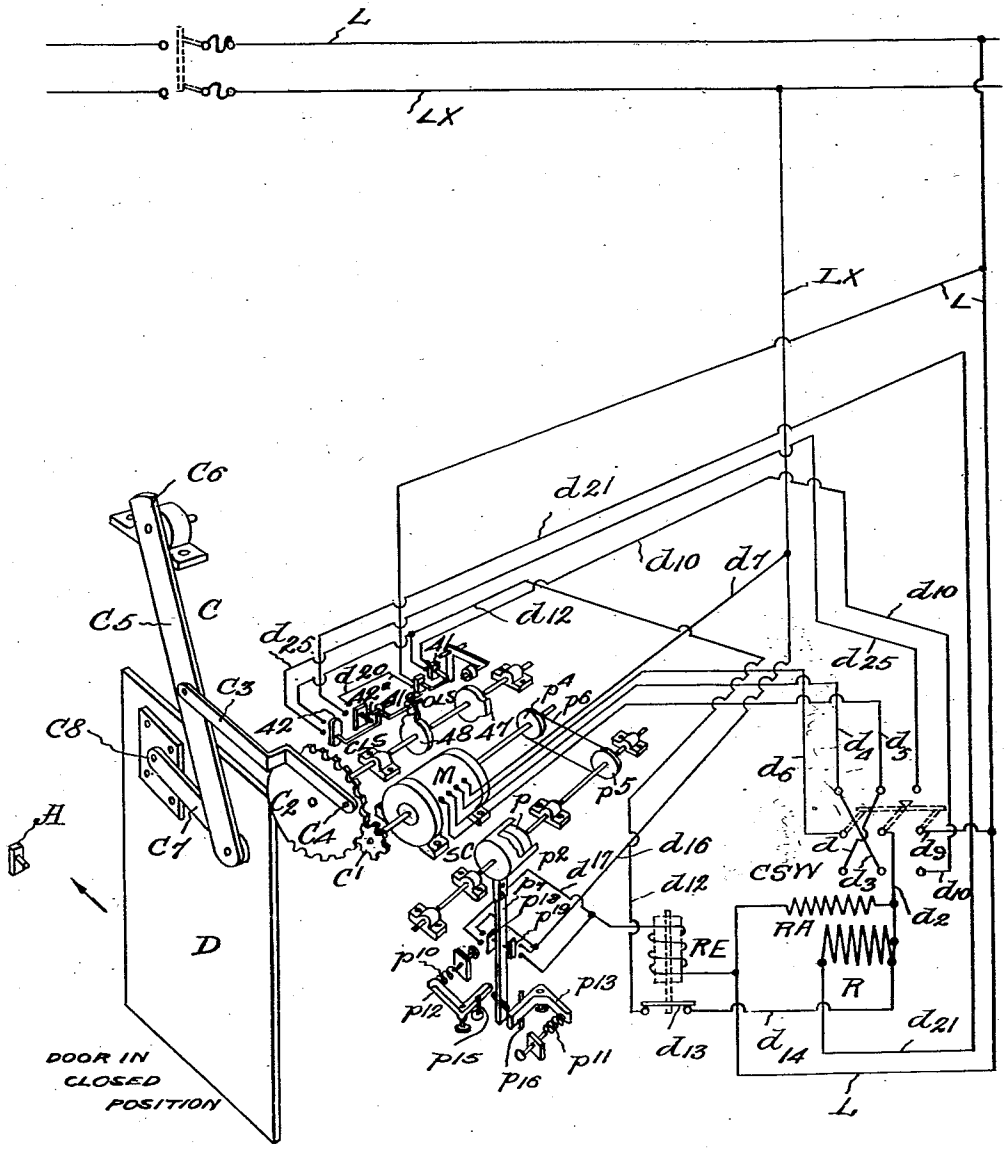
Nov. 28, 1944. J. H. BANKS ET AL 2,363,929

ELECTRIC OPERATOR FOR OPENING AND CLOSING DOORS

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Fig. 1.



