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CONTROL APPARATUS

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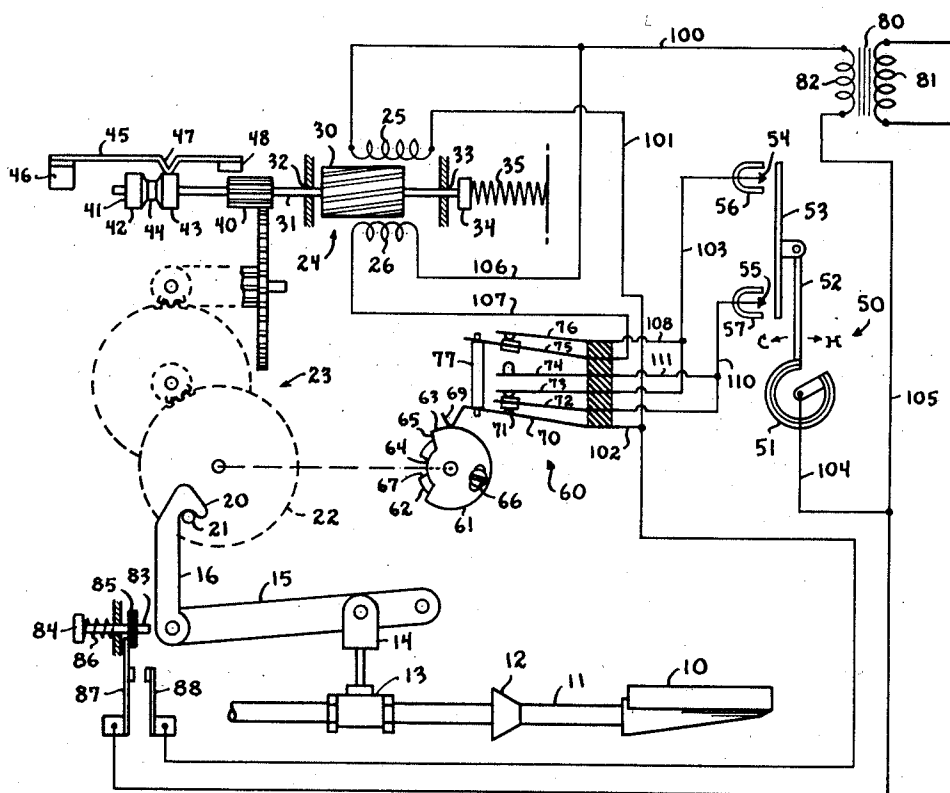


Fig. 1

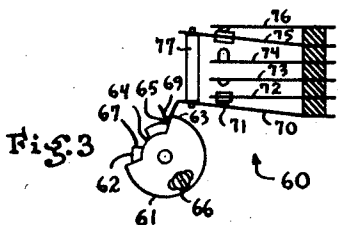


Fig. 3

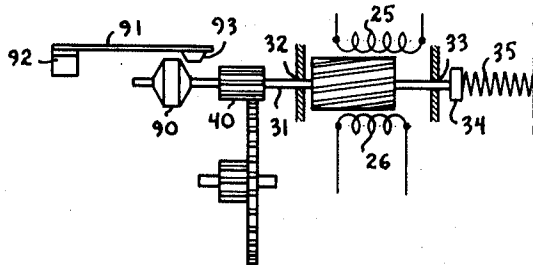


Fig. 2

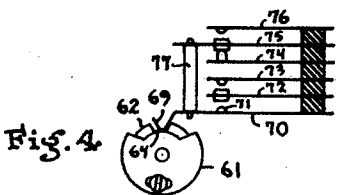


Fig. 4

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CONTROL APPARATUS

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16 Claims. (Cl. 172-239)

The present invention relates to control apparatus in general and particularly to motorized valves.

An object of this invention is to construct an improved valve of the type which is biased to closed position and operable toward open position by an electrical motor.

