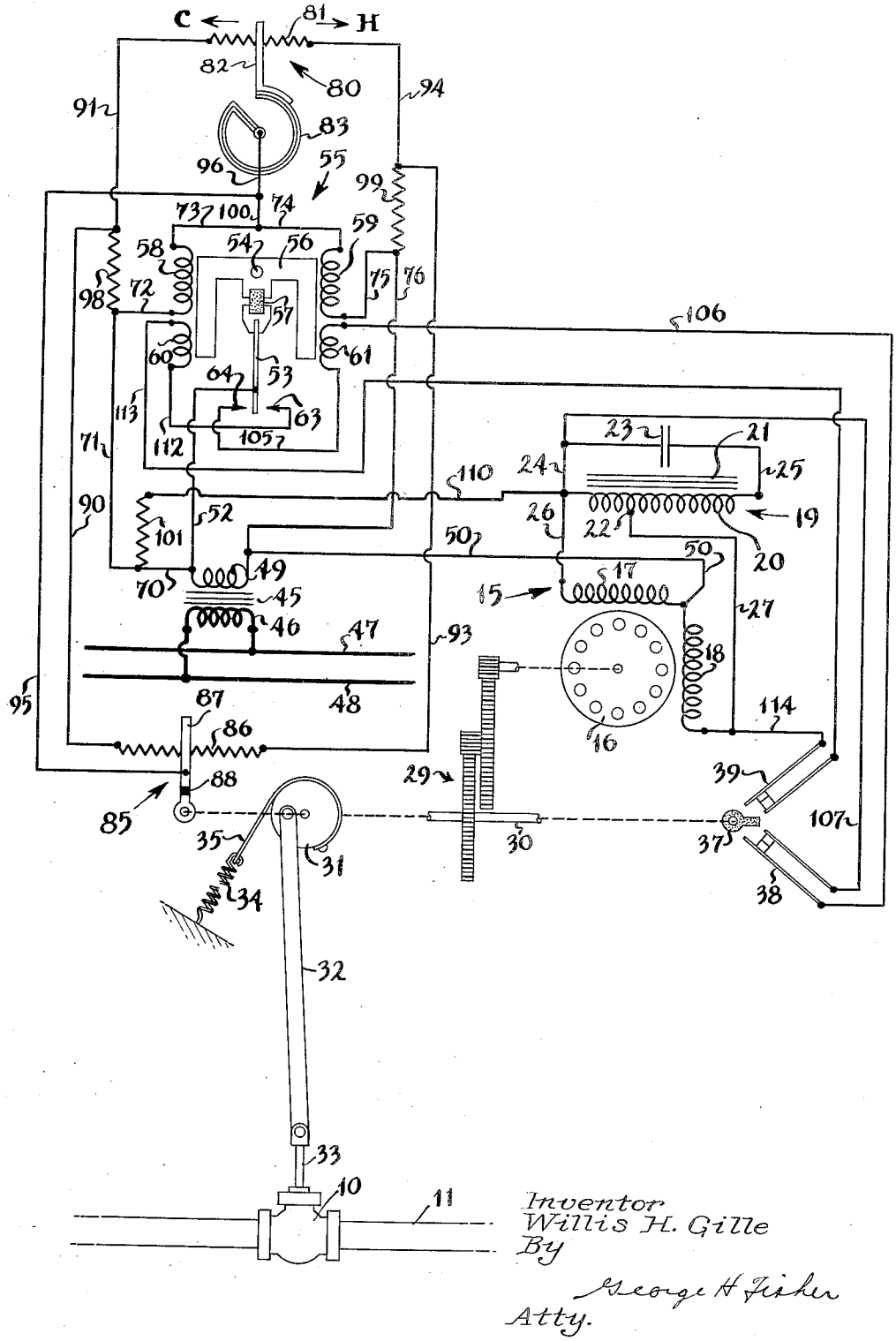
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MOTORIZED CONTROL SYSTEM

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Inventor
Willis H. Gille
By
George H Fisher
Atty.

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MOTORIZED CONTROL SYSTEM

Willis H. Gille, St. Paul, Minn., assignor to Minneapolis-Honeywell Regulator Company, Minneapolis, Minn., a corporation of Delaware

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This invention relates to improvements in a motorized control system, particularly one in which an object biased to closed position is variably positioned by a reversible motor.