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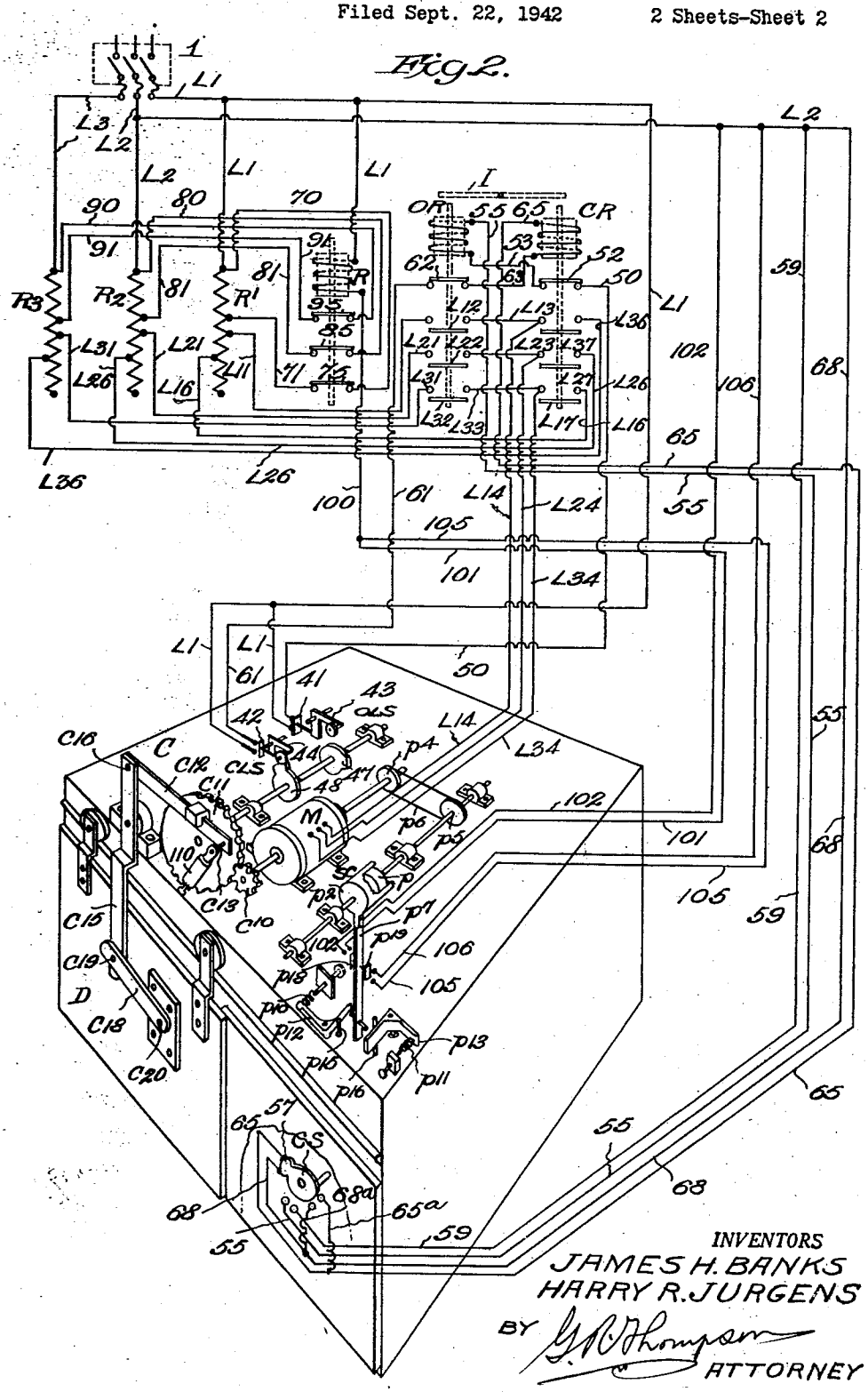
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Fig 2.



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ELECTRIC OPERATOR FOR OPENING AND CLOSING DOORS

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Application September 22, 1942, Serial No. 459,278

9 Claims. (Cl. 268—53)

This invention relates to electric operators for opening and closing doors or the like, and provides improvements therein.

It is desirable, especially in elevator practice, to have doors open and close with reasonable speed. Heretofore this has been accomplished with electric operators by using a motor having somewhat greater power than required merely to open and close the door, in order to obtain rapid acceleration in the initial part of the door movement from an open or closed position, and then, when the door has reached a predetermined point, or distance from its initial starting position, in its movement at which the acceleration would normally reach a predetermined speed, the motor is retarded to prevent further acceleration, the door movement being continued under the combined effect of momentum and the retarded force of the motor. Such means, however, suffer from the disadvantage that when the direction of movement of the door is reversed during its opening or closing movement or when the door movement is stopped or checked at an intermediate point by an outside obstacle or force, as by collision with a person or by the hand of a person to avert collision, etc., the remainder of the opening or closing movement is sluggish or relatively slow, or stalled.

The present invention overcomes the above-stated objections and deficiencies of prior electric operators for opening and closing doors. It provides an electric operator which accelerates until a predetermined speed is attained immediately upon reversal of the door movement, or upon resumption of an opening or closing movement following an obstruction to such movement, whatever the position of the door intermediate its fully opened or fully closed position, and the sluggish door movement, or stalling, under similar conditions, of prior electric operators, overcome.

In elevator practice the car-door often effects the opening and closing of the hatch-way door at the various floors through coupling means. These hatch-way doors have variations in the effort required to open and close them, as for example, frictional differences, weight difference, etc. The present invention takes care of these variations in a very simple manner. The motor will continue to accelerate until it reaches the predetermined speed at which the speed control device acts, so that when the load on the motor is lighter than normal the speed control device will act quickly and when the load is heavier than normal the motor will accelerate longer, and the end result is that the opening and closing interval is substantially constant for all the various doors.

The present invention also acts to compensate for voltage variations in the line connected to the motor. When there is an excess of voltage the speed control device will act more quickly than at normal voltage, and when there is a deficiency of voltage, the motor will continue to accelerate longer than at normal voltage.

Such problems heretofore have been met only in an unsatisfactory way and by the use of rather complicated means.

The invention is especially applicable to the elevator art, and may receive various embodiments in that and other arts. In the elevator art there are a number of types of door closures, and many electrical ways of effecting the door movements, and of effecting the elevator movement, and the invention may have different embodiments best suited to the system of elevator control and operation with which it is incorporated.

The embodiments of the invention are illustrated in the accompanying drawings, wherein:

Fig. 1 is a diagrammatic view illustrating a simple and general application of the invention to the opening and closing of doors; and

Fig. 2 is also a diagrammatic view illustrating one mode of applying the invention to the opening and closing of a door on an elevator-car, the hoisting and signalling means being omitted from this illustration.

Referring to said drawings, D designates a door, gate or the like, which is to be moved by the electrical operator, and M designates an electric motor forming part of the electrical operating means, the power of which is applied to the opening and closing of the door through suitable connections C. These connections have various forms.