Another object of the present invention is to provide a braking mechanism for a motor-driven valve which shall be effective to hold the valve in a predetermined open position, but which shall be ineffective in the event of power failure.

Another object is to provide improved and simplified control apparatus for a motorized valve whereby the valve may be automatically moved to any of three positions, for example, full open, intermediate and closed.

A further object of the present invention is to provide, in an electrically actuated valve of the type which may be energized in one manner for movement toward open position and in another manner for holding in an open position, a braking mechanism which is effective only when the valve is energized for holding.

A further object of the invention is to provide an improved and simplified control circuit for a motorized valve operable between closed, intermediate, and open positions. A still further object is to provide, in such a control circuit, means for adjusting the intermediate position with respect to the open and closed positions.

A further object of the present invention is to provide a motor operator device having an armature movable in an endwise direction and winding means controllable for energization at different intensities, and braking means operated upon endwise movement of said armature to a position indicative of energization of said winding means at one predetermined intensity.

Other objects and advantages of the present invention will become apparent from a consideration of the attached specification, claims, and drawing, in which:

Figure 1 represents, somewhat diagrammatically, a valve operating arrangement embodying my invention,

Figure 2 represents a modification of the braking mechanism shown in Figure 1, and

Figures 3 and 4 illustrate certain parts of the arrangement shown in Figure 1, in different positions corresponding to different conditions of operation.

In Figure 1, a burner 10 is shown, to which a mixture of fuel and air is supplied through a pipe 11. The air may be admitted to the pipe

11 by means of a manifold 12 of any conventional type. The supply of fuel through the pipe 11 is controlled by a valve 13.

The valve 13 is operated by means of a stem 14 projecting upwardly therefrom, the upper end of which is connected to a lever 15. The left-hand end of the lever 15 is pivotally connected to a vertical link 16. The upper end of the vertical link 16 is provided with a hook 20 which cooperates with a pin 21 attached to a gear 22. The gear 22 is the last of a train, generally indicated at 23, driven by a motor 24, which is provided with two stator windings 25 and 26.

The valve 13 is provided with a spring or other internal biasing means (not shown) which tends to keep it in closed position and is capable of moving the valve and gear train to closed position when the motor 24 is deenergized.

The motor 24 is provided with a rotor 30 which turns on a shaft 31. The shaft 31 is mounted for rotation and for endwise translation in bearings 32 and 33. The right-hand end shaft 31, as it appears in the drawing, is provided with a thrust bearing plate 34. A compression spring 35 bears against the plate 34, the other end of the spring 35 being fixed.

A pinion 40 and a cam 41 are also mounted on the shaft 31 of motor 24. The cam 41 is provided with high end portions 42 and 43 and a low central portion 44. A spring 45 is supported at one end 46 and biased so that a suitably formed central portion 47 engages the cam 41, and serves as a follower therefor. A dog 48 is supported at the end of the spring on 45 opposite its support 46. The arrangement is such that when the follower portion 47 is riding on the high parts 42 and 43 of the cam 41, the dog 48 is held out of engagement with the pinion 40. When the follower 47 drops to the low central portion of the cam 41, the dog 48 moves into engagement with the teeth of pinion 40, thereby preventing rotation of the pinion.

Winding 25, hereinafter referred to as the running winding, is more powerful than winding 26, hereinafter referred to as the holding winding. As indicated in the drawing, the center of winding 26 may be located somewhat to the left of the center of winding 25, for a purpose to be described.