In certain types of motorized control systems, it is desirable to variably position an object with the aid of a controller at a remote point so that the object may assume any desired position. This type of system is particularly of utility in condition control systems where the main controller is automatically operated in accordance with the value of some controlling condition and in which the operated element is a regulator for a condition changing means. Thus by way of example, the main controller may be thermostatically actuated while the operated device may be the valve in a steam line leading to radiators. In such a system, it is desirable that some mechanical means be employed to bias the device to one extreme safe position. In the case of the valve mentioned above, the valve would preferably be biased to closed position. The purpose of this is that in case the electrical power should fail, the valve or other device would move to a safe position. The introduction of the biasing means, however, introduces the problem that some means must be employed to hold the operator when it is desired to have the same stationary.

In my prior Patent No. 2,032,658, granted March 3, 1936, a system of the type above described was employed in which a special motor was utilized. This motor had three windings, one a holding winding, the other a lifting winding and the third a bucking winding which served to neutralize the effect of the holding winding. In general, when it was desired to move the operated element against its bias, the holding and lifting windings were both energized, when it was desired that the operated element be stationary, the holding winding alone was energized, and when it was desired that the device move toward the position to which it was biased both the holding and bucking windings were energized so that the device returned to closed position by reason of its bias.

While the system of the above patent is very satisfactory in its operation, it necessitates the use of a special type of motor having three windings. Moreover, with this type of system, the device is not positively driven to its biased position. Since it is necessary to have the device moved to its biased position by the biasing means only under certain emergency conditions, it is desirable that during normal operation the valve be positively driven to closed position so as to insure quicker and more positive return movement. The present invention has for its general object the overcoming of the above mentioned defects of the patented system.

An object of the present invention is to provide a control system for an operator biased to one position and moved by a reversible motor to and from said position, in which the motor is constantly partially energized through a circuit the complete energization of which causes the motor to move the operator against its bias, said partial energization being just sufficient to create a torque overcoming the bias of the spring so that the operator is held in the desired position.

Further objects of the present invention will be apparent from a consideration of the accompanying specification, claims and drawing.

Referring to the drawing, the control system of the present invention is shown in schematic form. In order to better understand the invention, the same has been shown as applied to a temperature control system although it is to be understood that the invention is not so limited.

The valve is indicated by the reference numeral 10 and is shown controlling the flow of fluid through a pipe 11. The pipe 11 may convey any suitable heat producing medium, such as steam to radiators or gas to a gas burner.

A motor 15 is employed for operating the valve 10. This motor 15 is of the capacitor type. The motor comprises a rotor 16 and two field windings 17 and 18. Associated with the motor is an autotransformer 19 having a winding 20 and a core 21 of magnetic material. A condenser 23 is connected by conductors 24 and 25 to the outer terminals of the winding 20. Since the transformer 19 is used as a step-up transformer, the condenser 23 by being connected across the outer terminals of winding 20 is connected in the high voltage secondary circuit. The winding 20 is tapped at 22 and the portion between the left-hand end of winding 20 and the tap 22, which forms the primary of the transformer, is connected by conductors 26 and 27 to the opposite ends of windings 17 and 18, the inner ends of which are connected together. Inasmuch as the condenser 23 by reason of its connection in the secondary circuit of transformer 19 introduces a capacitance effect in the primary circuit, the arrangement including the autotransformer has the same effect as though a condenser 23 of larger capacity were connected in place of the primary portion of winding 20. Thus, in considering the operation of the motor, the primary portion of

transformer winding 20 may be considered as replaced by a condenser.

The motor 16 is connected through a gear train 29 to a shaft 30. The shaft 30 has secured thereto a crank disc 31. This crank disc is connected through a link 32 to a stem 33 of valve 10. The valve is biased to closed position by a spring 34 acting on crank disc 31 through a strap 35, or any other suitable means.

Secured at another point on shaft 30 is an arm 37 of insulating material. Arm 37 is adapted to cooperate with the limit switches 38 and 39. Each of these limit switches comprise a short and a long contact carrying blade, the blades being biased into contact making engagement with each other. In case of excessive movement of the valve, the arm 37 of shaft 30 is adapted to engage the long blade of the respective limit switch and separate the contacts thereof. As will be more obvious from a subsequent description, the limit switches are in series with the motor so that operation of the motor is terminated upon one of these limit switches being opened.

A step-down transformer 45 is employed for supplying low voltage power for operation of the system. The transformer comprises a line voltage primary 46 which is connected to line wires 47 and 48 leading to a suitable source of power (not shown). The transformer also comprises a secondary 49. One terminal of the secondary 49 is connected through conductor 50 to the junction of windings 17 and 18. The other terminal of secondary 49 is connected through a conductor 52 to a switch blade 53 and when this switch blade is suitably positioned, it serves to connect the other terminal of secondary 49 to one end or the other of the windings 17 and 18.