As shown in Fig. 1 the connections comprise a pinion *c1* meshing with a gear *c2*, and a link *c3* connected at one end to a crank pin *c4* on the gear *c2*, and at its other end to a lever *c5*. The lever is pivoted at one end as indicated at *c6*, and at its other end is connected to a link *c7* which is connected to the door D, as indicated at *c8*.

In Fig. 2 the connections C comprise a pinion *c10* meshing with a gear *c11*. A link *c12* connected at one end to a crank pin *c13* on gear *c11* and at its other end to a lever *c15* by a pin *c16*. To the opposite end of lever *c15* is a link *c18* connected by pins *c19* and *c20* to the opposite end

of lever c15 and to the door D. The arrangement of the crank pin c13 is such that the crank pin travels in an arc in the neighborhood of dead center as the door approaches its fully closed or fully opened position, thereby providing for a mechanical slowing down of the door movement as the door closely approaches its fully opened or fully closed position.

The electrical operator further includes retarding means and a control device SC responsive to the speed of the motor M and operating at a predetermined speed to cause said retarding means to act. As shown in the drawings, the retarding means may be electrical and act on the motor to reduce its power, and thereby its speed. The motor M is one having greater power than is required to open or close a door in a predetermined time. For example, if it be predetermined to allow one second for a door to move from closed to open position the power of motor M without retardation would be such as to effect the opening in considerably less time. The effect of the extra powered motor and of the retarding means is that in the first part of the door opening movement the motor operates at full power, thereby quickly accelerating the speed of opening of the door, and, when the door opening movement has reached a predetermined speed, the retarding means comes into action to retard the door opening movement. The degree of retardation is usually so contrived that the speed of opening reached when the retarding means comes into action is approximately maintained until shortly before the door reaches its fully open position; that is, the effect of the retardation is to stop further acceleration of the door opening movement under the action of the motor.

The action of the motor and of the retarding means on the door closing movement is substantially the same as in the door opening movement, though in practice it is often arranged to have the time of door closing somewhat longer than the time of door opening, for example, 2 seconds. A mode of effecting this differential is hereinafter described.

As heretofore stated, the action of the retarding means, according to the present invention, is under the control of the speed of the motor (or of a part moving synchronously therewith), so that whenever the movement of the door in an intermediate position is reversed, or whenever the speed of the door closing movement drops below the speed at which the retarding means goes into action, whatever the intermediate position of the door, the resumption of the door movement is effected under the full power of the motor.

The speed control device SC is advantageously in the form of a rotatably mounted permanent magnet *p* in the field of which is mounted a rotatable part *p2* usually of nonferrous light weight metal. When the magnet *p* is caused to rotate, its magnetic field generates eddy currents in part *p2*. These currents in turn set up a magnetic field of their own, causing a magnetic drag between the magnet and the rotatable part *p2*. The eddy currents and the resultant magnetic drag increase as the speed of rotation of the magnet *p* is increased. The permanent magnet *p* is rotatably connected in a suitable manner to the motor M, as by means of pulleys *p4* and *p5* and a belt *p6*, and thereby rotates at the same speed, or at a speed proportional to, the speed of the motor. The part *p2* may move in response to the magnetic drag of the rotating permanent magnet *p*. The function of the speed control device SC is to bring into operation the retarding means upon the motor reaching a predetermined speed in the course of its acceleration as will now be more fully described.

Referring to the form of embodiment shown in Figs. 1 and 2, the rotatable part *p2* has an arm *p7* and there are two springs *p10*, *p11*, on opposite sides of the arm *p7* but not attached thereto which act to oppose rotation of the arm p7 and consequently of the rotatable part *p2*. The springs *p10*, *p11*, are connected to pivoted arms *p12*, *p13*, which arms are stopped by pins *p15*, *p16*, so that the arm *p7* is acted on by only one spring at a time. Connected to the rotatable part *p2* are bridge contacts *p18*, *p19*, and these are conveniently mounted on the arm *p7* as shown. These bridge contacts *p18*, *p19*, close circuits which bring a resistance into the circuit of motor M to thereby reduce its power, a description of which will now follow with reference to each figure of the drawings.

Referring to Fig. 1, the motor may be, as here shown, a universal series motor, operable from a single phase alternating current supply or from a direct current supply. Motor M has a resistance R in its circuit which functions as a retarding means.

In this embodiment the flow of current through the motor is not entirely interrupted, a feeble current being passed through the motor in the fully open and fully closed position of the door, so that the motor may act as a positive means for holding the door in its open and closed position. A resistance RA may be provided which cuts down to a small amount the current which flows through the motor in the fully open and fully closed positions of the door.

The resistances R and RA may be by-passed through a circuit which includes bridge-contact *d13* of relay RE. The circuit through the electromagnet of relay RE is under the control of the bridge-contacts *p18*, *p19*, on the rotary part *p2* of the speed control device SC. The motor circuits through the resistance R and the by-pass around resistances R and RA may be under the control of an open-limit switch OLS and a closed-limit switch CLS.

For the door opening movement, the switch CSW is thrown to operate the motor M in the door opening direction (down position Fig. 1) and with this switch closed the motor M is initially energized under the full power of the line, current flowing from line L, conductor *d9*, switch CSW, conductor *d10*, bridge-contact 41 of limit switch OLS, conductor *d12*, bridge-contact *d13* of relay RE, conductor *d14* by-passing resistances R and RA, conductor *d2*, switch CSW and then in series through the armature and field of motor M by way of conductors *d3*, *d4*, *d5*, *d*, switch CSW, conductor *d6*, and then to line LX by conductor *d7*.