When the motor windings 25 and 26 are deenergized, the spring 35 biases the shaft 31 to the position shown in the drawing. In this position, the follower 47 is riding on the high dwell portion 43 of the cam 41, thereby holding dog 48 out of engagement with the pinion 40. If the winding

23 alone is energized, the rotor 30 is magnetically attracted and moves a short distance to the right, compressing spring 35, and moving cam 41 so that follower 47 drops to the central portion 44 of cam 41, thereby causing engagement of dog 43 with pinion 40. When windings 25 and 26 are both energized, the rotor 30 is attracted still further to the right, because of the relatively greater strength of winding 25 and its physical position to the right of winding 26. This movement of rotor 30 carries cam 41 further to the right, causing the follower 47 to move to the high dwell portion 42 of cam 41. Movement of the follower 47 to the high dwell portion 42 of cam 41 causes disengagement of dog 43 from pinion 40 and allows free rotation of the rotor 30 under the influence of windings 25 and 26.

It is not necessary that the winding 25 be disposed with its magnetic center to the right of the magnetic center of winding 26, as shown in the drawing, in order to cause movement of rotor 30 to different positions upon selective energization of the two windings. The same result may be produced by the difference in strength of the two windings, alone, as the stronger winding is able to compress the spring 35 more than the weaker, and hence moves the rotor 30 further to the right.

Furthermore, it should be obvious that the brake arrangement shown in Fig. 1 is not limited to engagement of dog 48 with pinion 40 on the motor shaft. A similar dog could be readily designed to engage other points on the gear train between the motor and the valve.

Energization of the motor windings 25 and 26 is controlled by a thermostat generally indicated as 50 which is located in the room or space being heated by the burner 10 and consists of a bimetallic element 51 operating in arm 52. As indicated by the legend in the drawing, the operation of the bimetallic element 51 is such as to move the arm 52 to the left as the temperature decreases. Pivotaly attached to the arm 52 is a double-ended contact arm 53 of magnetic material. The upper end of the contact arm 53 which is longer than the lower end cooperates with a stationary contact 54 and the lower end cooperates with a stationary contact 55. Permanent magnets 56 and 57 are provided adjacent each of the stationary contacts so as to give a snap action to the thermostat in a manner to be described later.

A switching device 60, operated in accordance with the position of the valve 13, cooperates with the thermostat 50 in controlling the energization of the motor windings 25 and 26. The switching mechanism 60 is operated by a pair of cam members 61 and 62. The cam member 62 is fixed on the same shaft as the gear 22 and is connected with cam 61 by an adjustable pin and slot connection 66. That part of the cam 61 concerned with the operation of the switch mechanism 60 comprises a high dwell portion 63 and a low dwell portion 64 connected by an intermediate abrupt drop-off portion 65. The cam member 62 is of smaller diameter than the cam member 61 and is of uniform circular periphery except for a deep notch 67. The radius of cam 62 is intermediate that of the high dwell portion 63 of cam 61 and that of low dwell portion 64 of cam 61.

The cam members 61 and 62 are preferably formed of insulating material. A flexible follower arm 70 is rigidly supported at one end and suitably formed at its other end 69 to engage the surface of the cam members 61 and 62. The follower 70 is provided with a contact 71 intermediate

its length. A series of flexible contact members 72, 73, 74, 75 and 76 are mounted above the flexible arm 70 to be actuated thereby. These flexible contact members are insulated from each other by suitable insulating blocks by which they are supported. The flexible arm 70 and the flexible arm 75 are connected by an insulating member 77.

The system is supplied with energy through a transformer 80 having a primary winding 81 and a secondary winding 82.

Means are provided for holding the valve 13 partially open when the system is deenergized as a result of power failure. This means includes a rod 83 operable by a push button 84. The rod 83 is biased for movement to the left by a spring 86 surrounding the rod between the button 84 and a fixed part which supports the rod. During power failure conditions, the left-hand end of the lever 15 may be manually moved upwards and the push button 84 may then be operated so that the end of the rod 83 prevents downward movement of the lever 15. An insulating disc 85 on the rod 83 engages a flexibly biased switch arm 87 and normally tends to hold it out of engagement with the stationary contact 88. When the push button 84 is moved to the right, however, the disc 85 moves to the right also and the bias of the switch arm 87 carries it into engagement with the stationary contact 88.

