Aug. 26, 1941. H. F. COLLINS 2,253,557

COMBINED LIMIT SWITCH AND RELAY

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Fig. 1.

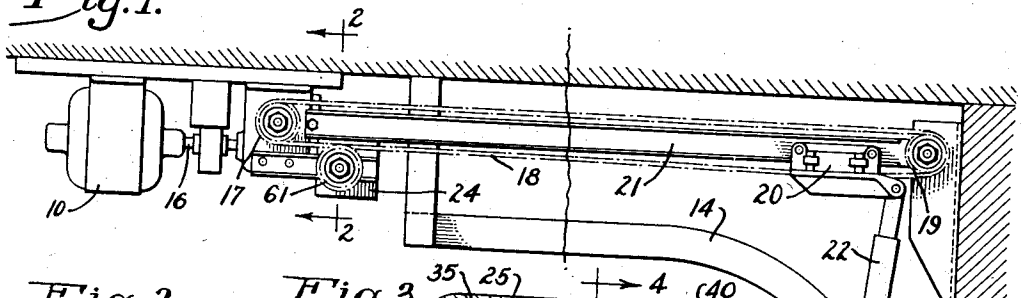


Fig. 2.

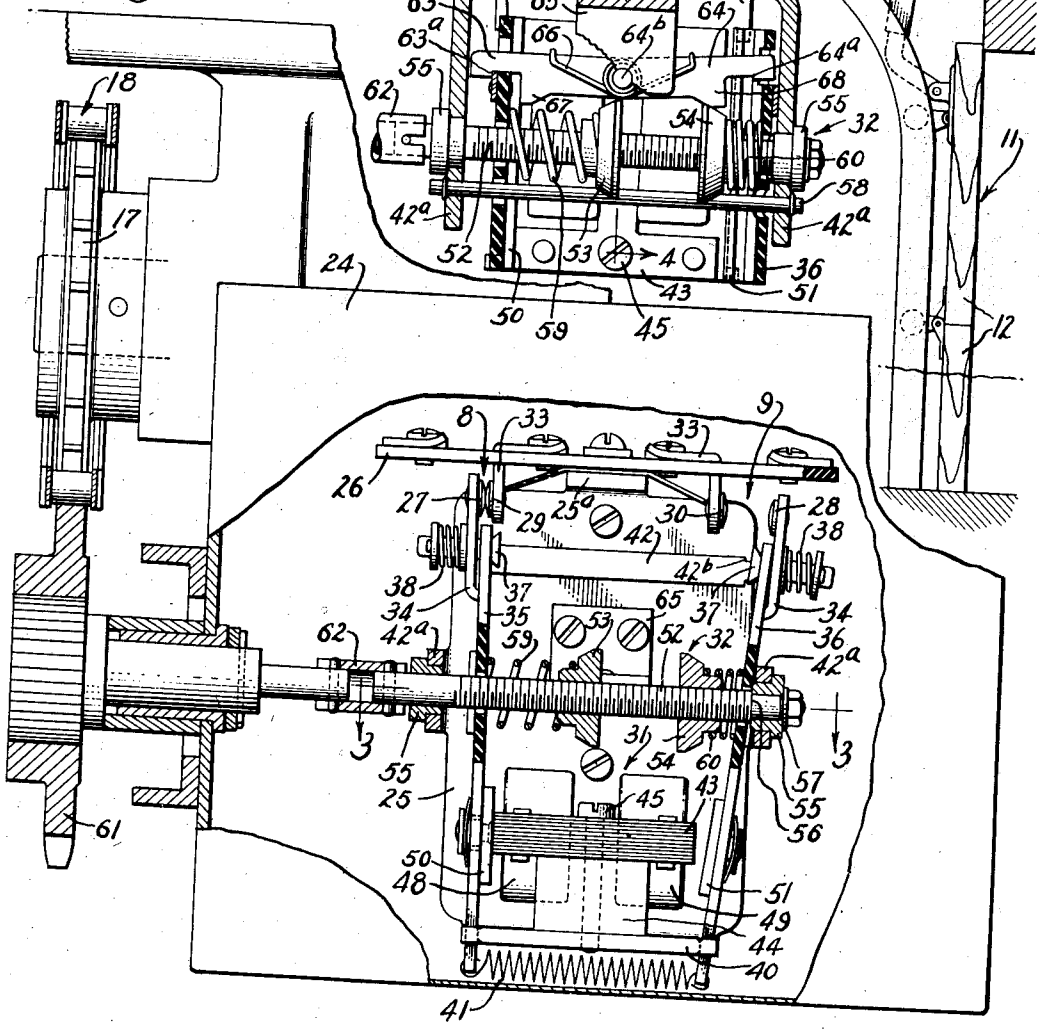


Fig. 3.

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Fig. 4.

