the simple follow-up system just described is that it requires a variation in the condition being controlled from the desired value in order to cause movement of the motor from mid-position. Thus the thermostat 50 is desired to control at 70° F. and will maintain the space temperature at this desired value for intermediate heating loads. However, during times of light load it is necessary to decrease the supply of heat and in order for the motor 1 to completely stop the supply of heat, the space temperature must rise to 71° F. Conversely during cold weather when maximum heating is required the space temperature must fall to 69° F. before the motor 1 will cause the valve or damper to be wide open. The simple follow-up system therefore is not capable of maintaining the space temperature at the control point of the thermostat, namely 70° F., for all load conditions.

In order to avoid this undesirable result and to provide a system which will maintain the condition controlled at the desired value regardless of load, the diaphragm or cell 21 is provided. This cell is formed to be normally contracted so that it will expand upon increase in pressure therein and will contract upon decrease in such

pressure. The pressure applied to the cell 21 is controlled by means of a compensating valve assembly which is formed in a boss 60, forming a part of the upper housing member 10. This boss 60 is provided with a central chamber 61 provided with an inlet valve 62 and a vent valve 63. These valves may be arranged similarly to the valves 37 and 45 previously described. The valve chamber for valve 62 communicates through a passage 64 with the air supply passage 41. Consequently when this valve is open, air under pressure is supplied to the chamber 61. The valve chamber of the valve 63 communicates with atmosphere through a port 65 and thus vents chamber 61 when open. The valves 62 and 63 are actuated by a valve lever 66 which is pivotally secured to a diaphragm 67 which seals the open end of chamber 61. Valve lever 66 is actuated by the diaphragm 13 and is shown as being attached to this diaphragm by means of a spring clip 68. Leading from the chamber 61 is a passage 69 the flow of air through which is controlled by a needle valve screw 70, this valve communicating with a flexible tube 71 which is attached to the compensating diaphragm or cell 21. The needle valve 70 provides for restricting communication of the chamber 61 with the compensating cell 21. This causes the pressure within the cell 21 to change very slowly in the event that either valve 62 or 63 is open.

With the parts in the positions shown, the temperature within the space is at the control point of thermostat 50, namely 70° F. This has caused the diaphragm 13 to assume intermediate position in which the valve lever 66 permits both valves 62 and 63 to be closed. Consequently, the chamber 61 and the compensating cell 21 remain under a constant pressure. As long as this condition remains, the cell 21 will not change in length and consequently does not change the relationship between the diaphragm 13 and the floating lever 25. The system will therefore control as previously described and the pressure within cell 21 will remain substantially constant due to the lag caused by the needle valve or restriction 70. In other words, when the position of the motor is changed due to a temporary change in temperature at thermostat 50, the opening of either valve 62 or 63 will have no effect upon the pressure in compensating cell 21.

However, if the load upon the system increases due for instance to falling outside temperature, the temperature within the space will fall below 70° which causes the motor 1 to increase the supply of heat. At this time the increase in heat supply is obtained due to the space temperature falling below the control point of thermostat 50. However, upon the temperature within the space falling below this control point the diaphragm 13 contracts for causing movement of valve lever 66 in a direction for opening the vent valve 63. This will vent the chamber 61 and permit venting of the compensating cell 21 at a very slow rate as determined by the adjustment of screw 70. This slow venting of cell 21 will cause counter-clockwise rotation of the floating lever 25 about pivot 56 thus tending to open valve 45 for decreasing the pressure in the motor diaphragm thereby increasing the supply of heat to the space. This action of increasing the heat supply to the space will slowly continue and cause the space temperature to begin rising, which will cause expansion of the diaphragm 13. This expansion of diaphragm 13 due to the rising space temperature will continue until it re-assumes intermediate position at which the space temperature is at 70° F. and the valves 62 and 63 are closed. The pressure within the compensating cell 21 will now remain constant until another change in the heating load. The thermostat 50 and follow-up arrangement will therefore continue to control the motor position for counteracting temporary fluctuations in space temperature.