The switch blade 53 is a switch blade of a relay 55. This relay comprises a U-shaped armature 56 pivotally mounted at 54. The switch blade 53 is secured to the armature 56 through an insulated connection 57. Acting on opposite legs of the armature 56 are main relay coils 58 and 59 and booster relay coils 60 and 61. The relay is of the type that is normally balanced and under normal conditions the coils 58 and 59 are equally energized so as to maintain the U-shaped armature in the position shown in the drawing. The switch blade 53 is adapted to cooperate with contacts 63 and 64. In its balanced position the switch blade 53 is out of engagement with both of these contacts, but upon being unbalanced in either direction, it is moved into engagement with one of these contacts.

The two relay coils 58 and 59 are connected directly across the secondary 49 in series. The circuit by which they are connected is as follows: from the left-hand terminal of secondary 49 through conductors 70, 71 and 72, relay coil 58, conductors 73 and 74, relay coil 59 and conductors 75 and 76 to the right-hand terminal of secondary 49. It will thus be seen that the relay coils 58 and 59 are constantly maintained energized.

Controlling the relative energization of the two relay coils 58 and 59 is a control potentiometer 80. This potentiometer comprises a resistance 81 and a contact arm 82. While it is, of course, to be understood that contact arm 82 may be actuated by any suitable means, the contact arm is shown as actuated by bimetallic element 83, inasmuch as the device is illustrated with a temperature control system. The bimetallic element 83 is so arranged that upon a decrease in temperature, the contact arm 82 is moved to the left, and upon an increase in temperature it is moved to the right. This is indicated in the drawing by legends in which the letters "C" and "H" indicate cold and hot, respectively.

Also controlling the relative energization of the relay coils 58 and 59 is a rebalancing potentiometer generally designated by the reference numeral 85. The rebalancing potentiometer comprises a resistance 86 and a contact arm 87 movable thereover. The contact arm 87 is secured to shaft 30 and is movable therewith. A section of insulating material 88 is inserted in the arm 87 to insulate the contact arm from the shaft 30.

The two potentiometers 80 and 85 are connected in parallel with each other. The outer ends of the resistances of the respective potentiometers are connected through conductors 90 and 91 on the one side and 93 and 94 on the other. The contact arm 87 is connected through conductors 95 and 96 and bimetallic element 83 with contact arm 82. The control potentiometers are not only connected in parallel with each other but are connected through protective resistors 98 and 99 with the relay coils 58 and 59 and with the opposite terminals of secondary 49. It will be noted that the protector resistances 98 and 99 connect the outer ends of the relay coils 58 and 59 through conductors 72 and 75 with the conductors joining the outer terminals of the resistors of the two potentiometers. A wire 100 connects the conductors 95 and 96 joining the contact arms of the two potentiometers to the junction of conductors 73 and 74 so that contact arms 82 and 87 are connected to the junction of the relay coils 58 and 59.

It will be readily seen from the above description of the manner in which the potentiometers are connected to the source of power and to relay coils 58 and 59 that these potentiometers act as voltage dividers for the relay coils 58 and 59. Thus, any movement of contact arm 82 to the right as a result of a temperature increase causes the voltage across relay coil 59 to be reduced and that across relay coil 58 to be increased with the resultant increase and decrease with respect to the energization of these two coils. Similarly, upon contact arm 82 moving to the left, the energization of relay coil 58 is decreased and that of 59 is increased. The same action takes place upon a movement of contact arm 87. When this contact arm moves to the right on resistance 86, the energization of relay coil 59 is decreased with respect to that of relay coil 58, and when the contact arm 87 moves to the left, an opposite unbalance in the energization of relay coils 58 and 59 occurs.

The protective resistors 98 and 99 are provided to insure that the secondary 49 will not be short-circuited. It will be noted that when the arms 82 and 87 are in opposite extreme positions, a circuit can be traced across the terminals of secondary 49 through the contact arms of the two potentiometers, which circuit includes only the protective resistors 98 and 99. If these resistors were not present, there would be a direct short circuit across the transformer secondary.

A resistor 101 is provided for the purpose of continually maintaining one of the motor energizing circuits partially energized as described in the early portion of this specification. The function of this resistor 101 and the connection thereof in the circuits will be described in connection with the operation of the system.