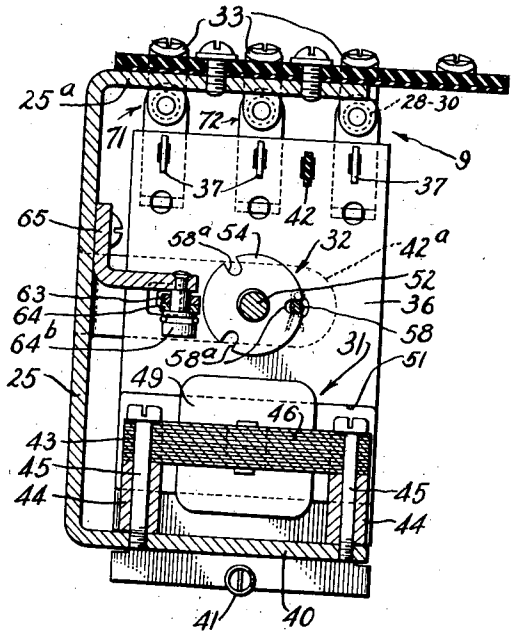
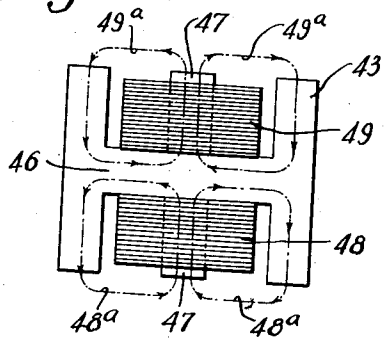


Fig. 5.



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Fig. 7.

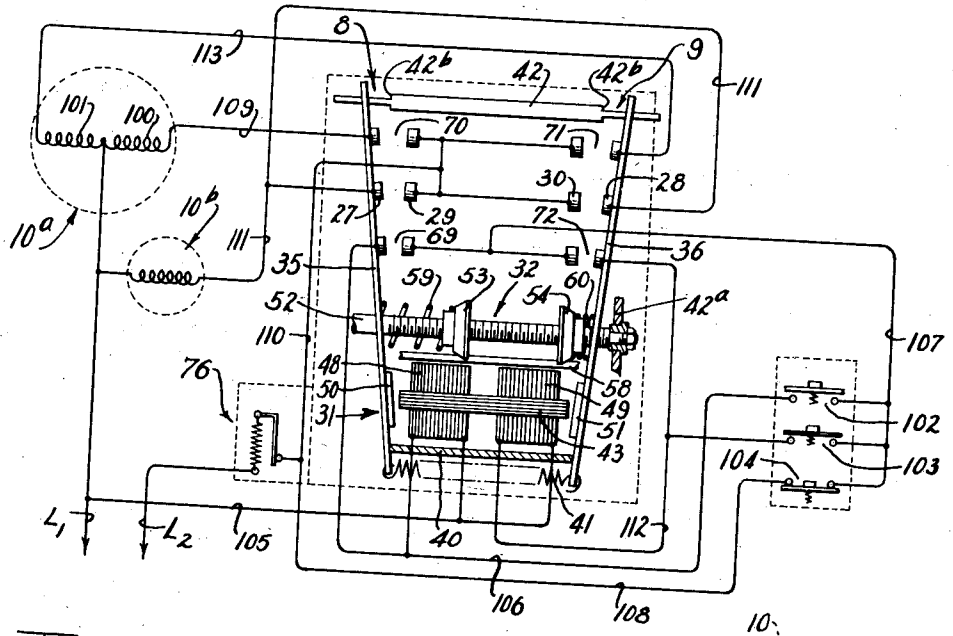
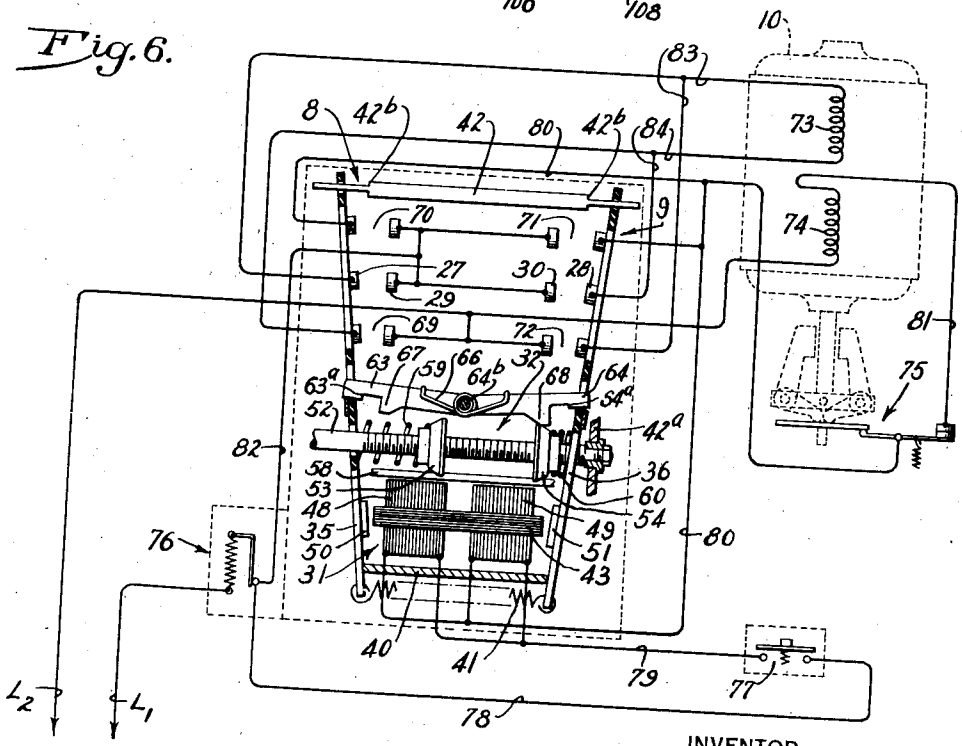


Fig. 6.



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UNITED STATES PATENT OFFICE

2,253,557

COMBINED LIMIT SWITCH AND RELAY

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Application February 27, 1939, Serial No. 258,621

23 Claims. (Cl. 200—104)

The invention relates to a novel electrical device which may be conveniently termed a combined limit switch and relay since it is adapted to perform the functions of both of those heretofore separate devices. In other words, it embodies a switch which is controlled not only by a mechanism operated by some associated driven device movable to a predetermined limit position, in the manner of a limit switch, but such switch is also controlled by an electromagnetic actuator which may be energized under the control of some remote switch in the manner of a relay.