There is also a circuit to the motor through resistance RA, the circuit being traced from L, resistance RA, conductor *d2*, switch CSW, and from said switch through the motor M to line LX by the path described just above.

When the door D has moved a short way (an inch or so) from its fully closed position, cam 48 of limit switch CLS allows bridge-contacts 42 and 42*a* to close the gaps between conductors *d20* and *d21* and between *d12* and *d25*, and bridge-contacts of OLS closing the gaps in the circuits there at all times except when the door is in its fully open position, a third motor circuit, through the retarding resistance R is established.

In this embodiment of Fig. 1 this circuit is traced from line L by way of bridge-contact *41a* of limit switch OLS, conductor *d20*, bridge-contact *42a* of limit switch CLS, conductor *d21*, resistance R, conductor *d2*, switch CSW and then through the armature and field of motor M to line LX by way of conductors *d3*, *d4*, *d5*, *d*, *d6*, *d7*, as previously described. While the motor circuit which by-passes the resistances R and RA remains established, the door opening movement and the speed of the motor M will accelerate until a predetermined speed is reached at which the speed control device SC acts. At said predetermined speed of the door opening movement the bridge-contact *p18* closes the gap between conductors *d16* and *d17*, causing current to flow through the coil of relay RE and causing the bridge-contact *d13* to break the circuit between conductors *d12* and *d14*, thus causing resistances R and RA to act as a retarding means on the motor M and consequently on the speed of the opening movement of the door D. The acceleration of the door on its opening movement is thereby checked after the action of the speed control device SC as just explained. The circuit through the coil of relay RE is traced from line L through the coil of relay RE, and conductors *d17* and *d16* and bridge-contact *p18* to line LX.

As the door D closely approaches the limit of its opening movement, the cam **47** will act to open limit switch OLS, thereby interrupting the flow of current through the motor circuit which includes the resistance R as well as through the circuit which by-passes resistances R and RA, should this circuit be not interrupted at the time at bridge-contact *d13* of relay RE by the action of speed control device SC. After the motor circuits are opened at open-limit switch OLS the only current which flows through the motor is the feeble one which passes through the resistance RA and which acts to bias the motor in a direction to hold the door in the fully open position, as previously described.

For the door closing movement, the switch CSW is thrown to operate the motor in the reverse direction to that on the door opening movement (up position as shown in the drawings). The circuits to the motor M to and from switch CSW are the same as those previously traced except that the current from line L now flows from the switch to the motor over conductor *d5* instead of over conductor *d4* and the return to LX being via conductors *d4*, *d6*, *d7*, thus reversing the direction of rotation of the motor. The rotating magnet *p* now turns in a direction opposite to that on the opening movement, and when the acceleration of the motor M and door D reaches a predetermined speed the coil of relay RE is energized to interrupt the circuit which by-passes resistances R and RA through the action of bridge-contact *p19* of the speed control device SC. By increasing the tension of spring *p11*, the speed control device SC can be adjusted to act at a higher opening speed than the closing speed, so that the door D may be opened more quickly than it is closed.

As the door D closely approaches the limit of its closing movement the cam **48** will act to open limit switch CLS, thereby interrupting the circuit which passes through the resistance R (bridge-contact *42a* of limit switch CLS opens a gap between conductors *d20* and *d21*) and also the circuit which by-passes the resistances R and RA (bridge-contact **42** opens a gap between conductors *d12*, *d25* should the latter circuit be not already interrupted at the bridge-contact *d13* of relay RE). In its fully closed position a feeble current flow through the motor is maintained so that the motor M acts as a positive means for holding the door in its fully closed position. Said feeble current will flow from line L by way of resistance RA, conductor *d2*, switch CSW and then in series through the field and armature of motor M to line LX by way of conductors *d5*, *d4*, *d6*, *d7*, as previously described.

Continuing now the description of the action of the speed control device SC to bring resistance into the circuit of the motor M in reference to the embodiment shown in Fig. 2, the motor M in this embodiment is illustrated as a three-phase alternating current motor.

The retardation of the motor may be effected by electrical resistances R1, R2, R3, in the circuits of the motor. These three resistances are by-passed in whole or in part through the bridge-contacts of the relay R, and the energization of the relay R will break circuits which by-pass the resistances R1, R2, R3, thereby bringing these resistances into action to retard the speed of motor M. The energization of the relay R is under the control of the speed control device SC. The direction of rotation of the motor M is under the control of relays OR and CR, relay OR bringing about the running of the motor in a direction to open the door and the relay CR to bringing about the rotation of the motor M in the direction to close the door. The operation of the relays OR and CR may be effected through control switches OLS and CLS respectively.

The embodiment of Fig. 2 includes means for immobilizing the electrical operator in the fully open and fully closed position of the door. The immobilization may be effected in a number of ways. The current flow to the motor M may be greatly reduced or cut off entirely. In the embodiment of Fig. 2, switches OLS and CLS are provided for cutting off the flow of current to the motor M at or from near the open limit and the closed limit, respectively, of the door. These switches OLS and CLS are included in the circuits of the relays OR and CR. The limit switches OLS and CLS may have various forms and be operated in various ways. In the embodiment illustrated the switches OLS and CLS comprise bridge-contacts **41**, **42**, mounted on levers **43**, **44**, which levers are operated on to move the bridge pieces **41**, **42** to positions to open the circuits by cams **47**, **48** on the shaft of the gear *c11*, which gear and shaft move in synchronism with the door. The circuits from the switches OLS and CLS are traced as follows:

Circuit of switch OLS: Line L1, bridge-contact **41**, conductor **50**, bridge-contact **52** of relay CR, conductor **53**, coil of relay OR, conductor **55**, bridge-contact **57** of control switch CS and conductor **59** back to line L2.