Figure 2 illustrates a modified form of the brake mechanism shown in Figure 1. In Figure 2, the shaft 31 carries a brake drum 90. A flexible arm 91 adjacent the shaft 31 is supported at one end 92 and carries at its opposite end a brake shoe 93. The brake shoe 93 is of some suitable friction material. When the shaft 31 is moved endwise upon energization of the windings 25 and 26, the drum 90 is carried into and out of engagement with the brake shoe 93. The brake shoe 93 engages drum 90 and prevents rotation of the shaft 31 when the winding 26 only is energized. The operation is entirely analogous to the engagement of dog 48 with pinion 40 when the winding 26 only is energized, as described in connection with Figure 1.

Operation

The various parts of my system are shown in Figure 1 in the position they assume when the valve 13 is closed and the thermostat 50 is satisfied. Under such conditions, let it be assumed that the temperature in this space served by the thermostat 50 begins to drop. The arm 52 is thereby moved to the left by the action of the bimetallic element 51, and the upper end of the contact arm 53 moves into the field of the permanent magnet 56. This movement continues until the strength of the magnetic field is sufficient to attract the contact arm 53 with a sudden snapping movement. This causes engagement of contact arm 53 with stationary contact 54, thereby completing an energizing circuit for both windings 25 and 26 of motor 24.

The energizing circuit for motor winding 25 may be traced from the upper terminal of transformer secondary winding 82 through a conductor 100, winding 25, a conductor 101, a conductor 102, contact arms 72, 72 and 73, a conductor 103, contact 54, contact arm 53, arm 52, bimetallic element 51, and conductors 104 and 105 to the lower terminal of transformer secondary winding 82.

The energizing circuit for winding 26 may be traced from the upper end of transformer secondary winding 82 through conductor 100, a con-

ductor 106, winding 26, a conductor 107, contact arms 75 and 76, a conductor 108, conductor 103, contact 54, switch arm 53, arm 52, bimetallic element 51, and conductors 104 and 105 to the lower terminal of transformer secondary winding 82.

Energization of windings 25 and 26 causes rotor 30 to be attracted to its extreme right hand position, thereby lifting follower 47 to the high dwell portion 42 of cam 41, and disengaging dog 48 from pinion 40. Energization of windings 25 and 26 also causes rotor 30 to rotate, thereby driving the valve 13 toward open position. As the valve 13 is moved toward open position, the cam members 61 and 62 are rotated in a clockwise direction. The movement of valve 13 towards open position continues until the cam members 61 and 62 reach the position illustrated in Figure 3. When the cam members 61 and 62 reach this position, the follower 69 drops from the high portion 63 of cam 61. This movement allows the contact members 72 and 73 to separate before follower 69 engages cam member 62, thereby opening the energizing circuit for the winding 25. Winding 26 is now energized alone, and rotor 30 is moved to the left by the action of compression spring 35. The spring 35 moves the shaft 31 to the left until the rotor 30 is at a position where the force of spring 35 balances that of winding 26, at which time follower 47 drops into the low dwell portion 44 of the cam 41, thereby causing engagement of dog 48 with the pinion 40. Energization of winding 26 holds the rotor 30 in this intermediate position against the action of spring 35. The motor 24 is therefore locked against rotation by engagement of dog 48 with pinion 40. Because of this locking of the shaft 31, the rotor 30 may not be caused to rotate because of small changes in the applied voltage, such as are common on commercial power lines.

The cam members 61 and 62 are therefore positively held in the position shown in Fig. 3, where the follower 69 has just moved off the high dwell portion 63 of cam 61, and has not yet engaged cam 62. It will be seen that by means of the pin and slot connection 66, the position to which the valve 13 is moved upon closure of contacts 53 and 54 may be adjusted.