It is customary in control systems of, for example, electric motors arranged to move a member between predetermined limit positions, to provide switch mechanisms including limit and reversing switches actuated by the driven member and two separate electromagnetic relays for starting the motor in opposite directions. The multiplicity of switching devices entailed in such a system manifestly contributes largely to its cost.

It is the main object of the present invention to provide a single unit adapted to accomplish the combined functions of a limit switch and relay.

A more detailed object is to arrange two control switches for operation selectively and in a novel manner by mechanical and electromagnetic actuators so that the two switches will function to start, stop, and determine the direction and extent of movement of a controlled member.

Another object is to provide a combined limit switch and relay of the above character in which different cycles of a motor controlled thereby are initiated alternately in response to successive energization of a single magnetic actuator.

Still another object of the invention is to provide an improved form of combined limit switch and relay of such character as to cause opening of the switches with a rapid snap action.

The invention also resides in the novel construction of the mechanical actuator for the switches and the manner of insuring closure of switches alternately.

Further objects and advantages of the invention will become apparent as the following description proceeds taken in connection with the accompanying drawings in which

Figure 1 is a side elevation of an electric motor operator adapted to be controlled by a switch mechanism embodying the present invention.

Fig. 2 is an enlarged vertical sectional view along the line 2—2 in Fig. 1 showing particularly the novel combined limit switch and relay unit.

Fig. 3 is a transverse sectional view along the line 3—3 in Fig. 2.

Fig. 4 is a vertical sectional view along the line 4—4 in Fig. 3.

Fig. 5 is a detail plan view of the electromagnet for the switch unit.

Fig. 6 is a schematic view and wiring diagram of limit switch and relay unit shown in Figs. 2 to 4 together with its associated circuits.

Fig. 7 is a schematic wiring diagram of a modification.

While the combined limit switch and relay constituting the present invention are susceptible of various modifications and alternative constructions, I have shown in the drawings and will herein describe in detail the preferred embodiments. It is to be understood that I do not thereby intend to limit the invention by such disclosure but aim to cover all modifications and alternative constructions falling within the spirit and scope of the invention as expressed in the appended claims.

The combined limit switch and relay is usable in widely varying environments as a device of general utility in the control of a driving means for imparting movements in opposite directions to a driven member which may take many different forms. For example, the member may be a closure for an opening, the movable carriage or head of a machine tool, a conveyor, etc. To illustrate one typical environment, the drawings show the invention as applied to the control of a reversible electric motor 10 (Fig. 1) for moving a carriage 20 back and forth along a track 21. The movements of the driven member or carriage may, for example, be utilized to actuate a door 11 comprising hinged sections 12 pivotally connected to the carriage by a link 22 and slidable along a trackway 14 between vertical closed and horizontal open positions.

The motor 10 is connected through its shaft 16 and suitable gearing (not shown) with a sprocket 17. A chain 18 to which the carriage is fastened is led over the sprocket 17 and a second idler sprocket 19, rotation of the motor being connected into reciprocatory movement of the driven member.

Generally stated, the combined limit switch and relay comprises two switches respectively controlling the motor to cause opposite movements of the driven member combined with mechanism for actuating the two switches selectively and at the proper times to effect movement of the driven member alternately in opposite directions through predetermined distances, to energize the

motor for starting each cycle, and to deenergize the motor automatically and terminate each cycle with the driven member at one of its limits. The arrangement is also such that each cycle may be initiated through the closure of the proper one of these same switches by means of an electromagnetic actuator or actuators energized under the control of some separate switch device such, for example, as a remotely located push button switch.

For the sake of maximum compactness and simplification of construction, the two switches and their actuating mechanism are arranged in a single unitary structure. This unit has been shown herein (Figs. 1 and 2) as located within a generally rectangular sheet metal casing 24 housing a sheet metal frame 25 on which the parts of the unit are mounted. A plate 26 of insulating material is secured to a forwardly projecting arm 25a (Fig. 4) at the top of the frame. In brief, the switch unit includes as its principal elements (Fig. 2) the two alternatively closable switches 8 and 9, an electromagnetic actuator 31, and a mechanical actuator mechanism 32 responsive to the movements of the member which is driven by the motor controlled by the switches. In the particular arrangement shown closure of the switch 8 by engagement of movable and fixed contacts 27—29 energizes the motor 10 to effect movement of the door 11 from closed to open position. Similarly closure of the switch 9 by engagement of movable and fixed contacts 28—30 causes rotation of the motor in the opposite direction to close the door. The limit position responsive actuator 32 serves to open one or the other of the sets of contacts as may be required to stop the motor 10 when the door 11 reaches one of its limit positions, while the electromagnetic actuator 31 closes the particular switch required to energize the motor to move the door away from the particular limit position in which it may be located at the time the cycle of movement is started.

Herein, the stationary contacts 29 and 30 are carried by inverted L-shaped brackets 33 fixed to the top plate 26 and providing mounting terminals. If preferred, the switches 8 and 9 may have a common fixed terminal. The movable contacts have been shown herein as carried by fingers 34 on the outer ends of switch arms 35 and 36 formed from suitable insulating material. The fingers 34 may be fashioned as stampings from sheet metal and are generally L-shaped in form with the lower ends thereof fulcrumed on the outer faces of the corresponding switch arms. Headed pins 37 pass through registering holes in the fingers 34 and arms 35—36 and support helical compression springs 38 which yieldably urge the fingers 34 inwardly, the springs 38 being interposed between the outer faces of the fingers 34 and transverse pin and washer on the outer ends of the pins 37. By virtue of this arrangement, proper pressure between the contacts is assured when the supporting switch arm is drawn inwardly to switch closing position.