Operation

The various elements are shown in the drawing in the position which they assume when the controlling condition is at approximately the desired value. As pointed out previously, the effect of a fall in the temperature adjacent thermostatic element **83** is to cause the bimetallic element **82** to be deflected to the left. The operation will now be traced assuming that this drop in temperature does occur. A movement of the contact arm **82** to the left causes the relay coil **58** to become less highly energized than relay coil **59**, as previously explained. This causes switch arm **53** to move into engagement with contact **64**. The movement of switch arm **53** into engagement with contact **64** establishes the following energizing circuit to the motor: from the left-hand terminal of secondary **49** through conductor **52**, switch arm **53**, contact **64**, conductor **105**, booster coil **61**, conductor **106**, limit switch **38**, conductors **107**, **24** and **26**, motor winding **17** and conductor **50** to the other terminal of secondary **49**. The establishment of this circuit causes field winding **17** to be directly connected across the secondary **49**. Field winding **18** is connected in parallel with field winding **17** between conductors **24** and **50** through a circuit including the primary portion of winding **20** and conductor **27**. The field winding **18** is thus connected to the secondary in series with the primary portion of transformer **19**, which primary portion, as previously explained, has the effect of a condenser in the circuit. The result is that the current through field winding **18** leads that through field winding **17** causing a phase displacement in the energization of the two windings. This phase displacement in the energization of the two windings is effective to cause rotation of the motor **15**.

It will be noted that the circuit to the motor **15** included the booster coil **61**. The energization of booster coil **61** upon the closure of switch blade **53** with contact **64** aids relay coil **59**, thus further increasing the unbalancing in the energization of the relay. Since the action of the control potentiometer **80** is quite gradual, the initial engagement of switch arm **53** with contact **64** may be quite insecure and unsteady. The effect of the booster coil **61** is to immediately increase this unbalance of the relay so that the switch arm **53** is held firmly in engagement with contact **64**.

The effect of the establishment of the motor circuit previously traced is to cause the motor to rotate in a direction to move crank disc **31** in a clockwise direction. This movement of crank disc **31** is effective to move the valve **10** towards open position against the biasing action of spring **34**. It will thus be seen that the effect of the decrease in temperature is to place the motor in operation and to cause it to drive valve **10** towards open position.

The rotation of shaft **30** in a manner to cause clockwise rotation of crank disc **31** also causes clockwise rotation of the contact arm **87** of the rebalancing potentiometer **85**, or in other words, causes the contact arm **87** to move to the right on resistor **86**. Inasmuch as control potentiometers **85** and **80** are connected in parallel to the relay coils **58** and **59**, it will be apparent that this movement to the right of contact arm **87** tends to compensate for the movement to the left of contact arm **82**. The result is that after the movement of contact arm **87** has continued for a predetermined distance, dependent upon the extent of the movement of contact arm **82**, the energization of the relay coils **58** and **59** will be rebalanced so that the relay switch arm **53** will move to its neutral position. It will be understood, of course, that this does not occur until relay coil **59** becomes slightly more energized than relay coil **58** so as to counteract for the booster coil **60**. Inasmuch as the effect of booster coil **60** is relatively slight, however, as compared with the effect of main relay coils **58** and **59**, a separation of switch arm **53** from contact **64** occurs when relay coils **58** and **59** are substantially rebalanced. As soon as switch arm **53** moves out of engagement with contact **64**, the previously traced circuit to the motor will be interrupted.

Upon the interruption of the previously traced motor circuit, the spring **34** would be effective to cause the valve **10** to be moved back towards closed position, if some means were not provided for counteracting the effect of spring **34**. The present invention is concerned with the provision of such means. As previously pointed out, resistor **101** is intended to supply current to the motor in a manner to move the same in valve opening direction but to only partially energize the motor so that the motor does not overcome the torque exerted by spring **34**. It is to be understood that in view of the fact that there is considerable friction loss in the gear train and in the other moving parts, the torque exerted by the motor when partially energized does not need to exactly equal the torque exerted by the spring on the crank disc **31**.

Referring to the drawing, it will be noted that the following circuit is always established to the motor **15**: from the left-hand end of secondary **49** through conductor **70**, resistance **101**, conductors **110** and **26**, motor field winding **17**, and conductor **50** to the other terminal of secondary **49**. Motor field winding **18** is also connected through the primary portion of winding **22** in parallel with the field winding **17** in the same manner as was the case when the motor energizing circuit was established by engagement of switch arm **53** with contact **64**. However, due to the presence of resistance **101** in the circuit just traced, the torque exerted by the motor is considerably less than that exerted when switch arm **53** is engaged with contact **64**. The reduced torque of the motor is not sufficient to overcome the spring plus the friction in the gear train so that the valve remains in whatever position it is in when the switch blade **53** separates from contact **64**.