The valve 13 is now in its intermediate position, which may be for example, half open. The valve remains in this position until some change in the temperature of the space adjacent the thermostat 50 takes place. If the temperature continues to drop, the arm 52 continues to move to the left and the lower end of switch arm 53 approaches more closely the stationary contact arm 55. This motion continues until the arm 53 reaches a point where the strength of the field of permanent magnet 57 is sufficient to attract the arm 53 with a snapping action. Engagement of contact arm 53 with contact 55 completes a new energizing circuit for winding 25 which may be traced from the upper terminal of transformer secondary winding 82 through conductor 100, winding 25, conductors 101 and 102, switch blades 70 and 72, a conductor 110, contact 55, contact arm 53, arm 52, bimetallic element 51, and conductors 104 and 105 to the lower terminal of secondary winding 82.

When winding 25 is energized, the rotor 30 is again attracted to its extreme right-hand position, and the dog 48 is disengaged from pinion 40, thereby permitting rotation of the motor 24. The motor rotates in a direction such as to drive the valve 13 further towards open position and moves the cams 61 and 62 in a clock-wise direction. As

this movement of the cams starts, follower 69 moves down into engagement with cam 62, causing contact 75 to separate from contact 76 and engage contact 74. This opens the previously traced energizing circuit for winding 25, but a new energizing circuit for winding 26 is now established by engagement of contact members 74 and 75.

This new energizing circuit may be traced from the upper end of transformer secondary winding 82 through conductor 100, conductor 106, winding 26, conductor 107, contacts 75 and 74, a conductor 111, conductor 110, contact 55, contact arm 53, arm 52, bimetallic element 51, and conductors 104 and 105 to the lower terminal of secondary winding 82.

This movement of the valve 13 continues until the valve is fully open, at which time the cams 61 and 62 reach the position shown in Figure 4. In this position, the follower 69 has moved from the cam 62 down on to the low dwell portion 64 of the cam member 61. This breaks the energizing circuit for winding 25 between the contact members 70 and 72.

Energization of winding 26 alone causes rotor 30 to move again to its intermediate longitudinal position, so that cam 41 operates dog 48 into engagement with pinion 40, and the valve is held in its full open position. Let it now be assumed that the temperature in the space adjacent the thermostat 50 begins to rise. As the temperature rises, the bimetallic element 51 tends to move the arm 52 to the right, which motion is opposed by the attraction of the permanent magnets 56 and 57. The force exerted by the bimetallic element 51 soon becomes large enough to overcome the attraction on one of these magnets. Since magnet 56 is operating at the end of a longer lever arm than the magnet 57, the latter is overcome first, thereby separating contact arm 53 from the contact 55 with a sudden snap action. This opens the energizing circuit last traced for winding 26, thereby allowing rotor 30 to move to its extreme left-hand position. This movement causes the release of dog 48 from pinion 40, and valve 13 starts to move towards its closed position under its internal bias, dragging the gear train and rotating the motor 24. This motion continues until the cams 61 and 62 move back to the position illustrated in Figure 3, when the contact members 75 and 76 engage, thereby again completing the original energizing circuit for holding winding 25. Energization of holding winding 26 causes the rotor 30 to move endwise to its intermediate position thereby again causing engagement of dog 48 with pinion 40.

The valve then remains in its intermediate position. If the temperature adjacent thermostat 50 continues to rise, the force supplied by the bimetallic element 51 will become sufficient to overcome the attraction of permanent magnet 56 for the switch arm 53. When this occurs, contact 54 will be separated from contact arm 53 with a snap action, thereby opening the energizing circuit for winding 25. Opening of this circuit will allow the rotor 30 to move again to its extreme left-hand position thereby again disengaging dog 48 from pinion 40. The internal bias of valve 13 will again come into play, moving the valve to closed position and driving the cams 61 and 62 to the position shown in Fig. 1.

It should be apparent that the circuit disclosed herein would be operative, at least theoretically, without the braking mechanism disclosed. It has been found, however, that because of the

voltage fluctuations present in all commercial power systems, a valve operating mechanism of this type cannot successfully hold the valve in its intermediate position, unless a brake is used. When no brake is used, an increase in the supply voltage above its normal value will cause the valve to creep towards open position when only the holding winding is energized. On the other hand, a decrease in supply voltage causes the valve to creep toward closed position.