The switch arms 35—36 are flat and generally rectangular in form (Fig. 4), being pivotally mounted in opposed relation on opposite ends of a horizontal foot 40 fashioned on the bottom of the frame 25. The side edges of the foot 40 are notched to receive the arms 35—36 (Figs. 2 and 4), thereby preventing their lateral displacement, while the arms themselves are also complementally notched to loosely engage the foot 40 and thereby prevent longitudinal displacement of the arms. In order to bias the switch arms 35—36 into position in which the contacts carried thereby are open, a contractile spring 41 (Fig. 2) is connected between the lower ends of the arms. Outward pivotal movement of the arms 35—36, under the bias of the spring 41, is, however, limited by forwardly projecting ears or stops 42a formed on the lateral side edges of the frame 25. It will thus be seen that when one of the arms 35—36 is pulled outwardly (for example, to the position of the arm 36 in Fig. 2) the contact carried by it is amply spaced from the corresponding fixed contact so as to interrupt a circuit between them.

In the form shown in Figs. 2 to 6, simultaneous closure of both of the movable contacts 27 and 28 is positively prevented by a stop bar 42 (Figs. 2 and 6) the ends of which project loosely through holes in the opposed switch arms 35—36. The distance between shoulders 42b on the bar is so chosen, with respect to the spacing of the stationary contacts 29—30, that the movable contacts 27—28 cannot be brought close enough together to close simultaneously. Accordingly, the switches 8 and 9 must be closed alternately.

The electromagnetic switch actuator 31 has been shown herein (Figs. 2, 4 and 5) as including a generally rectangular laminated core 43 supported on the frame foot 40 by spacer blocks 44 through which screws 45 are inserted. The core 43 is made up of two E-shaped portions arranged back to back with the legs of each E pointing outwardly from a common transverse portion 46 (Fig. 5). The central longitudinal core legs 47 of the E's carry energized windings 48 and 49. In some instances, as will hereinafter appear, both of the windings 48 and 49 are energized and deenergized simultaneously and, consequently, a single winding could be used in such case. In other instances, however, as is also hereinafter illustrated, it is desirable to accomplish the establishment of a magnetic field in only one end of the core structure at a time and it is to take care of such possibility that two windings are provided.

Cooperating with the electromagnet structure described above is a pair of armatures 50 and 51 (Fig. 2) in the form of rectangular ferro-magnetic plates carried on the inner faces of the switch arms 35 and 36, respectively. With this arrangement, when the winding 48 is energized the armature 50 is attracted to pull the switch arm 35 into switch-closed position and similarly, when the winding 49 is energized the armature 51 is attracted to pull the other switch arm 36 into switch-closed position. Due to the shunting effect of the transverse iron section 46 at the center of the core 43, very little of the flux set up by either of the windings 48 and 49 passes to the opposite end of the core so that, in general, the flux set up by each coil threads only the adjacent armature. The flux paths for the respective windings are indicated by the lines of arrows 48a and 49a (Fig. 5).

The limit position responsive actuator mechanism 32 is, in general, adapted to shift one or the other of the switch arms 35—36 into switch-open position and simultaneously to condition the other switch arm to be swung to switch-closed position by a subsequent energization of the magnetic actuator 31. In the illustrative construction, the mechanism noted has been shown in the form of a traveler mechanism and embodies a rotatable screw 52 having a pair of traveling nuts 53 and 54 threaded thereon, the screw being

journaled in bushings 55 supported by the frame ears 42a. Longitudinal movement of the screw 52 in one direction is prevented by abutment of a shoulder 56 thereon against one of the bushings 55, and in the other direction by abutment of a washer 57 against the opposite face of such bushing. Similarly the traveling nuts 53 and 54 are confined against rotative movement by a rod 58 (Fig. 3) supported by the frame ears 42a and received in registering notches 58a (Fig. 4) in adjacent sides of the nuts.

Yieldable operative connections are formed between the traveling nuts 53—54 and the adjacent switch arms 35—36 by helical compression springs 59 and 60. When the screw 52 is rotated in one direction or the other both of the nuts 53—54 travel in the same direction with the result that one of them compresses its associated spring until the adjacent switch arm is forced to open position in a manner to appear later while, at the same time, the compression in the other spring is diminished to such a point that the adjacent switch arm can be readily moved to switch-closed position upon a subsequent energization of the electromagnetic actuator 31.

To drive the screw 52 in unison with the controlled motor 10 and the driven member 20, a sprocket 61 (Figs. 1 and 2) is arranged to be turned by the lower reach of the drive chain 18 and is connected directly with the screw 52 by a coupling 62. Thus, the rotation of the screw normally bears a predetermined ratio to the travel of the door. The traveling nuts 53—54 may be adjusted initially so that they will cause their associated switch arms 35—36 to be opened at the corresponding limits of travel of the door since the movements of the nuts are always proportional to the distance of door movement.