In the event that the heating load upon the system decreases, the space temperature will rise and the thermostat 50 and follow-up mechanism will cause an immediate change in position of the damper or valve for maintaining the space temperature within the control range of the thermostat. However, due to the decreasing load the space temperature will temporarily rise above 70° F. and consequently the bellows 13 will cause the valve lever 66 to open the supply valve 62 thereby slowly increasing the pressure in the compensating cell 21. The resulting slow expansion of the cell 21 will cause rotation of the floating lever 25 about pivot 56 in a direction for opening valve 37 and supplying additional air to the motor. Expansion of the cell 21 thus causes the supply of heat to the space to be slowly decreased, which permits the space temperature to fall back to the control point of thermostat 50 at which time the valve 61 will again be closed and the cell 21 will remain at its new length.

If desired, the tube 71 may also communicate with an external chamber for thus further decreasing the rate of pressure change within the compensating cell 21.

From the foregoing description it will be apparent that I have provided a control device which will positively position a pneumatic motor in accordance with the demand of its controller and which also compensates for changes in load upon the system in a manner to maintain the condition being controlled at the center of the control range of the controller or in other words, at the desired control point. It will also be apparent that this compensation is obtained by the use of a variable linkage comprising an expansible cell, the pressure in which is directly controlled by the condition responsive device in a manner to cause a slow and continuous compensating action until the value of the condition is returned to the exact desired value.

While throughout this description it has been assumed that the device is utilized for controlling a heating system and definite values of pressure and temperature have been mentioned, it will be understood that the invention is not limited to heating systems and may be used for controlling any condition. Also it will be understood that the various values of temperature and pressure may be varied as desired for different types of installations. Also while my improved load compensating arrangement is of especial utility in combination with the follow-up system which provides for a quick initial response, it will be apparent that this compensating arrangement is of utility in systems not utilizing positive follow-up. As many modifications which are within the scope of this invention will occur to those skilled in the art, I desire to be limited only by the scope of the appended claims.

I claim as my invention:

1. In a control system, in combination, a control device to be variably positioned, reversible motor means for actuating said control device,

said reversible motor means comprising an expansible chamber having a movable wall, motor control valve means for selectively causing movement of said motor means in either direction and for stopping said motor means in any one of a plurality of intermediate positions, a condition responsive means, connecting means by means of which the movement of said condition responsive means is mechanically transmitted to said motor control valve means to cause said motor control valve means to move in a manner to cause the movable wall of said motor means to move proportionately to change in condition at said condition responsive means, a variable linkage in said connecting means between said condition responsive means and said motor control valve means comprising a cell adapted to expand and contract upon changes in pressure applied thereto, compensating valve means for controlling the pressure applied to said cell, and means connected for actuation by said condition responsive means for positioning said compensating valve means in a manner to vary said linkage when the condition being controlled is not at the control point of said condition responsive means.

2. In a control system, in combination, a control device to be variably positioned, reversible motor means for actuating said control device, said reversible motor means comprising an expansible chamber having a movable wall, motor control valve means for selectively causing movement of said motor means in either direction and for stopping said motor means in any one of a plurality of intermediate positions, a condition responsive means, connecting means by means of which the movement of said condition responsive means is mechanically transmitted to said motor control valve means to cause said motor control valve means to move in a manner to cause the movable wall of said motor means to move proportionately to change of condition at said condition responsive means, a variable linkage in said connecting means between said condition responsive means and said motor control valve means comprising a cell adapted to expand and contract upon changes in pressure applied thereto, compensating valve means for controlling the pressure applied to said cell, said compensating valve means including inlet and exhaust valves for admitting fluid to said cell or for exhausting said cell, and means connected for actuation by said condition responsive means for positioning said compensating valve means in a manner to close said supply and exhaust valves when the condition being controlled is at the control point of said condition responsive means while opening one or the other of said valves when said condition means deviates from said control point.