It will be noted that the resistor **101** is effective to always cause a partial energization of the circuit to the motor, which when completely energized causes it to rotate in valve opening direction. It will further be noted that resistor **101** is merely a high impedance shunt around the switch formed by switch **53** and contact **64**, the booster coil **61** and the limit switch **38**. It is necessary for the resistor **101** to shunt the limit switch **38** since by so doing the opening of the limit switch **38** does not interrupt the energizing circuit to the motor through resistance **101**. As previously indicated, the limit switches **38** and **39** are designed to interrupt the motor circuit when the valve reaches an extreme limit of its movement. The limit switch **38** is designed to open the motor circuit when the valve approaches its extreme open position. In the case of a biased valve, however, it is undesirable to completely deenergize the motor when the limit switch opens. If this were done, the biasing means would be effective to immediately start moving

the valve backward until the limit switch would be reclosed. This would again cause the motor to move forward again breaking the limit switch whereupon the previous action would be repeated. Thus if some means were not provided for maintaining the motor at least partially energized after the limit switch was interrupted, the motor would continue to "hunt" around the limit switch. By connecting resistor 101 in parallel with the limit switch 38, the opening of limit switch 38 does not affect the circuit to resistor 101. Accordingly, as soon as this limit switch is opened, the only energizing circuit to the motor is that through resistor 101 and the motor and valve 10 remains in this position.

The action which has been described above is that which occurs upon a temperature drop. It will be noted from the preceding description that the effect of this temperature drop was to cause valve 10 to be moved towards open position by an amount corresponding to the deflection of the arm 82. The result of such temperature drop was thus to cause valve 10 to be moved to a more open position so as to increase the flow of heat producing medium through pipe 11. Under normal circumstances, this increase in the flow of heat producing element will cause the temperature adjacent bimetallic element 83 to rise so that contact arm 82 is deflected to the right. The deflection of contact arm 82 to the right causes relay coil 58 to become more highly energized than relay coil 59 with the result that switch blade 53 is now moved into engagement with contact 63. As soon as this takes place, the following circuit is established to the motor: from the left-hand terminal of secondary 49 through conductor 52, switch blade 53, contact 63, conductor 112, booster coil 60, conductor 113, limit switch 39, conductor 114, motor field winding 18, and conductor 50 to the other terminal of secondary 49. The establishment of this circuit results in the field winding 18 being connected directly across the secondary 49. At the same time, the field winding 17 is connected between conductor 114 and conductor 50 through conductor 27, the primary portion of winding 20 and conductor 26. Accordingly, the field winding 17 is also energized but through a circuit including the primary portion of winding 20 in series therewith. The inclusion of the primary portion of winding 20 causes the current through field winding 17 to lead that in phase through field winding 18 so that the motor tends to rotate in a direction opposite to that previously described.

It will be noted that the circuit just traced included the booster coil 60. The energization of this booster coil causes the contact pressure between arm 53 and contact 63 to be increased in the same manner as the energization of booster coil 61 increased the contact pressure between arm 53 and contact 64.

The movement of switch arm 53 into engagement with contact 63 does not disconnect resistor 101 from the motor. It will be noted that resistor 101 in effect forms a shunt around the primary portion of winding 20 of the transformer 19. This shunt circuit may be traced as follows: from winding 101 through conductors 70 and 52, contact arm 53, contact 63, conductor 112, booster coil 60, conductor 113, limit switch 39, conductors 114 and 27, the primary portion of winding 20 and conductor 110 to the other terminal of resistor 101. Thus disregarding the presence of the booster coil 60, the resistor 101 is in parallel with the primary portion of winding 20 and hence serves to modify the capacitance effect thereof when switch arm 53 is in engagement with contact 63. The result is that the phase displacement between the current energizing winding 17 and that energizing winding 18 is not as great as that occurring in the other two cases just traced. Since there is less phase displacement, the torque of the motor tending to close the valve is considerably less than that tending to open the valve. The presence of the resistor 101 is useful in this connection since if the full closing torque of the motor were applied the effect of this torque in addition to that of spring 34 would cause an excessive torque to be applied to close the valve. While the torque tending to close the valve is not excessive, it is nevertheless sufficient to cause a positive movement of the valve by the motor towards closed position.