To hold the switch contacts closed throughout a cycle of movement of the motor 10, either a mechanical or electrical arrangement may be employed. Both have been shown herein, the mechanical latch arrangement being embodied in the device of Figs. 1 to 6, inclusive, and the electrical arrangement in that of Fig. 7. Referring first to the mechanical system, the latches 63 and 64 (Figs. 3 and 4) are pivoted on a vertical pin 64b fast on an L-shaped bracket 65 screwed to the inner face of the frame 25. Opposite ends of the latches project through registering apertures in the switch arms 35—36 and have shoulders 63a and 64a engageable with the arms to hold the same in their switch-closed positions in which the arm 35 is disposed in Fig. 3. A torsion spring 66 coiled around the pivot 64b and having arms engaging the latches biases the latter toward latched position.

On the forward edge of the latches are formed cam projections 67 and 68 engageable with the tapered outer faces of the traveling nuts 53—54. With such an arrangement, each latch is spring pressed into latching engagement with its associated switch arm whenever the latter is shifted to switch-closed position, and holds the arm until the adjacent nut traveling in unison with the driven member reaches the corresponding limit position whereupon the latch is cammed out of active position to release the switch arm. In the meantime, the spring 59 or 60, as the case may be, has been compressed so that upon release of the latch, its stored energy is imparted to the switch arm to switch-open position with a rapid snap action.

The operation of the switch unit of Figs. 1 to 5, described above, can best be understood by explaining the sequence of operation of the parts in controlling a specific set of associated circuits. Such an exemplary arrangement is shown diagrammatically in Fig. 6. By comparison of Figs. 2 and 6, it will be seen that four switches or contacts 69—72 are provided in addition to the switches 8 and 9. These additional switches, in the exemplary circuit, are provided merely because of the character of the particular motor shown and can, of course, be omitted or augmented as the requirements of a particular installation may dictate. These contacts may be mounted side by side with the contacts 27—30 and may be of substantially identical construction as shown in Fig. 4 so that the switches 69 and 70 will be actuated in unison with the switch 8 and the switches 71 and 72 will operate with the switch 9.

The motor 10 has been shown in Fig. 6 as being of the split-phase alternating current type with a running winding 73 and a starting winding 74, the latter being open-circuited as the motor comes up to speed by the usual centrifugal switch 75. Reversal of rotation is accomplished by reversing the instantaneous polarity of the voltage applied to the running winding 73 and, consequently, the switch arrangement is desirably such as to insure the starting winding 74 being in circuit before voltage is applied to the running winding 73 to start the motor in either direction. As a further safety measure, a thermal responsive overload switch 76 is interposed in one of the supply lines L_1—L_2 from which current is furnished for the motor and the control circuits.

Assuming the door 11 to be closed, the parts of the control unit will be positioned as shown in Fig. 6 with all of the switches open. To initiate an opening cycle, the operator has only to depress a control push button 77 momentarily. Closure of this push button switch energizes both of the parallel connected windings 48 and 49 (through a circuit L_1—78—77—79—49 and 49—80—75—81—74—L_2). The winding 48 only will be effective to pull in its associated switch arm 35, since the other switch arm 36 is blocked against full movement to switch-closed position by the nut 54 and the then compressed spring 60 which opened the switch 9 at the end of the previous cycle. It should be noted that the centrifugal switch 75 is included in the electromagnet energizing circuit above so that the electromagnets can only be energized when the centrifugal switch is closed and, hence, when the starting winding 74 is in circuit.

In response to closure of the switch 8, the motor running winding 73 is energized (through a circuit L_1—76—82—29—27—83—73—84—69—L_2) for rotation of the motor in a direction to open the door 11, and the starting winding 74 is simultaneously energized (through a circuit L_1—76—82—70—80—75—81—74—L_2) when the switch arm 35 is pulled into switch-closed position (as shown in Fig. 2) by the energization of the associated electromagnet winding 48 as described above. As the motor 10 comes up to speed the centrifugal switch 75 open-circuits the starting winding 74 in the usual manner and the motor continues the opening movement of the door.

Continued energization of the motor 10 for the duration of the opening cycle is assured since the latch 63 engages the switch arm 35 as soon as the latter is pulled into switch-closed position. Ac-

cordingly, the operator may release the push button 77 immediately.

In the course of the opening movement, the screw 52 (in the limit position control mechanism 32) is rotated and the traveling nuts 53—54 are moved progressively to the left (as viewed in Fig. 6). These nuts are set so that at the opposite limit of travel of the driven member, that is, when the door is fully opened, the nut 53 will engage the cam projection 67 on the latch 63 and cam the latch out of engagement with the switch arm 35. Thereupon the spring 59, which has been compressed in the final movement of the nut 53, snaps the switch arm 35 to open position, thereby open-circuiting and stopping the motor 10. The movement of the nut 54, on the other hand, has, during this cycle of operation, released the pressure on the spring 60 so that upon a subsequent energization of the electromagnetic actuator 31 the other switch arm 36 will be freed and thus conditioned for closing movement. It will thus be seen that when the motor stops, both switch arms 35—36 are again in their open positions but in this instance the switch arm 35 is blocked against reclosure by the compression of the spring 59 while the other switch arm 36 is free to close.

To initiate reverse movement of the driven member by the motor or in other words close the door, the operator need only momentarily depress the same push button switch 77. As before, both of the electromagnet windings 48 and 49 are energized, but since, at this time, the arm 35 is blocked by the spring 59, only the winding 49 is effective to move its associated switch arm 36. Closure of the switch 9 by this latter switch arm energizes the motor starting winding 74 (through a circuit L_1—76—82—71—80—75—81—74—L_2) and also energizes the running winding 73, but in this instance with reverse polarity as compared to that described above for door opening movement (through a circuit L_1—76—82—30—28—84—73—83—72—L_2).