3. In a control system, in combination, a control device to be variably positioned, reversible motor means for actuating said control device, said reversible motor means comprising an expansible chamber having a movable wall, motor control valve means for selectively causing movement of said motor means in either direction and for stopping said motor means in any one of a plurality of intermediate positions, a pressure actuated device, a source of fluid at a pressure differing from atmospheric, a condition responsive controller connected to said pressure actuated device and to said source for varying the pressure applied to said pressure actuated device in proportion to change in the condition to which said controller responds, connecting means by means of which the movement of said condition responsive means is mechanically transmitted to said motor control valve means to cause said motor control valve means to move in a manner to cause the movable wall of said motor means to move proportionately to change of said condition, a variable linkage in said connecting means between said condition responsive means and said motor control valve means comprising a cell adapted to expand and contract upon changes in pressure applied thereto, compensating valve means for controlling the pressure applied to said cell, and means connected for actuation by said pressure actuated device for positioning said compensating valve means in a manner to vary said linkage when the condition being controlled deviates from the control point of said condition responsive controller.

4. In a control system, in combination, a control device to be variably positioned, reversible motor means for actuating said control device, said reversible motor means comprising an expansible chamber having a movable wall, motor control valve means for selectively causing movement of said motor means in either direction and for stopping said motor means in any one of a plurality of intermediate positions, a pressure actuated device, a source of fluid at a pressure differing from atmospheric, a condition responsive controller connected to said pressure actuated device and to said source for varying the pressure applied to said pressure actuated device in proportion to change in the condition to which said controller responds, connecting means by means of which the movement of said condition responsive means is mechanically transmitted to said motor control valve means to cause said motor control valve means to move in a manner to cause the movable wall of said motor means to move proportionately to change of said condition, a variable linkage in said connecting means between said condition responsive means and said motor control valve means comprising a cell adapted to expand and contract upon changes in pressure applied thereto, compensating valve means for controlling the pressure applied to said cell, said compensating valve means including inlet and exhaust valves for admitting fluid to said cell and for exhausting said cell, and means connected for actuation by said pressure actuated device for positioning said compensating valve means in a manner to close said supply and exhaust valves when the condition being controlled is at the control point of said condition responsive controller, while opening one or the other of said valves when said condition deviates from said control point.

5. In a control system, in combination, a control device to be variably positioned, reversible motor means for actuating said control device, said reversible motor means comprising an expansible chamber having a movable wall, valve means for controlling the application of pressure to said expansible chamber, a condition responsive means, a follow-up device actuated upon movement of said motor means, said condition responsive means and said follow-up device being mechanically connected to said valve means and conjointly controlling said valve means for thereby causing movement of said motor means in proportion to changes in the condition to which the condition responsive means responds, compensating means associated with said valve means for controlling said valve means con-

jointly with said condition responsive means and said follow-up device for varying the relationship between said condition responsive means and said motor means, said compensating means comprising a cell in the connection between said condition responsive means and said valve means adapted to expand and contract upon changes in pressure applied thereto, compensating valve means for controlling the pressure applied to said cell, and means connected for actuation by said condition responsive means for positioning said compensating valve means in a manner to vary the pressure in said cell when the condition being controlled deviates from the control point of said condition responsive means.

6. In a control system in combination, a control device to be variably positioned, reversible motor means for actuating said control device, said reversible motor means comprising an expansible chamber having a movable wall, valve means for controlling the application of pressure to said expansible chamber, a condition responsive means, a follow-up device actuated upon movement of said motor means, said condition responsive means and said follow-up device being mechanically connected to said valve means and conjointly controlling said valve means for thereby causing movement of said motor means in proportion to changes in the condition to which the condition responsive means responds, compensating means associated with said condition responsive means for adjusting said condition responsive means, said compensating means comprising a cell in the connection between said condition responsive means and said valve means adapted to expand and contract upon changes in pressure applied thereto, compensating valve means for controlling the pressure applied to said cell, and means connected for actuation by said condition responsive means for positioning said compensating valve means in a manner to vary the pressure in said cell when the condition being controlled deviates from the control point of said condition responsive means.