The above described movement of the motor in a direction to cause the valve to move to closed position is effected through a counter-clockwise movement of crank disc 31. This counter-clockwise movement of shaft 30 necessary to effect such movement of crank disc also causes a counter-clockwise movement of contact arm 87, or in other words, a movement to the left of contact arm 87. It will be noted that this movement to the left of contact arm 87 is opposite to the original movement to the right of contact arm 82 which initiated the movement of the motor in valve closing direction. Accordingly, after this movement has continued a predetermined amount depending upon the amount which contact arm 82 has been deflected, the energization of relay coils 58 and 59 will again be substantially rebalanced so that switch arm 53 moves out of engagement with contact 63. As soon as this takes place, the motor is again energized solely through the circuit including impedance 101 so that the valve remains in the position it assumes when switch blade 53 moves out of engagement with contact 63.

If it should so happen that the movement of the valve in valve closing direction should continue until the valve reaches the desired minimum open position, the limit switch 39 will be interrupted. This has the effect of interrupting the circuit to the motor tending to close the valve leaving the motor energized only by the inclusion of the impedance 101.

It will be readily seen that I have devised a new and highly effective method of controlling a biased member driven by a reversible motor so that the object may be stopped in any desired position. While the particular arrangement illustrated shows a capacitor motor as the motor of my system, it will be obvious that the invention is not so limited but is applicable to any type of reversible motor. This is one of the important advantages of the present system since by the use of the features of the present invention, it is not necessary to employ a particular type of motor. Obviously, the cost is much less than where it is necessary to employ an extra winding since a resistor is a relatively inexpensive device.

While I have shown a specific embodiment of my invention, it is to be understood that this is for purposes of illustration only and that my invention may be modified within the scope of the appended claims.

I claim as my invention:

1. A control apparatus of the class described, comprising, in combination, an operator biased to a predetermined position, reversible electrical

motor means connected to said operator for moving the same towards and from its biased position, means for completely energizing said motor in a first direction such that the same is rendered operative to move the operator away from its biased position, means to constantly partially energize the motor in the same direction so that upon the energization by said first named means being terminated, said motor will be stalled to maintain the operator in its new position, and means to energize the motor in the opposite direction in an amount exceeding the partial energization by said previously named means whereby the biasing means and the motor cooperate to return said operator to its biased position.

2. A control apparatus of the class described, comprising, in combination, an operator biased to a predetermined position, reversible motor means connected to said operator, a source of energy, first circuit means between said source of energy and said motor operative when closed to cause energization of said motor in a manner to cause the same to move the operator against its bias, second circuit means operative when closed to cause energization of said motor in a manner to cause reverse movement of said motor to move the operator in the opposite direction, a switch controlling each of said circuit means, and an impedance connected in parallel with the switch in said first circuit means and effective to insure energization of the motor sufficiently that the same is able to maintain the operator in any position to which it is moved when said first and second circuit means are open.

3. A control apparatus of the class described, comprising, in combination, an operator biased to a predetermined position, a condenser motor comprising first and second windings connected together at one end and a condenser connected between the other terminals of the windings, a source of energy, means for connecting said source of energy to the common terminals of said two windings, and switching means for selectively connecting said source of energy with the terminal of either of said other windings so as to cause said motor to move in either of two directions depending upon which of said windings is connected directly to said source of energy, means operatively connecting said motor to said operator and effective upon said motor moving in a direction accompanying a direct connection of said first winding to move said operator against its bias, and an impedance connected between said source of energy and the terminal of said first winding independently of said switching means to cause said motor to be constantly energized in a manner to maintain said operator against its bias in any given position.

4. A control apparatus of the class described, comprising, in combination, an operator biased to a predetermined position, reversible motor means connected to said operator, a source of energy, first circuit means between said source of energy and said motor operative when closed to cause energization of said motor in a manner to cause the same to move the operator against its bias, second circuit means operative when closed to cause energization of said motor in a manner to cause reverse movement of said motor to move the operator in the opposite direction, a switch controlling each of said circuit means, an impedance connected in parallel with the switch in said first circuit means and effective to insure energization of the motor sufficiently that the same is able to maintain the operator in any position to which it is moved when said switch in said first circuit means is open, operating means for said switch, and means including a device responsive to a condition operative to move said switch so as to close either said first or said second circuit means upon a change in the value of said condition and to maintain said switch in said circuit controlling position until said operator has been moved an amount corresponding to such change.