When the switch arm 36 swings to switch-closed position the shoulder on the latch 64 moves in behind the arm and the switch 9 is retained closed until the door 11 reaches its fully closed position. During the ensuing rotation of the motor, the screw 52 turns in a corresponding direction and the nuts 53—54 travel to the right (as viewed in Fig. 6). As the door approaches its limit position, the nut 54 cams the latch 64 outwardly releasing the arm 36 to the action of the compressed spring 60 thereby opening the switch with a snap action and stopping the motor. At this time, all of the switch parts will be restored to the positions occupied at the beginning of the first door opening cycle described above.

In the modified construction of Fig. 7, the combined relay and limit switch unit is substantially identical in construction with that of Figs. 1 to 6, except that the main switches 8 and 9 are held closed electrically rather than mechanically by the latches 63 and 64 which are omitted. This is accomplished through the provision of holding circuits controlled by sealing contacts operated in unison with the respective switches 8 and 9. In all other respects, the construction may be identical and the same reference numerals have been used for corresponding parts.

As to the associated apparatus, the switch unit of Fig. 7 is shown as arranged to control a reversible electric motor 10a corresponding to the motor 10 above. In this case, however, the motor embodies two separate energizing windings 100 and 101 which are alternatively excited to operate the motor in opposite directions and cause door opening and closing movements, respectively. A normally set brake (not shown) may be provided for holding the motor against rotation when it is deenergized, a solenoid 10b serving, when energized, to release this brake. In this instance, the manual control station includes three push putton switches 102—104.

The switch unit has been shown in Fig. 7 with its parts disposed in the positions which they occupy with the motor driven member in one limit position, door closed position in this instance. To open the door, the operator need only press the "open" push button 102 momentarily. Closure of the associated switch energizes the winding 48 (through a circuit L_1—105—48—106—102—107—104—108—76—L_2) whereupon the associated arm 35 is attracted and the switch 8 closed. The electromagnet 48 is retained energized throughout the ensuing cycle by holding or sealing circuit completed through a switch 69 in shunt with the push button switch 102 and closed by movement of the arm 35 at the same time as the main switch 8. The motor winding 100 is thus held energized (through circuit L_1—100—109—70—110—76—L_2) while the brake solenoid 10b is energized (through a circuit L_1—10b—111—27—29—110—76—L_2) to release the motor brake. It will be noted that when the door opening cycle is initiated in the manner described, the magnet winding 49 is not energized, and, consequently there is little or no flux threading the armature 51 tending to pull the switch arm 36 into closed position.

In the course of the door opening cycle, the screw 52 is rotated and the nuts 53—54 are moved to the left (Fig. 6). The relative positions are such that at the completion of the predetermined stroke of the door actuator or carriage 20, the nut 53 will finally compress the spring 59 sufficiently to overcome the pull of the magnet 48 and force the switch arm 35 to open position, thereby opening the switches 8, 69, and 70. At the same time, the other nut 54 has permitted the spring 60 to expand so that the switch arm 36 will be free to close upon initiation of the next cycle of operation. Opening of the contacts controlled by the switch arm 35, of course, deenergizes the motor 10a and also interrupts the holding circuit for the electromagnet winding 48.

To cause reverse rotation of the motor and initiate movement of the door from open to closed position, the operator need only momentarily close the "close" push button switch 103. This completes the circuit for the corresponding electromagnet 49 (through a circiut L_1—105—49—112—103—107—104—108—76—L_2) so that the associated switch arm 36 is pulled into switch-closed position. This movement of the arm 36 closes the sealing switch 72 for completing a holding circuit for the electromagnet winding 49, in shunt with the push button switch 103, so as to retain this winding energized throughout the door-closing cycle. At the same time, the main switch 30—28 and 71 are closed, the latter completing an energizing circuit for the motor winding 101 (through a circuit L_1—101—113—71—110—76—L_2). Closure of the switch 28—30 Causes the brake solenoid 10b to be energized (through a circuit L_1—10b—111—28—30—110—76—L_2).

During the door closing movement, the screw 52 rotates to cause movement of the nuts 53 and 54 to the right (Fig. 7). At the completion of the stroke, the spring 60 is compressed sufficiently by the nut to move the switch arm 36 to open position against the pull of the magnet 49 thereby interrupting the motor and brake solenoid circuits, as well as the holding circuit. It will thus be seen that the switch parts are all restored to the position which they occupied at the beginning of the first door opening cycle described above.

To stop the motor at any time during rotation in either direction, the manually operable push button switch 104 is opened. This switch is included in the energizing circuits of each of the windings 48 and 49 so that its opening immediately deenergizes the then active elecromagnet and permits the attracted switch arm 35 or 36 to be pulled open by the biasing spring 41. Thereafter, the motor can be restarted in either direction by a momentary closure of the corresponding one of the push button switches 102—103 just as in the case when it is moved from one of its limit positions to the opposite limit position, as described above.

From the foregoing, it will be seen that the novel switch unit herein described is readily adaptable for use with a variety of types of associated control circuits depending upon the requirements of a particular installation. Furthermore, the switch unit can be readily arranged to control a variety of different types of motors or other power transmission mechanisms by utilizing the number of switch contacts required for the particular installation.