With a sensitive switching arrangement such as that disclosed, such creeping causes objectionable oscillation, or hunting, of the valve. For example, assume that the valve is in its intermediate position, with the cam operated switches in the position shown in Fig. 3. If, due to a decrease in supply voltage, the valve started to creep toward closed position, the creep would continue until contacts 72 and 73 engaged, whereupon winding 25 would be momentarily energized to drive the valve a short distance towards open position. The valve would again start creeping closed, and this cycle would be repeated as long as the supply voltage remained below its normal value. Provision of a braking mechanism such as that disclosed avoids such objectionable sensitivity to variations in supply voltage.

Other modifications of my invention will readily occur to those skilled in the art. I therefore do not wish to be limited by the disclosure here, but only by the scope of the appended claims.

I claim as my invention:

1. In combination, a device to be actuated between a safe position and an active position, means for biasing said device toward said safe position, means including a rotary electrical motor for operating said device toward said active position, an armature for said motor mounted for rotation and endwise translation between a first position and a second position, means biasing said armature to said first position, braking means for preventing rotation of said armature, said braking means being applied by translation of said armature to a third position intermediate said first and second positions, winding means for said motor and means for selectively energizing said winding means at one of two levels of intensity, said winding means being effective when energized at the higher of said levels to translate said armature to said second position and rotate said armature so as to move said device against its bias, and effective when energized at the lower of said two levels to translate said armature to said third position, thereby applying said brake to prevent rotation of said armature.

2. In combination, a device to be actuated between a safe position and an active position, means for biasing said device toward said safe position, means including a rotary electrical motor for operating said device toward said active position, an armature for said motor mounted for rotation and endwise translation between a first position and a second position, means biasing said armature to said first position, braking means for preventing rotation of said armature, means associated with said armature for engaging said braking means when said armature is in a third position intermediate said first and second positions, winding means for said motor, means for controlling the energization of said winding, said controlling means being selectively operable to energize said winding in a first manner whereby said armature is translated to said

second position and rotated to move said device toward said active position, in a second manner whereby said armature is translated to said third position and said braking means is engaged to prevent movement of said device, or to deenergize said winding whereby said armature is translated to said first position by said armature biasing means, permitting rotation of said armature and movement of said device toward said safe position by said device biasing means.

3. In combination, a device to be actuated between a safe position and an active position, means for biasing said device toward said safe position, a rotary electrical motor for operating said device toward said active position, means including a gear connecting said motor and said device, an armature for said motor, a shaft for said armature mounted for rotation and endwise translation between a first position and a second position, means biasing said armature to said first position, braking means including a dog for engaging said gear to prevent rotation thereof, and cam means on said shaft for actuating said braking means upon endwise translation of said shaft, said cam means being effective when said shaft is in said first or second positions to disengage said dog from said gear, and effective when said shaft is in a third position intermediate said first and second positions to engage said dog with said gear.

4. In combination, a device to be actuated between a safe position and an active position, means for biasing said device toward said safe position, means including a rotary electrical motor for operating said device toward said active position, an armature for said motor mounted for rotation and endwise translation between a first position and a second position, means biasing said armature to said first position, braking means for preventing rotation of said armature, means associated with said armature for engaging said braking means when said armature is in a third position intermediate said first and second positions, a lifting winding and a holding winding for said motor, said lifting winding being effective when energized to move said armature to said second position and simultaneously cause it to rotate, said holding winding being effective to move said armature to said third position, thereby engaging said brake, a first pair of circuits for energizing said lifting winding a second pair of circuits for energizing said holding winding, first switch means responsive to a condition indicative of the need for operation of said device for selectively closing said circuits, said first switch means comprising a pair of sequentially actuated switches, each of said switches being connected in one of each pair of circuits, and second switch means responsive to the position of said device for selectively controlling said circuits whereby said device is moved and held in a position determined by the operation of said first switch means.