Circuit of limit switch CLS: Line L1, bridge-contact **42**, conductor **61**, bridge-contact **62** of relay OR, conductor **63**, coil of relay CR, conductor **65**, bridge-contact **57** of controller switch CS and conductor **68** back to line L2. When turned in the opposite direction, the control switch CS may establish the same circuit through the bridge-contact **57** and conductors **65***a* and **68***a* in multiple with conductors **65** and **68**.

On the door opening movement, the current flows between the motor M and the three lines L1, L2, L3 in different phase, pass through the relay OR, and is traced as follows: Line L1, resistance R1, conductor L11, bridge-contact L12

of relay OR, conductors L13 and L14 to motor M. When relay R is deenergized current also passes from line L1 over the by-pass circuit 70, bridge-contact 75 of relay R, conductor 71, part of resistance R1, conductor L11, bridge-contact L12 and conductors L13 and L14. From the line L2 the flow of current to and from the motor is by way of resistance R2, conductor L21, bridge-contact L22 of relay OR and conductors L23 and L24. Also when relay OR is deenergized, current flows by way of by-pass conductor 80, bridge-contact 85 of relay R, conductor 81, part of resistance R2, and from said resistance to the motor by way of conductors L21, etc. as previously described. From line L3, the current flow to and from the motor M is traced as follows: Line L3, resistance R3, conductor L31, bridge-contact L32 of relay OR and conductors L33 and L34 to the motor. When relay R is deenergized there is a conducting path through a circuit which by-passes the resistance R3, traced as follows: L3, conductor 90, bridge-contact 95 of relay R, conductor 91, part of resistance R3, and from thence to the motor via conductors L31, etc. previously described.

On the door closing movement the current flow between the motor M and the three lines L1, L2, L3, passes through the relay CR and the direction of the rotation of motor M is the reverse of that on its door opening movement. The flow is traced as follows: from Line L1, resistance R1, conductor L16, bridge-contact L17 of relay CR and conductor L34 to motor M. When relay R is deenergized, there is also a flow of current by-passing resistance R1, by way of conductor 70, bridge-contact 75 of relay R, conductor 71, part of resistance R1, and then to the motor by way of conductors L16, etc., previously described. From line L2 the current flow is by way of resistance R2, conductor L26, bridge-contact L27 of relay CR, and conductor L24 to motor M. When relay resistance R is deenergized there is also a flow through the circuit by-passing resistance R2, comprising conductor 80, bridge-contact 85 of relay R, conductor 81, part of resistance R2, and then to motor M by way of conductors L26, etc., previously described. From line L3, the current flow to motor M is by way of resistance R3, conductor L36, bridge-contact L37 of relay CR and conductor L14 to motor M. When relay R is deenergized there is also a flow by-passing resistance R3 by way of conductor 90, bridge contact 95 of relay R, conductor 91, part of resistance R3, and then to motor M by way of conductors L36, etc., previously described.

The circuits of motor M for the door closing operation, as here shown, may pass through more of the resistances R1, R2, R3 than where the motor is running in the door opening direction. This is done so that the door closes at a slower speed than that at which it is opened. By using a larger amount of resistance in the circuits when the motor M is operating in the door closing direction, a desired differential between the opening and closing speeds of the door may be obtained.

When the door on its opening or closing movement reaches a predetermined speed, the speed control device SC operates to energize the relay R and thereby break the by-pass circuits around resistances R1, R2, R3, thereby decreasing the flow of the current to the motor M and retarding its action, which retardation may be so arranged that after reaching the predetermined speed the motor no longer accelerates the door closing or door opening movement.

The circuit through the coil of relay R is from line L1, said relay coil, conductor 100, conductor 101, bridge-contact *p18* of speed control device SC, conductor 102 to line L2, and also from line L1, said relay coil, conductor 100, branch conductor 105, bridge-contact *p19* of speed control device SC, and conductor 106 to line L2. The speed control device is adjusted, as heretofore described, to close the circuit through the coil of relay R at one or the other of the bridge-contacts *p18*, *p19* according to the speed and direction in which the motor M is rotating and when the bridge-contacts *p18* or *p19* bridge the space between conductors 101, and 102 or 105 and 106, the circuit through the coil of relay R is closed, and the relay is energized to break the by-pass circuits around the resistances R1, R2, R3 in the circuits of motor M.

Description of operation based on the embodiment of Fig. 2

The door D being in closed position, as shown, the electric operator operates to open the door as follows: Controller switch CS is turned so that its bridge-contact 57 closes the gap between conductors 55 and 59, and completes a circuit through relay OR, from line L1 through bridge-contact 41 of limit switch OLS, conductor 50, bridge-contact 52 of relay CR, conductor 53, coil of relay OR, conductor 55, bridge-contact 57 of controller switch CS, conductor 59, to line L2. The energization of relay OR closes the circuit to the motor M by the bridge-contacts L12, L22, L32. Relay R is not energized at this time; its bridge-contacts 75, 85, 95 closes the circuits by-passing resistances R1, R2, R3. Current in three phases flows to the motor M from lines L1, L2, L3, through circuits previously described; which include the by-pass circuits by way of conductors 70, 71 and bridge-contact 75, conductors 80, 81, and bridge-contact 85, and conductors 90, 91 and bridge-contact 95. The motor M turns with its maximum opening power and starts the door opening movement through the action of pinion *c10*, gear *c11*, lever *c12*, lever *c15* and link *c18*. The door in opening quickly accelerates under the maximum opening power of the motor M. Meanwhile the magnetic rotor *p* is turning in synchronism with the motor M and door D and is exerting a torque or magnetic drag on the rotatable part *p2*.