I claim as my invention:

1. A switch mechanism of the type described comprising, in combination, a pair of switch arms supported in spaced and opposed relation for individual swinging movement toward and away from each other into and out of switch closing positions, means yieldably urging both of said arms to switch open position, an electromagnetic device for pulling said arms toward said closed positions, a releasable latching mechanism engageable with said switch arms when either of them is in its closed position, a screw arranged transversely of said switch arms and rotatable in accordance with the movement of an associated movable member, means including a pair of traveling nuts threaded on a portion of said screw between said switch arms and fixed against rotation for releasing said latching mechanism, and compression springs interposed between respective ones of said traveling nuts and the adjacent ones of said switch arms for biasing the switch arms outwardly to open position with variable forces determined by the positions of said nuts.

2. A switch mechanism of the type described comprising, in combination, a pair of switch arms having contacts thereon, cooperating stationary contact means, means supporting said switch arms in spaced and opposed relation for swinging movement toward and away from each other into and out of closed position with respect to said stationary contact means, means yieldably urging both of said switch arms to open position, an electromagnetic device located between said switch arms for pulling the same inward to closed position, a releasable latching mechanism engageable with said switch arms when either of them is in its closed position, a screw arranged transversely of said switch arms and rotatable in accordance with the movement of an associated movable member, and means including a pair of traveling nuts threaded onto said screw and fixed against rotation for releasing said latching mechanism.

3. In a combined relay and limit switch unit, the combination of two switches individually movable from their open positions to respective closed positions, individual electromagnetic actuators for each of said switches tending when energized to urge the associated switch to closed position, and means responsive to the position of an associated movable member for opening one of said switches against the force of its energized actuator and for conditioning the other switch for closure by its actuator.

4. A switch mechanism of the type described comprising, in combination, a pair of switch arms supported in spaced and opposed relation for movement toward and away from each other, an electromagnetic device adapted when energized to exert a pull on said arms, a screw arranged transversely of said switch arms and rotatable in accordance with the movement of an associated movable member, a pair of traveling nuts threaded onto said screw and fixed against rotation, and compression springs interposed between respective ones of said traveling nuts and the respective switch arms for biasing the switch arms outwardly with variable forces determined by the shifting of said nuts as said screw rotates in accordance with movement of the associated movable member.

5. In a device of the type described the combination of, a pivotally mounted switch arm, a compression spring bearing against said arm and urging the same toward switch-open position, a latch for releasably retaining said arm in switch-closed position, a rotatable screw fixed against endwise movement and disposed substantially in alinement with said compression spring, and a traveling nut threaded on said screw and operable upon rotation of the screw in one direction to successively compress said spring and then release said latch.

6. In a combined relay and limit switch unit, the combination of two switches arranged for alternative actuation from their open positions to respective closed positions, electromagnetic means for urging said switches to closed position, means for resiliently urging said switches to open position, and means responsive to the position of an associated movable member for increasing the force exerted by said resilient means on one of said switches to a value such that said electromagnetic means is ineffective to close said one switch.

7. In a combined relay and limit switch unit, the combination of two switches, electromagnetic means for urging said switches to closed position, means for resiliently urging said switches to open position, and means responsive to the position of an associated movable member for increasing the force exerted by said resilient means on one or the other of said switches depending upon the position of said movable member and for decreasing the force exerted on the remaining switch so that said electromagnetic means is thereafter effective to close said remaining switch and ineffective to close the other switch.

8. In an apparatus of the type described, the combination of a switch, electromagnetic means for urging said switch to closed position, a second switch actuatable by said electromagnetic means and adapted to complete a holding circuit therefor, and means actuatable by an associated movable member for substantially simultaneously

opening both of said switches against the force exerted by said electromagnetic means.

9. In a device of the character described, a switch, a member movable in opposite directions to close and open said switch, means adapted to hold said member releasably in switch closing position, an actuating element movable into and out of a predetermined position and operable by movement into such position to disable said releasable means, spring means normally urging said member toward switch open position and arranged to be placed under increased stress during movement of said part toward said predetermined position, whereby to open said switch with a snap action and oppose subsequent movement of the member to reclose the switch, and electromagnetic means adapted when energized with said element retracted from said predetermined position to close said switch, said electromagnetic means being unable to overcome said spring and close the switch when said member is in said predetermined position.

10. In a device of the character described, a switch, a member movable in opposite directions to close and open said switch, electromagnetic means tending when energized to close said switch, a holding circuit for said electromagnetic means which circuit is closed and opened in response to closure and opening of said switch, and an actuating element movable into and out of a predetermined position and operating in its movement toward such position to open said switch against the action of said electromagnetic means.

11. In a device of the character described, a switch, a member movable in opposite directions to close and open said switch, electromagnetic means tending when energized to close said switch, a holding circuit for said electromagnetic means which circuit is closed and opened in response to closure and opening of said switch, an actuating element movable into and out of a predetermined position and operating in its movement toward such position to open said switch against the action of said electromagnetic means, and spring means acting between said member and said element and tending to open said switch, the stress of said spring being increased during the approach of said element to said limit position.

12. In a device of the character described, the combination of two switches, two actuating members for said switches movable in opposite directions to close and open their respective switches, means normally urging said members toward switch-open positions, a rotary element, two parts each associated with one of said members and movable together in opposite directions during rotation of said element in opposite directions, and springs each acting between one of said members and the associated one of said parts and adapted to be placed under increasing and decreasing stresses during the movement of the associated part toward and away from the associated member.

13. A combined limit switch and relay unit comprising, in combination, a switch member movable to open and closed positions, an electromagnetic actuator operable when energized to move said switch member to closed position, and means actuated in response to the limit-positioning of an associated movable member for moving said same switch member to open position irrespective of the condition of energization of said electromagnetic actuator.