5. A two-stage control system, comprising in combination, a device biased to a safe position and adapted to be actuated to either of two active positions, means including a rotary electrical motor for operating said device, a lifting winding and a holding winding for said motor, a first pair of circuits for energizing said lifting winding, a second pair of circuits for energizing said holding winding, first switch means responsive to a condition indicative of the need for operation of said device for selectively closing said circuits, said first switch means comprising a pair of sequentially actuated switches, each of said

switches being connected in one of each pair of circuits, and second switch means responsive to the position of said device for selectively controlling said circuits whereby said device is moved and held in a position determined by the operation of said first switch means.

6. A two-stage control system, comprising in combination, a device biased to a safe position and adapted to be actuated to either of two active positions, means including a rotary electrical motor for operating said device, a lifting winding and a holding winding for said motor, an armature for said motor mounted for rotation and endwise translation between a first position and a second position, means biasing said armature to said first position, braking means for preventing rotation of said armature, means associated with said armature for engaging said braking means when said armature is in a third position intermediate said first and second positions, said lifting winding being effective when energized to move said armature to said second position and rotate said armature, said holding winding being effective when energized to move said armature to said third position, first switch means comprising a pair of switches sequentially operated in response to a condition indicative of the need for operation of said device, second switch means operated in accordance with the position of said device, connections between said first and second switch means and said windings whereby upon closure of one of said pair of switches said device is moved to a predetermined one of said active positions by energization of said lifting winding, and held in said predetermined position by energization of said holding winding.

7. A two-stage control system, comprising in combination, a device biased to a safe position and adapted to be actuated to either of two active positions, means including a rotary electrical motor for operating said device, a lifting winding and a holding winding for said motor, braking means for preventing rotation of said armature and operable simultaneously with energization of said holding winding, a first pair of circuits for energizing said lifting winding, a second pair of circuits for energizing said holding winding, first switch means responsive to a condition indicative of the need for operation of said device for selectively closing said circuits, said first switch means comprising a pair of sequentially actuated switches, each of said switches being connected in one of each pair of circuits, and second switch means responsive to the position of said device for selectively controlling said circuits whereby said device is moved and held in a position determined by the operation of said first switch means.

8. In combination, a device to be positioned, a rotary electrical motor for positioning said device, an armature for said motor mounted for rotation and endwise translation between a first position and a second position, means biasing said armature to said first position, braking means for preventing rotation of said armature, means associated with said armature for engaging said braking means when said armature is in a third position intermediate said first and second positions, a first winding for said motor, said first winding being effective when energized to move said armature to said second position and rotate it, and a second winding for said motor, said second winding being effective when energized to move said armature to said third position and thereby actuate said braking means.

9. In combination, a device to be actuated between a safe position and an active position, means for biasing said device toward said safe position, means including a rotary electrical motor for operating said device toward said active position, a first winding for said motor, effective to cause rotation thereof and movement of said device against said biasing means, a second winding for said motor effective to hold said motor and said device from movement by said biasing means, a source of electrical energy for said windings, and braking means actuated simultaneously with energization of said second winding alone to prevent movement of said motor and said device.

10. In combination, a device to be actuated between a safe position and an active position, means for biasing said device toward said safe position, means including a rotary electrical motor for operating said device toward said active position, a first winding for said motor effective to cause rotation thereof and movement of said device against said biasing means, a second winding for said motor effective to hold said motor and said device from movement by said biasing means, a source of electrical energy for said windings, switch means responsive to the position of said device for controlling energization of said second winding, and braking means actuated simultaneously with energization of said second winding alone to prevent movement of said motor and said device.

