

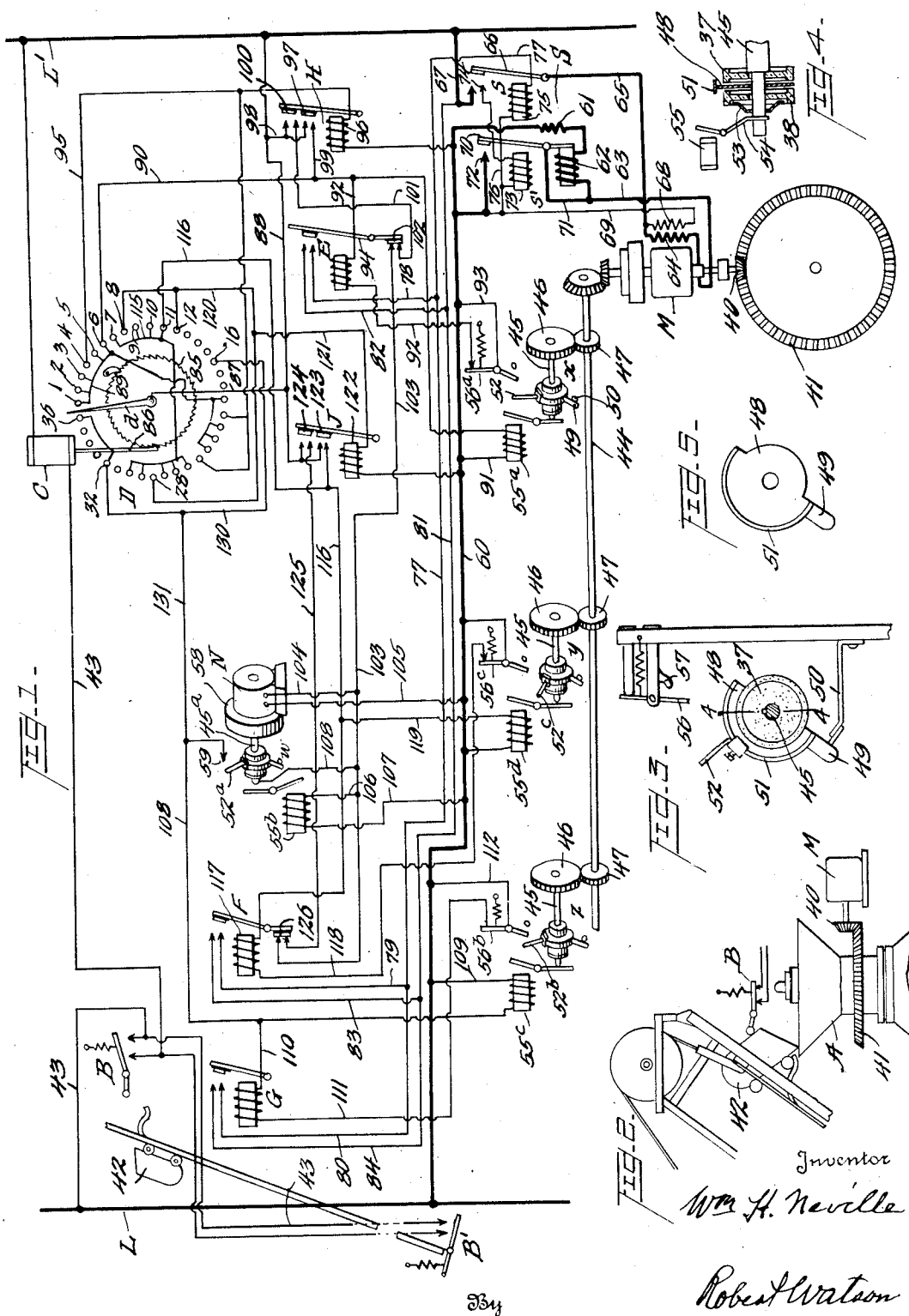
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ELECTRIC MOTOR CONTROL SYSTEM

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ELECTRIC MOTOR CONTROL SYSTEM

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8 Claims. (Cl. 172-239)

This invention relates to a control system for causing predetermined movements of an electric motor and its load, through the medium of an automatically operated master switch. The invention is used for rotating a receptacle at the top of a blast furnace so as to distribute the loads of fuel and other materials which are dumped into the receptacle, and which are, at intervals, dumped from the receptacle into the furnace. For the purpose of illustration, the invention will be described as applied to this use, although it has other uses.