5. A control system of the class described, comprising, in combination, a regulator for a condition changing device, means biasing said regulator to an extreme position, reversible electrical motor means connected to said regulator for moving the same towards and from its biased position, means for constantly partially energizing said motor in a first direction so that in any position of said regulator said motor will exert sufficient torque opposing said biasing means to maintain said regulator in said position, and means including a device responsive to a condition operative upon said condition changing in a first direction to completely energize said motor in said first direction to move said regulator against its bias and to maintain such energization until said regulator has moved an amount proportional to said change, said means further being operative upon said condition changing in the opposite direction to energize said motor in substantially the opposite direction in an amount exceeding said constant partial energization in the first direction and to maintain such energization until the biasing means and the motor jointly have moved the regulator an amount proportional to such change.

6. A control apparatus of the class described, comprising, in combination, an operator biased to a predetermined position, a reversible electrical motor connected to said operator, said motor having two phase windings, a single phase source of power, phase displacing means, means including a switch for connecting said windings to said source of power with said phase displacing means in series with one or the other of said windings so as to cause said motor to rotate in one direction or the other, and means normally constantly connecting said windings through an impedance to said source of power with said phase displacing means so connected as to cause said motor to develop a torque opposing the bias on said operator, said impedance having a value such that said torque is sufficient to counteract the effect of said bias whereby said operator is held in the desired position.

7. A control apparatus of the class described, comprising, in combination, a regulator for a condition changing device, means biasing said regulator to an extreme position, reversible motor means connected to said regulator, a source of energy, first circuit means between said source of energy and said motor operative when closed to cause energization of said motor in a manner to cause the same to move the regulator against its bias, second circuit means operative when closed to cause energization of said motor in a manner to cause reverse movement of said motor to move the regulator in the opposite direction, a switch controlling each of said circuit means, an impedance connected in parallel with the switch in said first circuit means and effective to insure energization of the motor sufficiently that the same is able to maintain the regulator in any position to which it is moved when said first and second circuit means are open, normally balanced opposed electrical means controlling the position

of said switch, a condition responsive variable impedance controlling the relative energization of said electrical means, a second follow-up variable impedance also controlling the relative energization of said electrical means, a connection between said motor and said variable impedance operative upon a movement of said motor caused by an unbalance in the energization of said switch controlling means produced by a change in the value of said condition responsive variable impedance, to vary said impedance in a direction and to an extent sufficient to effect rebalance in the energization of said electrical means after a change in the position of said regulator proportional to the change in the value of said condition responsive impedance.

8. A control apparatus of the class described, comprising, in combination, an operator biased to a predetermined position, reversible motor means connected to said operator, a source of energy, first circuit means between said source of energy and said motor operative when closed to cause energization of said motor in a manner to cause the same to move the operator against its bias, second circuit means operative when closed to cause energization of said motor in a manner to cause reverse movement of said motor to move the operator in the opposite direction, a switch controlling each of said circuit means, an impedance connected in parallel with the switch in said first circuit means and effective to insure energization of the motor sufficiently that the same is able to maintain the operator in any position to which it is moved when said switch in said first circuit means is open, normally balanced opposed electrical means controlling the position of said switch, a control potentiometer and a rebalancing potentiometer each having a fixed resistance and a movable contact and jointly controlling the relative energization of said switch controlling electrical means, a connection between said motor and the movable contact of said rebalancing potentiometer operative upon a movement of said motor caused by a change in the position of the movable contact of the control potentiometer with the resultant unbalance in the energization of said switch controlling means to move said contact of said rebalancing contact in a direction and to an extent sufficient to effect rebalance in the energization of said electrical means after a change in the position of said operator proportional to the change in the position of the movable contact of said control potentiometer.

9. A control apparatus of the class described, comprising, in combination, a regulator for a condition changing device, said regulator being biased to a predetermined position, reversible motor means connected to said regulator, a source of energy, first circuit means between said source of energy and said motor operative when closed to cause energization of said motor in a manner to cause the same to move the regulator against its bias, second circuit means operative when closed to cause energization of said motor in a manner to cause reverse movement of said motor to move the regulator in the opposite direction, a switch controlling each of said circuit means, an impedance connected in parallel with the switch in said first circuit means and effective to insure energization of the motor sufficiently that the same is able to maintain the regulator in any position to which it is moved when said switch in said first circuit means is open, normally balanced opposed electrical means controlling the position of said switch, a control potentiometer and a rebalancing potentiometer each having a fixed resistance and a movable contact and jointly controlling the relative energization of said switch controlling electrical means, a condition responsive device and connections between said condition responsive device and the movable contact of said control potentiometer, and a connection between said motor and the movable contact of said rebalancing potentiometer operative upon a movement of said motor caused by a change in the position of the movable contact of the control potentiometer with the resultant unbalance in the energization of said switch controlling means to move said contact of said rebalancing contact in a direction and to an extent sufficient to effect rebalance in the energization of said electrical means after a change in the position of said regulator proportional to the change in the position of the movable contact of said control potentiometer.