14. A switch mechanism of the type described comprising, in combination, a pair of switch arms supported in spaced and opposed relation for movement toward and away from each other, an electromagnetic device adapted when energized to exert a pull on said arms, means including supplemental switch contacts carried by said switch arms for establishing a holding circuit for said electromagnetic device to retain the same energized when one or the other of said pair of switch arms is pulled to switch-closed position, a screw arranged transversely of said switch arms and rotatable in accordance with the movement of an associated movable member, a pair of traveling nuts threaded on said screw and fixed against rotation, and compression springs interposed between respective ones of said traveling nuts and the respective switch arms for biasing the switch arms outwardly with variable forces determined by the shifting of said nuts as said screw rotates in accordance with movement of the associated movable member.

15. In a device of the type described the combination of, a switch, means including a compression spring for urging said switch toward its open position, means for releasably retaining said switch in closed position, a rotatable screw fixed against endwise movement and disposed substantially in alinement with said compression spring, and a traveling nut threaded on said screw and operable upon rotation of the screw in one direction to successively compress said spring and then release said retaining means.

16. In a device of the character described, a switch, a member movable in opposite directions to close and open said switch, means including an electromagnet for urging said member to switch-closing position and releasably holding the same closed, an actuating element movable into and out of a predetermined position and operable by such movement into said position to disable said releasable holding means, and spring means normally urging said member toward switch-open position and arranged to be placed under increased stress during movement of said element toward said predetermined position, whereby to open said switch with a snap action and upon subsequent movement of the member to reclose the switch, said electromagnet being ineffective to overcome said spring and close the switch when said element is in said predetermined position.

17. In a combined relay and limit switch unit, the combination of a pair of alternatively closable switches, means including an electromagnetic actuator for simultaneously urging said switches to closed position and for releasably retaining closed one or the other of said switches which actually reaches closed position under its urging, a mechanical switch-shifting mechanism movable alternatively between first and second positions, said mechanism being operative when in either of said positions to open one of said switches and restrain the same against reclosure by said electromagnetic means and to condition the other switch in the pair for closure, and power actuated means operable independently of said electromagnetic actuator and in response to the limit-positioning of an associated movable member for moving said mechanical switch-shifting mechanism between said first and second positions thereof.

18. A combined limit switch and relay for controlling the movement of a part to be driven alternately in opposite directions comprising, in

combination, two switches to be closed alternately according to the direction of movement of said part, electromagnetic means for closing said switches, and a control means responsive to the movement of said part and acting during the movement thereof from one of two limit positions under the control of one of said switches to prevent closure of the other one of said switches by energization of said electromagnetic means.

19. A combined relay and limit switch for controlling the movement of a part to be driven alternately in opposite directions comprising, in combination, two switches respectively operative to control the movement of said part in one direction or the other, electromagnetic means tending when energized to close said switches, and a control mechanism including a traveler driven in timed relation to said part and movable between two limit positions, and means operable by said traveler when it is moved into either limit position to render said electromagnetic means ineffective to close one of said switches and effective to close the other one of said switches.

20. A combined relay and limit switch for controlling the movement of a part to be driven alternately in opposite directions comprising, in combination, two switches respectively operative to control the movement of said part in one direction or the other, electromagnetic means tending when energized to close said switches, and a control mechanism including a traveler driven in timed relation to said part and movable between two limit positions, means operable by said traveler when it is moved into either limit position to render said electromagnetic means ineffective to close one of said switches and effective to close the other one of said switches, and means operative as an incident to the closure of either of said switches by said electromagnetic means to hold the same releasably in closed position and to positively block the other switch against closure.

21. A combined relay and limit switch for controlling the movement of a part to be driven alternately in opposite directions comprising, in combination, two switches respectively operative to control the movement of said part in one direction or the other, electromagnetic means tending when energized to close said switches, and a control mechanism including a traveler driven in timed relation to said part and movable between two limit positions, means operable by said traveler when it is moved into either limit position to render said electromagnetic means ineffective to close one of said switches and effective to close the other one of said switches, means operative as an incident to the closure of either of said switches by said electromagnetic means to hold the same releasably in closed position, said traveler being operative in its movement into either limit position to render ineffective the holding means for one or the other of said switches according to the direction of movement of the traveler.

22. A combined relay and limit switch for controlling the movement of a part to be driven alternately in opposite directions comprising, in combination, two switches respectively operative to control the movement of said part in one direction or the other, electromagnetic means tending when energized to close said switches, and a control mechanism including a traveler driven in timed relation to said part and movable between two limit positions, means operable by said traveler when it is moved into either limit position to render said electromagnetic means ineffective to close one of said switches and effective to close the other one of said switches, means operative as an incident to the closure of either of said switches by said electromagnetic means to hold the same releasably in closed position, said traveler being operative in its movement into either limit position to render ineffective the holding means for one or the other of said switches according to the direction of movement of the traveler, and means operative by the traveler in its movement into either of said limit positions to open said switches with a snap action upon release of the holding means therefor.

23. A combined relay and limit switch for controlling the movement of the part to be driven alternately in opposite directions comprising, in combination, two switches to be closed alternately according to the direction of movement of said part, electromagnetic means for closing said switches, means operative as an incident to the closure of said switches by said electromagnetic means to hold them in closed position, and a control mechanism including a traveler driven in timed relation to said part and movable between two limit positions, said traveler being operative in its movement into either limit position to render ineffective the holding means for one or the other of said switches according to the direction of movement of the traveler, spring means controlled by said traveler when in either of said limit positions to hold one or the other of said switches in open position, and means operative in response to the closure of the other one of said switches to positively prevent closure of the first mentioned switch.

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