Rotation of the part *p2* under the drag of the rotating magnet *p* is opposed by the spring *p10* acting on the arm *p7* of part *p2* which carries the bridge-contact *p18*. The tension of spring 10 is so adjusted that the drag exerted by the rotating magnet *p* is insufficient to bring the bridge-contact *p18* in contact with the ends of conductors 102 and 101 until a predetermined speed on the opening movement of the door is attained. When said predetermined speed is attained and the gap between the wires 102 and 101 is closed by the bridge-contact *p18*, the relay R is energized, current flowing from L1 through the coil of relay R, conductors 100, 101, bridge-contact *p18*, conductor 102 to line L2. Energization of magnet R breaks the circuit in the by-pass conductors 70, 71, 80, 81, and 90, 91 at the bridge-contacts 75, 85, 95. Current can thereafter only flow from lines L1, L2, L3 to conductors L11, L21, and L31, leading to the motor M, through the intervening resistances R1, R2, R3. This dimin-

ishes the flow of current to the motor M and thereby diminishes its power, so that the door opening movement is retarded. The effect ordinarily desired is to prevent further acceleration of the door in the opening direction, maintaining a speed during most of the remainder of the door opening movement corresponding approximately to that obtained at the time the power of the motor is diminished.

As the door closely approaches the limit of its opening movement it is usually checked and the electric operator immobilized. A number of means may be provided for this purpose. The current of the motor may be much reduced leaving it feebly energized, or the circuit may be broken. As here shown, means are provided for breaking the circuit to the motor M. This means is the switch OLS previously referred to. Cam 47 moves in synchronism with the door and also the motor M, and as the door approaches close to its limit of opening movement, the cam turns the lever 43 which moves the bridge-contact 41 to break the circuit between the lines L1 and 50. This in turn deenergizes the relay OR allowing the plunger which carries bridge-contacts L12, L22, L32 to drop, breaking the circuits from the lines L1, L2, L3 to the motor.

A door check 110 may also be provided, the action of which is to check the momentum of the door near its limits of opening and closing movement.

To close the door, the controller switch CS is turned so that its bridge-contact 57 closes the gap between the conductors 65 and 68, or 65*a* and 68*a* and completes a circuit through the relay CR from line L1 to the bridge-contact 42 of the limit switch CLS, conductor 61, bridge-contact 62, conductor 63, coil of relay CR, conductor 65, bridge-contact 57 of controller switch CS, and conductor 68 to line L2. The energization of relay CR closes the circuit to the motor M by the bridge contacts L17, L27, L37, the arrangement being such that the current now flows to the motor M from the lines L1, L2, L3, in such a way as to cause it to turn in a reverse direction from that previously described, that is, the motor now rotates in a direction to operate on the connection C to close the door. Relay R not being energized at this time its bridge contacts 75, 85, 95 close the circuits which by-pass the resistances R1, R2, R3. Current in three phases now flows to motor M from lines L1, L2, L3 through circuits previously described, which circuits include the by-pass circuits by way of conductors 70, 71 and bridge-contact 75, conductors 80, 81 and bridge-contact 85, and conductors 90, 91 and bridge-contact 95. The motor M turns with its maximum closing power and starts the door closing movement through the connections C previously described. The door in closing, quickly accelerates under the maximum closing power of the motor M, which power, however, in the embodiment shown, may be less than the full opening power of the motor on the door opening movement, as previously described. Magnetic rotor *p* of the speed control device SC is rotating in synchronism with the motor M. The tension of the spring *p11* of the speed control device SC is so adjusted that the drag exerted by magnetic rotor *p* on rotary part *p2* is insufficient to bring the bridge-contact *p19* into contact with the terminals of conductors 105, 106 until a predetermined speed of the door on its closing movement is attained. This predetermined speed may be different from that at which the relay R goes into action on the door opening movement, and this differential may be taken care of through adjustment of the springs *p10*, *p11*. When the predetermined speed is attained on the door closing movement, an electrical connection is established between lines 105, 106 by the bridge-contact *p19*, the relay R is energized, current flowing from L1 through the coil of relay R, conductors 100, 105, bridge-contact *p19*, and conductor 106 to line L2. Energization of relay R results in breaking the circuits which by-pass portions of the resistances R1, R2, R3, and with these resistances in the circuit of motor M its power is reduced and the door closing movement retarded. The effect usually arranged is that the door closing movement no longer accelerates, but continues at a fairly even rate until the door reaches a position close to its closed position. As the door closely approaches the limit of its closing movement, the limit switch CLS goes into action, breaking the circuit through the coil of relay CR through the action of cam 48 and lever 44 on the bridge-contact 42, opening the gap between the conductors L1 and 61. When the coil of relay CR is deenergized, its plunger which carries the bridge-contacts L17, L27, L37 drops, thereby breaking the circuit from the lines L1, L2, L3 to the motor M. The momentum of the door may be checked by the door check 110 and the door comes to a stop in its fully closed position. It is biased or held there in various ways.

In the present embodiment, the crank pin *c13* is close enough to one of its dead center positions that a small counterweight CW on the link *c12* is sufficient to keep the doors in the closed position. The doors may be manually opened with reasonable ease by pulling directly on the door.