In carrying out the invention, I provide a master switch having a plurality of contacts and a contact member which is moved step by step into engagement with these contacts in succession, the means for actuating the contact member being a solenoid or magnet which is energized through a circuit controlled, when the invention is applied to a blast furnace, by a skip which carries the fuel and other material to the furnace top and dumps it into a rotatable receptacle. Circuits lead from the individual contacts, or groups of contacts, on the master switch to relays which control the starting of a motor which rotates the receptacle, and slip-switch mechanisms, operated by the motor, are adapted to open the magnet circuits of these relays to cause stoppage of the motor, each slip-switch mechanism having a readily adjustable part which may be set to cause stoppage of the motor after the receptacle has been given a desired angular movement about its axis. I also provide means, including a slip-switch circuit closing mechanism, whereby when the contact member of the master switch engages certain contacts, the extent of movement of the motor will be automatically augmented by a predetermined amount after it has moved to the extent determined by the setting of certain of the aforesaid slip-switch circuit opening mechanisms, as will be hereinafter explained. The distribution of the loads dumped into the receptacle may be varied by changing the connections of the relay circuits to the contacts of the master switch, and also by changing the settings of the adjustable members of the slip-switch mechanisms.

In the accompanying drawing,

Fig. 1 is a diagram illustrating the invention as applied to a blast furnace;

Fig. 2 is a detailed view showing part of the skip hoist and the rotatable receptacle and the switch which is closed by the skip when in dumping position, together with the motor for rotating the receptacle;

Fig. 3 is a side view of one of the slip-switch mechanisms;

Fig. 4 is a section through the same on the line 4-4 of Fig. 3, and,

Fig. 5 is a side view of the disk which is rotatable by the friction devices to actuate the switch.

In the accompanying drawing, Fig. 2, A indicates a rotary receptacle at the top of a blast furnace, as illustrated in McKee Patent 864,795, dated September 3, 1907, or Baker Patent 910,264, dated January 19, 1909, and M indicates an electric motor suitably geared to the receptacle, the gearing being represented conventionally by a pinion 40 on the motor shaft and a ring gear 41 on the receptacle. A skip hoist is shown having a skip 42 which carries loads of fuel and other materials to the top of the furnace and dumps them automatically into the receptacle. In the dumping position, the skip closes a normally open switch B and when the skip is lowered it closes a normally open switch B' which parallels the switch B in a circuit 43, which extends from a supply wire L through the coil of a solenoid C to a supply wire L'. The solenoid controls the operation of a master switch D, which in turn controls the mechanisms hereinafter described for operating the motor M to cause any desired angular movement of the receptacle A, for the purpose of properly distributing the loads of fuel, etc., in the furnace.

In the diagram, Fig. 1, the motor is shown geared to the ring gear 41 and also to a shaft 44 to which are geared several slip-switch mechanisms x, y, and z, each adapted, under control of the master switch, to open a circuit and cause the stoppage of the motor M after receptacle A has been given a predetermined angular movement about its axis. As shown, each mechanism has a shaft 45 upon which is mounted a gear 46, meshing with a pinion 47 on the shaft 44. These slip-switch mechanisms are similar to the mechanisms illustrated in patent to Whittingham, 1,851,228, dated March 29, 1932, and Reissue Patent 18,238, dated October 27, 1931, and are illustrated in Figs. 3, 4, and 5. As shown in these figures, two friction disks 37 and 38, preferably of carbon graphite composition, are keyed to the shaft 45, the latter disk being movable longitudinally of the shaft. Between these disks is arranged a metal plate 48, which is freely rotatable upon the shaft and is provided with a weighted arm 49 which normally rests against the stop 50. The plate has a peripheral rim 51 on which is mounted an adjustable radially projecting arm 52. A sheet metal washer 53 is mounted on the