7. In a control system, in combination, a control device to be variably positioned, reversible motor means for actuating said control device, said reversible motor means comprising an expansible chamber having a movable wall, valve means for controlling the application of pressure to said expansible chamber, a condition responsive means, a follow-up device actuated upon movement of said motor means, said condition responsive means and said follow-up device conjointly controlling said valve means for thereby causing movement of said motor means in proportion to changes in the condition to which the condition responsive means responds, compensating means associated with said valve means for controlling said valve means conjointly with said condition responsive means and said follow-up device for varying the relationship between said condition responsive means and said motor means, said compensating means comprising a cell adapted to expand and contract upon changes in pressure applied thereto, compensating valve means for controlling the pressure applied to said cell including inlet and exhaust valves for admitting fluid to said cell and for exhausting said cell, and means connected for actuation by said condition responsive means for positioning said compensating valve means in a manner to close said inlet and exhaust valves when the condition being controlled is at the control point of said condition responsive means, while opening one or the other of said valves when said condition deviates from said control point.

8. In a control system in combination, a control device to be variably positioned, reversible motor means for actuating said control device, said reversible motor means comprising an expansible chamber having a movable wall, valve means for controlling the application of pressure to said expansible chamber, a condition responsive means, a follow-up device actuated upon movement of said motor means, said condition responsive means and said follow-up device being mechanically connected to said valve means and conjointly controlling said valve means for thereby causing movement of said motor means in proportion to changes in the condition to which the condition responsive means responds, compensating means associated with said condition responsive means for adjusting said condition responsive means, said compensating means comprising a cell in the connection between said condition responsive means and said valve means adapted to expand and contract upon changes in pressure applied thereto, compensating valve means for controlling the pressure applied to said cell including inlet and exhaust valves for admitting fluid to said cell and for exhausting said cell, and means connected for actuation by said condition responsive means for positioning said compensating valve means in a manner to close said inlet and exhaust valves when the condition being controlled is at the control point of said condition responsive means, while opening one or the other of said valves when said condition deviates from said control point.

9. In a control system, in combination, a control device to be variably positioned, reversible motor means for actuating said control device, said reversible motor means comprising an expansible chamber having a movable wall, a condition responsive device, a source of fluid under pressure differing from atmosphere, a control line, said condition responsive device being connected to said source and to said control line for varying the pressure in said control line in accordance with the value of the condition to which said condition responsive device responds, positive positioning means for controlling said reversible motor means in a manner to cause movements of said motor proportionate to changes in pressure in said control line, said positive positioning means comprising valve means for controlling the pressure applied to said motor means, pressure actuated means connected to said control line, and follow-up means actuated by said motor means, said pressure actuated means and said follow-up means conjointly controlling said valve means, an expansible cell associated with said positive positioning means for adjusting said positive positioning means, said cell being adapted to expand and contract upon changes in pressure applied thereto, compensating valve means for controlling the pressure applied to said cell, and means actuated by changes in pressure in said control line for actuating said compensating valve means in a manner to change the pressure applied to said cell when the condition being controlled deviates from the control point of said condition responsive device.

10. In a control system, in combination, a control device to be variably positioned, reversible motor means for actuating said control device, said reversible motor means comprising an expansible chamber having a movable wall, a con-

dition responsive device, a source of fluid under pressure differing from atmosphere, a control line, said condition responsive device being connected to said source and to said control line for varying the pressure in said control line in accordance with the value of the condition to which said condition responsive device responds, positive positioning means for controlling said reversible motor means in a manner to cause movements of said motor proportionate to changes in pressure in said control line, said positive positioning means comprising valve means for controlling the pressure applied to said motor means, pressure actuated means connected to said control line, and follow-up means actuated by said motor means, said pressure actuated means and said follow-up means conjointly controlling said valve means, an expansible cell associated with said positive positioning means for adjusting said positive positioning means, said cell being adapted to expand and contract upon changes in pressure applied thereto, and compensating valve means for controlling the pressure applied to said cell, said compensating valve means including inlet and exhaust valves for admitting fluid to said cell and for exhausting said cell, and means actuated by changes in pressure in said control line for positioning said compensating valve means in a manner to close said inlet and exhaust valves when the condition being controlled is on the control point of said condition responsive device, while opening one or the other of said valves when said condition deviates from said control point.

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