If, on either the opening or closing movement of the door, such movement is checked, as by the door meeting an obstruction, or being obstructed manually by a person, the movement of the door and consequently that of the motor M would be slowed down, and this would result in either the spring *p10* or *p11* of the speed control device SC having greater force than the torque between the magnet *p* and the part *p2*, and the circuits at one or the other of bridge-contacts *p18*, *p19* will be broken, thereby deenergizing the relay R, allowing the plunger to drop, and the bridge-contacts 75, 85, 95 complete the by-pass circuits around the resistances R1, R2, R3, so that upon resumption of the movement of the door in either direction from whatever intermediate position it is at, the full closing or opening power of the motor M is again applied and continues to act, accelerating the door movement, until a speed is reached at which the relay R is again energized through the action of the speed control device SC.

Description of operation based on embodiment illustrated in Fig. 1

Door D being in closed position, control switch CSW is thrown to energize the motor M in the door opening direction (down position Fig. 1). The motor starts to move under the full opening power of the line, current flowing from line L, conductors *d9*, *d10*, bridge-contact 41 of limit switch OLS, conductor *d12*, bridge-contact *d13* of relay RE, conductor *d14* by-passing resistances R and RA, conductor *d2*, switch CSW and then in series through the armature and field of the motor M by way of conductors *d3*, *d4*, *d5*, *d*, switch CSW, conductor *d6* and then to line LX by conductor *d7*. The motor M, receiving full current, the door opening movement accelerates rapidly. When a predetermined speed of opening has been

reached, the drag of magnet *p* of speed control device SC on part *p2* is sufficient to overcome the resistance of spring *p10*, a circuit is completed through the coil of relay RE by bridge-contact *p18*, and the circuit which by-passes the resistances R and RA is interrupted at the bridge-contact *d13*. The current flow through the coil of relay RE is from line L through the coil, conductor *d17*, bridge-contact *p18* of speed control device SC, conductor *d16* to line LX. After the circuit which by-passes resistances R and RA was established, another circuit through the resistance R was established when the door had moved an inch or so, so that when the aforesaid by-pass circuit is interrupted, the current flow to the motor M is through the resistance R as well as resistance RA. The effect of the resistances R and RA is to retard the motor, the amount of retardation being usually contrived to prevent further acceleration of the motor on the door opening movement. The motor circuit through resistance R is traced as follows: Line L, bridge-contact *41a* of limit switch OLS, conductor *d20*, bridge-control *42a* of limit switch CLS, conductor *d21*, resistance R, conductor *d2*, switch CSW, conductor *d3*, *d4*, *d5*, *d*, switch CSW and conductors *d6* and *d7* to line LX. The circuit through resistance RA is from line L, resistance RA, conductor *d2*, switch CSW and from the switch through the motor to line LX over the conductors previously described.

Should the door opening movement be retarded or momentarily stopped by an extraneous object, or its direction of movement changed before the door D reaches its fully open position, the resumption of the opening movement, or movement in the reverse (closing) direction, will be under the full power of motor M at whatever position of the door the resumption of the door movement or the reversal of the door movement begins. This automatically occurs because when the door movement is retarded, or is reversed, the speed of motor M falls, and consequently the drag of magnet *p* of speed control device SC on part *p2* diminishes, whereupon spring *p10* acts on arm *p7* to move the bridge-contact *p18* to open a gap between conductors *d16* and *d17* and thus interrupt the flow of current through the coil of relay RE. Thereupon bridge-contact *d13* reestablishes the circuit which by-passes resistances R and RA and current flows to the motor M under the full power of the line.

As the door D closely approaches the limit of its opening movement, the cam 47 acts on limit switch OLS to open a gap between conductors *d19* and *d12* at bridge-contact 41 and between line L and conductor *d20* at bridge-contact *41a* thus interrupting the circuit previously traced which passes through resistance R, as well as the circuit which by-passes resistances R and RA, should the latter circuit then not be interrupted at the bridge-contact *d13* of relay RE.

Shortly after the limit switch OLS acts the door comes to a stop. An abutment or stop A may be provided at the open limit of the door. In this embodiment a feeble current continues to flow to the motor M through the resistance RA. The circuit as previously described is from line L, resistance RA, conductor *d2* to switch CSW, and from there through the field and armature of motor M to line LX by conductors *d3*, *d4*, *d5*, *d*, *d6*, *d7*. The feeble current acts on the motor M to bias it in the door opening direction to hold the door against the stop A.

Means for cushioning the impact of the door D with the stop may be provided. The door connections C provide in effect such a means. The pin on gear *c2* to which link *c3* is connected approaches at this time a dead center position and consequently the door is moving very slowly as it meets the abutment A.

To close door D, the switch CSW is thrown in a direction to admit the current to the motor M to cause the flow to be reversed and the motor to turn in the reverse direction to that on the door opening movement. On the drawings this is illustrated by the up position of switch CSW. Current flows to the motor from line L to switch CSW over the circuits previously traced, and from switch CSW to the motor and then to line LX, over the path previously traced except that current flows from conductor *d2* through the switch to conductor *d5*, instead of to conductor *d4*, as on the door opening movement. At this time relay RE is not energized and full current flows to the motor, so that the speed of the motor M and of the door D accelerates under the full power of the motor. After the first inch or so of the door movement, limit switch OLS acts to close the motor circuit, at the bridge-contacts 41 and *41a*, which includes resistance R as previously described. When the door attains a speed at which the drag of magnet *p* on part *p2* of the speed control device SC is great enough to move the part *p2* against the force of spring *p11*, bridge-contact *p19* closes the circuit through the coil of relay RE, whereupon said coil is energized and the bridge-contact *d13* of relay RE opens a gap between conductors *d12* and *d14* which by-pass the resistances R and RA. Thereafter current to the motor M passes through the resistances R and RA and the speed of the motor and that of the door D is retarded as previously described. The door closing movement may be made slower than the door opening movement by decreasing the tension of spring *p11* so that the acceleration of the door speed is less on the closing movement than on the opening movement at the time the speed control device SC acts to break the circuit which by-passes the resistances R and RA, this breaking of the by-pass circuit being effected by the relay RE in the manner previously described.