shaft adjacent the friction disk 38 and a forked lever 54 is movable by a magnet 55 against the washer to force the disk 38 toward the disk 37 and thus frictionally clamp the plate 48 so that it will rotate with the shaft 45 when the latter is turned by the motor. When the plate and its adjustable arm 52 are moved by the motor, the arm will engage one end of a centrally pivoted switch arm 56 and rock the arm against a stop 57, opening the switch. When this occurs, if the shaft continues to rotate, the friction disks will continue to rotate, while the metal plate 48 and its arm 52 will remain stationary, holding the switch open, until the magnet is de-energized, when the weighted arm 49 will rock the plate and its arm 52 back to the normal position shown in Fig. 3. The time required for opening the switch after the magnet is energized may be increased or decreased by adjusting the arm 52 further from or closer to the switch arm 56.

A similar slip-switch mechanism is shown at *w* operated by a small motor N which drives the shaft 45a at a slow speed through reducing gearing in a gear box 58. In this instance the adjustable arm 52a is used as a contact member, adapted to engage a fixed contact 59, to close a circuit, and to open the circuit when the friction devices are released from the metal plate which carries the arm.

The starter S for the motor M comprises a main contactor *s* for connecting the motor circuits to the supply circuit and an auxiliary contactor *s'* for cutting out the starting resistance. The closure of the main contactor is controlled by the master switch through relays, and the opening of the main contactor is controlled by the slip-switch devices *x*, *y* and *z*, as hereinafter explained. The armature circuit of the motor M extends from the supply wire L through conductor 60 to the starting resistance 61, thence through coil of series magnet 62 to conductor 63, thence through the armature and series field 64, thence by conductor 65 to contact arm 66 of the main contactor, and thence, when the contactor is closed, by conductor 67 to the supply wire L'. The shunt field 68 is connected between conductors 60 and 65 by conductor 69. The armature 70 of the auxiliary contactor is centrally pivoted and connected to conductor 63 by conductor 71 and is adapted to engage a contact 72 connected to conductor 60 and thereby short-circuit the starting resistance. When the main contactor closes the armature circuit through the series magnet 62 of the auxiliary contactor, it also closes a circuit through the coil of a shunt magnet 73, this latter coil having one terminal connected to conductor 60 and the other terminal connected to contact 74 of the main contactor. The series and shunt magnets 62 and 73 act in opposition, the former holding the arm 70 open until the armature current falls to a predetermined value, when the shunt magnet overpowers the series magnet and closes the contactor.

The coil of main contactor magnet 75 is in a circuit which can be closed by any one of the relays E, F or G, so that the closure of any one of these relays will cause the motor M to start. Thus one terminal of the coil of magnet 75 is connected by conductors 76 and 60 to the side L of the supply circuit and the other terminal of the coil is connected to conductor 77 which has leads 78, 79 and 80 extending to the normally open relay switches E, F, and G, respectively. A conductor 81, connected to the supply wire L' by conductor 67, has leads 82, 83 and 84, extending to the nor-

mally open relay switches E, F, and G, respectively.

The master switch D has a series of stationary contacts 1, 2, 3, etc., thirty-six such contacts being shown in the drawing and it has an arm *d* movable step by step over these contacts by a ratchet wheel 85, which is engaged by a pawl 86 operated by the solenoid C. The contacts are spaced apart and the ratchet wheel has twice as many teeth as there are contacts so that at one operation of the solenoid, the arm will be moved onto a contact and at the next operation it will be moved off of a contact. The contact arm is connected by conductors 87 and 88 to the side L' of the supply circuit. When the skip 42 comes to the dumping position, as shown in Fig. 2, the switch B is closed by the skip and if the arm *d* is at that time between the contacts 36 and 1 on the master switch, as shown in the diagram, the solenoid will cause it to be moved onto the contact 1. When the skip descends, the switch B will open and at the lower end of its travel, the skip will close the switch B', which parallels the switch B, and the solenoid will become energized and cause the contact arm to be moved to a point midway between contacts 1 and 2.