11. A two-stage control system, comprising in combination, a device biased to a safe position and adapted to be actuated to either of two active positions, means including a rotary electrical motor for operating said device, a lifting winding and a holding winding for said motor, a first pair of circuits for energizing said lifting winding, a second pair of circuits for energizing said holding winding, first switch means responsive to a condition indicative of the need for operation of said device for selectively closing said circuits, said first switch means comprising a pair of sequentially actuated switches, each of said switches being connected in one of each pair of circuits, cam means operated simultaneously with said device, a single follower for said cam means, and second switch means operated by said follower for selectively controlling said circuits whereby said device is moved and held in a position determined by the operation of said first switch means.

12. A two-stage control system, comprising in combination, a device biased to a safe position and adapted to be actuated to either of two active positions, means including a rotary electrical motor for operating said device, a lifting winding and a holding winding for said motor, a first pair of circuits for energizing said lifting winding, a second pair of circuits for energizing said holding winding, braking means operated upon energization of said holding winding alone for preventing rotation of said motor, first switch means responsive to a condition indicative of the need for operation of said device for selectively closing said circuits, said first switch means comprising a pair of sequentially actuated switches, each of said switches being connected in one of each pair of circuits, cam means operated simultaneously with said device, a single follower for said cam means, and second switch means operated by said follower for selectively controlling said circuits whereby said device is moved and

held in a position determined by the operation of said first switch means.

13. A two-stage control system, comprising in combination, a device biased to a safe position and adapted to be actuated to either of two active positions, means including a rotary electrical motor for operating said device, a lifting winding and a holding winding for said motor, a first pair of circuits for energizing said lifting winding, a second pair of circuits for energizing said holding winding, first switch means responsive to a condition indicative of the need for operation of said device for selectively closing said circuits, said first switch means comprising a pair of sequentially actuated switches, each of said switches being connected in one of each pair of circuits, cam means operated simultaneously with said device, a single follower for said cam means, and second switch means operated by said follower for opening each of said lifting winding circuits at predetermined positions of said device, while preventing closure of more than one of said holding circuits at any position of said device.

14. A two-stage control system, comprising in combination, a device biased to a safe position and adapted to be actuated to either of two active positions, means including a rotary electrical motor for operating said device, a lifting winding and a holding winding for said motor, a first pair of circuits for energizing said lifting winding, a second pair of circuits for energizing said holding winding, first switch means responsive to a condition indicative of the need for operation of said device for selectively closing said circuits, said first switch means comprising a pair of sequentially actuated switches, each of said switches being connected in one of each pair of circuits, cam means operated simultaneously with said device, a single follower for said cam means, second switch means operated by said follower for opening each of said lifting winding circuits at predetermined positions of said device, while preventing closure of more

than one of said holding circuits at any position of said device, said cam means comprising a pair of cam members of different effective sizes, and means for relatively adjusting said members so as to vary the position of said device at which one of said lifting winding circuits is opened by said cam means.

15. In a two-stage control system, in combination, a device biased to a safe position and adapted to be actuated to either of two active positions, means including a rotary electrical motor for operating said device, a lifting winding and a holding winding for said motor, a first pair of electrical connections through which said lifting winding may be energized, a second pair of electrical connections through which said holding winding may be energized, and multiple switch means operated simultaneously with said device for opening each of said first pair of connections at different predetermined positions of said device, while preventing closure of more than one of said second pair of connections at any position of said device.

16. A two-stage mechanism, comprising in combination, a device biased to a safe position and adapted to be actuated to either of two active positions, means including a rotary electrical motor for operating said device, a lifting winding and a holding winding for said motor, a first pair of branch circuits for energizing said lifting winding upon completion of either of said branch circuits, a second pair of branch circuits for energizing said holding winding upon completion of either of said second branch circuits, a first main circuit connected to one each of said first and second branch circuits, a second main circuit connected to the remaining first and second branch circuits, and switch means responsive to the position of said device for selectively controlling said branch circuits in such manner that said device is moved to and held in one or the other of said two active positions upon completion of one or the other of said main circuits.

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