Should the door meet an obstruction on the closing movement, or the direction of its movement be reversed, the consequent momentary stopping or slowing of the motor M will cause speed control device SC to act to deenergize the coil of relay RE in the manner previously described, and thereby establish the motor circuit which by-passes resistances R and RA. Thereupon motor M will be energized with full power and rapidly accelerate the door movement in the door closing direction, or in the reverse direction, from whatever position the resumption of closing movement, or the movement in the reverse direction, begins.

As the door approaches the limit of its closing movement, cam 48 acts on bridge-contacts 42 and *42a* to open a gap in the motor circuit which by-passes the resistances R and RA and also in the motor circuit which passes through resistance R, similar to the action on the opening movement. The door D comes to a stop against the door jamb or against an abutment and its stopping may be cushioned by suitable means. In the illustrated embodiment the connection C acts as a cushioning means. The pin on gear *c2* to which link *c3* is connected approaches its dead center position as the door closely approaches it

closed limit, so that the door is moving very slowly as it reaches its closed limit.

A small current continues to flow to motor M through the resistance RA, and the motor M remains energized to moderately oppose the movement of the door away from its closed position.

In the specification and claims the word "door" is to be understood as including gates and similar closures, as equivalents.

What is claimed is:

1. An electric operator for opening and closing doors in predetermined time intervals of opening and closing, comprising an extra-powered electric motor door-operating means actuated by the motor, said motor being capable of moving the load represented by the door and the door-equipment from closed to open position, and vice versa, much faster than the predetermined time interval, retarding means operable to limit acceleration of the motor-speed after a predetermined motor-speed has been attained, and a control device responsive to the speed of the motor, operable at said predetermined motor speed to bring into action said retarding means, and below said predetermined motor speed to take out of action said retarding means, so that said motor, irrespective of the position of the door at an initiation, resumption or reversal of its opening and closing movements, operates with its full power, undiminished by said retarding means, to rapidly accelerate the door opening or closing movement until the motor speed reaches said predetermined speed at which the retarding means is again brought into action.

2. An electric operator for opening and closing doors in predetermined time intervals of opening and closing, according to claim 1, wherein said retarding means is an electrical device for cutting down the electrical energy within the motor.

3. An electric operator for opening and closing doors and the like, according to claim 1, further including limit switches for interrupting the motor circuit at each limit of the operator action.

4. An electric operator for opening and closing doors in predetermined time-intervals of opening and closing, an extra powered electric motor door operating means actuated by the motor, said motor being capable of moving the load represented by the door and the door-equipment from closed to open position, and vice versa, much faster than the predetermined time interval, a motor circuit including a resistance actable as a retarding means for limiting acceleration of the motor speed after a predetermined motor speed has been attained, and a circuit by-passing said resistance in which condition the acceleration of the motor is not retarded by said resistance, a relay normally closing said by-pass circuit, and a control device responsive to the speed of the motor, operable at said predetermined motor speed to actuate said relay to open said by-pass circuit, thereby causing said resistance to act to retard the motor and limit its acceleration, and operable to again close said by-pass circuit when the speed of the motor falls below said predetermined speed, so that said motor, irrespective of the position of the door at an initiation, resumption or reversal of its opening or closing movements, operates with its full power, undiminished by said retarding means, to rapidly accelerate the door opening and closing movement until the motor speed reaches said predetermined speed at which the retarding means is again brought into action.

5. An electric operator for opening and closing doors and the like, according to claim 4, further including limit switches for interrupting the motor circuits through said resistance and the by-pass at each limit of the operator action.

6. An electric operator for opening and closing doors and the like, according to claim 4, further including a relatively high resistance motor circuit acting to feebly energize the motor at a limit of the operator action for exerting a positive force tending to hold the operator at its limit position.

7. An electric operator for opening and closing doors in predetermined time intervals of opening and closing, comprising an extra-powered reversible electric motor, door operating means actuated by the motor, said motor being capable of moving the load represented by the door and door equipment from closed to open position, and vice versa, much faster than the predetermined time interval, retarding means operable to limit acceleration of the motor speed in either direction after a predetermined motor speed has been attained, and a control device responsive to the speed of the motor in either direction, operable at said predetermined motor speed to bring into action said retarding means, and below said predetermined motor speed to take out of action said retarding means, so that said motor, irrespective of the position of the door, at an initiation, resumption or reversal of its opening and closing movements, operates with full power, undiminished by said retarding means, to rapidly accelerate the door opening or closing movement until the motor speed reaches said predetermined speed at which the retarding means is again brought into action.

8. An electric operator for opening and closing doors in predetermined time intervals of opening and closing, according to claim 7, wherein the predetermined time intervals for closing and opening the door are different, and wherein said control device comprises means for effecting differential action thereof on the door opening and door closing movements.

9. An electric operator for opening and closing doors in predetermined time intervals of opening and closing, according to claim 7, wherein the predetermined time interval for closing the door is longer than for opening, and wherein said control device comprises means for effecting differential action thereof in such manner that the retarding means is brought into action at a lower motor speed on the door closing movement than on the door opening movement.

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