Assuming the contact member to be in the position shown when the switch B is closed by the skip, the solenoid will move the arm onto contact 1 and this will complete circuits as follows: from the supply wire L' through conductors 88 and 87 to the arm *d*, contact 1, conductor 89 to conductor 90 and thence through coil of clutch magnet 55a and by conductors 91 and 60 to the side L of the supply circuit. The magnet will attract the lever of the slip-switch mechanism *x* and cause the friction devices to grip the plate between them. A circuit will simultaneously be closed from conductor 90 by way of conductor 92 through magnet coil of a relay switch E and thence to normally closed switch 56a and by conductors 93 and 60 to supply wire L. Coil of relay E will be energized and attract the centrally pivoted switch arm 94, the upper contact of which will connect the conductors 82 and 78 and thereby complete a circuit through the coil of the magnet 75 of the starter, and the motor M will operate the ring gear 41 and also the shafts of slip-switch mechanisms *x*, *y*, and *z*. As the clutch magnet 55a of the mechanism *x* is energized at this time, the adjustable arm 52 will move into engagement with the switch 56a and rock the latter to open position, thus interrupting the circuit through the magnet of relay E and causing the arm 94 to break the circuit through the coil of magnet 75 of the main contactor of the starter, stopping the motor.

It will readily be seen that the extent of movement of the motor, the ring gear and the receptacle A, in the operation just described, will be dependent upon the setting of the adjustable arm 52 on the frictionally driven plate which carries it. If the arm is set close to the switch 56a, the latter will open after the motor has rotated the receptacle through a small angle, and if the arm is set further away from the switch, the switch will open after the motor has rotated the receptacle through a greater angle. The clutch magnet 55a remains energized after the switch 56a has opened, until the skip, in its descent, closes the switch B', when the solenoid C will move the contact arm of the master switch off of the contact 1 and to a point midway between contacts 1 and 2. This will break the con-

nection to conductor 90 which leads to the clutch magnet and the magnet will be de-energized. The friction disks will then release the plate carrying the member 52, and the plate will rock back to its normal position, permitting the switch 56a to close so that the circuit of the magnet of relay E may be completed to the master switch for the next operation.

Assuming that the receptacle A was rotated through an angle of 90° after the contact arm *d* was moved onto contact 1 by the dumping of the first skip load, the operations above described will be repeated when the second skip load is dumped and the contact arm is moved onto contact 2, and again repeated when the third skip load is dumped, and the contact arm is moved onto contact 3, because these contacts are connected together by conductor 89. Thus, the receptacle will have moved through an angle of 270° and will contain three skip loads spaced 90° apart. When the fourth skip load closes the switch B, the contact arm *d* will be moved onto contact 4. The load will be dumped 90° from the third load, making four loads in the receptacle, 90° apart; but the receptacle will now be moved through a greater angle than 90° so that the fifth load will not be dumped on the first, but beside it. To this end, the arrangement is such that when the contact arm of the master switch is moved onto the contact 4 by the dumping of the fourth load, the motor will operate as before to turn the receptacle through the assumed angle of 90° and the motor will then stop but will be immediately started again and will turn the receptacle through a further angle, say 20°, for example. This is accomplished by the means now to be described.

The contact 4 is connected by conductor 95 to the coil of magnet 96 of a normally open relay switch H, and thence to conductor 60 which leads to supply wire L. The contact arm *d* of the master switch completes this circuit to the supply wire L'. When the magnet of the relay H is energized, the lower insulated contact 97 on its contact arm connects the side L' of the supply circuit through conductors 88, 98 and 99 with the conductor 90, which, as previously described, is connected through the coil of the clutch magnet 55a by conductors 91 and 60 to the supply wire L, and through conductor 92 and coil of relay E to the switch 56a and by conductors 93 and 60 to the supply wire L. The closure of the relay E, by connecting the leads 82 and 78 causes the motor M to start, and the motor operates until the slip-switch mechanism *x* opens the circuit of the magnet of the relay E, when the motor will stop, after the receptacle A has been given the 90° movement. The relay H will remain closed, and the clutch magnet 55a will remain energized and the mechanism *x* will hold the switch 56a open after the motor has stopped.