10. A control apparatus of the class described, comprising, in combination, an operator biased to a predetermined position, a reversible electrical motor connected to said operator, said motor having two phase windings, a single phase source of power, phase displacing means, means including a switch for connecting said windings to said source of power with said phase displacing means in series with one or the other of said windings so as to cause said motor to rotate in one direction or the other, means normally constantly connecting said windings through an impedance to said source of power with said phase displacing means so connected as to cause said motor to develop a torque opposing the bias on said operator, said impedance having a value such that said torque is just sufficient to overcome said bias whereby said operator is held in the desired position, normally balanced electrical means controlling the position of said switch, a control variable impedance and a rebalancing electrical impedance jointly controlling the balance in the energization of said switch controlling means, and connections between said motor and said rebalancing impedance operative upon a movement of said motor caused by a change in the value of the control impedance with the resultant unbalance in the energization of said switch controlling means to vary said rebalancing impedance in a direction and to an extent sufficient to effect rebalance in the energization of said electrical means after a change in the position of said operator proportional to the change in value of said control potentiometer.

11. In combination, an operator biased to one position, a reversible electric motor connected to said operator for moving the same towards and from said position, a source of electrical energy, a first circuit between said source and said motor operative when completely energized to cause said motor to move said operator away from said position against its bias, a second circuit between said source of energy and said motor operative when completely energized to move said operator towards said position independently of said biasing, and means for constantly partially energizing said first circuit whereby said motor continuously exerts a torque sufficient to overcome said bias and hold said operator stationary and for causing the resultant torque exerted by said motor upon closure of said second circuit to be reduced so as to compensate for the aiding effect of the bias.

12. In control apparatus of the class described, an operator biased to a predetermined position,

a reversible electric motor connected to said operator, said motor having two phase windings, a single phase source of power, means including a switch and a phase displacing means for selectively energizing said motor with different degrees of energization and with different amounts and directions of phase displacement, said means being effective in one position of said switch to cause said motor to be energized with the amount of and the extent and direction of phase displacement of the current through the windings such that the motor moves the operator against its bias, said means being effective in another position of said switch to cause said motor to be energized in such a manner that the torque developed just overcomes that exerted by the bias without moving said operator, and said means being effective in still another position of said switch to cause said motor to be energized with a substantially opposite but lesser phase displacement such that the torque developed aids and supplements that exerted by the bias.

13. In control apparatus of the class described, an operator biased to a predetermined position, a reversible electric motor connected to said operator, said motor having two phase windings, a single phase source of power, means including a switch and a phase displacing means for selectively energizing said motor with different degrees of energization and with different amounts and directions of phase displacement, said means being effective in one position of said switch to cause said motor to be energized with the amount of and the extent and direction of phase displacement of the current through the windings such that the motor moves the operator against its bias, and in another position of the switch to cause the motor to be energized with a substantially opposite but lesser phase displacement such that the torque developed aids and supplements that exerted by the bias.

14. A control apparatus of the class described, comprising, in combination, an operator biased to a predetermined position, a reversible electrical motor connected to said operator, said motor having two phase windings, a single phase source of power, a capacitance arrangement, a resistance, means including a switch for connecting said windings to said source of power with said capacitance arrangement and said resistance selectively connected so that in a first position of said switch a first of said windings is connected to said source of power in series with said capacitance arrangement and the other is connected to said power source independently of said capacitance arrangement to cause a phase displacement and an energization such that the resultant torque moves the operator against its bias, that in a second position of the switch the windings are similarly connected to said source of power but with said resistance in series with both windings so that the phase displacement remains unchanged but the energization is sufficiently reduced that the torque is able to hold the operator against its bias but not to move it, and in a third position of said switch, the first of said windings is connected to said source of power independently of said capacitance arrangement and said resistance and the second of said windings is connected to said power source in series with said capacitance arrangement and said resistance in parallel, so that the phase displacement is opposite to but less than when said switch is in its first or its second position with the result that the motor torque supplements and aids the biasing means in moving the operator towards its biased position.

15. In combination, a device biased to one position, a reversible capacitor motor connected to said device for moving it towards and from said biased position, means including a reversing switch for controlling the connection of the capacitance of said motor and hence the direction of rotation of said motor, a resistance, and means for connecting said resistance in parallel with said capacitance when said switch is in a position in which the torque of the motor is aided by the biasing means.

WILLIS H. GILLE.