The opening of the relay E while the relay H is closed completes a circuit to the motor N and the slip-switch mechanism *w*: from the side L' of the supply circuit through conductors 88 and 98 and upper contact 100 of relay H to conductor 101 and thence through lower contact 102 of relay E to conductor 103. The wire 104 leads from conductor 103 to the motor N and a return wire 105 extends to the conductor 60 which leads to the supply wire L; a wire 106 leads to clutch magnet 55b and a return wire 107 leads to conductor 60. A wire 108 extends from conductor 103 to the shaft of the slip-switch mechanism *w* and the arm 52a of this mechanism is thereby connected

to 103. The motor N starts and the arm 52a is brought into engagement with the stationary contact 59 after a short predetermined time, sufficient to allow the starter contactors to open and the motor M to come to a stop, the time of engagement of the members 52a and 59 being determined by the setting of the former on the plate by which it is carried.

When the member 52a engages the contact 59, a circuit is completed from conductor 103 to a conductor 108 which leads to clutch magnet 55c of the slip switch mechanism *z* and thence by conductors 109 and 60 to the supply wire L. A circuit is also completed through the magnet coil of relay G by conductors 110 and 111 to normally closed switch 56b and thence by conductors 112 and 60 to the supply wire L. The completion of these circuits causes the relay G to close and the slip-switch mechanism *z* to become operative. The relay, through conductors 80 and 77 and conductors 84 and 81 completes a circuit to the main contactor of the starter S and the motor M operates to move the receptacle A and also operates the shaft 44. The shaft, through the mechanism *z*, causes the tappet member 52b to rock the switch 56b to open position after the receptacle A has been given a predetermined angular movement, which we have assumed to be 20°. The opening of the switch 56b interrupts the circuit through the coil of relay G and the relay, in opening, interrupts the circuit to the main contactor of the starter, thereby stopping the motor M.

When the skip closes the switch B' after the fourth load has been delivered, the solenoid moves the contact arm of the master switch off of the contact 4 and this interrupts the circuit through conductor 95 to the relay H, which opens and breaks the circuits to the motor N and slip-switch mechanism *w*, including the magnet 55b. This mechanism immediately resets in its original position, breaking the circuit to clutch magnet 55c and allowing mechanism *z* to reset and close 56b, and the opening of relay H also opens the circuit of clutch magnet 55a, allowing the mechanism *x* to reset and the switch 56a to close.

As the contacts 5 and 6 of the master switch are electrically connected to the contacts 1, 2 and 3, when the contact arm engages contacts 5 and 6, the movements of the motor M will be the same as when the arm is on contacts 1, 2 or 3, the relay E and the mechanism *x* controlling these movements.

When the contact arm is moved to contact 7, the relay F and mechanism *y* will control the movement of the motor M. The tappet arm 52c of the mechanism *y* will be set at a different distance from the switch 56b than the distance between the arm 52 and switch 56a of the mechanism *x*, so that the extent of movement of the motor and receptacle A will be different from that which occurs when the arm is controlled by relay E and mechanism *x*. In the drawing the tappet arm of the mechanism *y* is shown further away from the switch 56c than the distance between the arm 52 and the switch 56a, from which it will be plain that the movement of the motor will be greater when it is controlled by the relay F and mechanism *y* than when it is controlled by relay E and mechanism *x*. This greater movement may be taken, for illustration, as 120°.

The contact 7 is connected by conductors 115 and 116 to coil of magnet 117 of normally open relay F and thence by conductor 118 through normally closed switch 56c to conductor 60 which

leads to supply wire L. A branch wire 119 leads from conductor 116 to clutch magnet 55d and thence to conductor 60. Hence, when the contact arm *d* is moved onto contact 7, the relay F will close and connect the leads 79 and 83 which will complete the circuit to the starter magnet 75, and the clutch magnet will make the mechanism *y* operative. The motor M will start and operate until the switch 56c is opened by the mechanism *y*, when the circuit to the magnet of the relay F will be broken and the relay will open the circuit of the starter magnet 75 and the motor will stop. The clutch magnet will remain energized and the switch 56c will remain open until the contact arm of the master switch is moved off of the contact 7 by the next operation of the solenoid, when the slip-switch mechanism *y* will reset and the switch 56c will close, making up the circuit of the magnet at that point. This operation will, of course, be repeated when the contact arm is moved onto any contact connected to the contact 7, such as the contacts 9, 10 and 11.

When the contact arm is moved onto the contact 8, a relay J will be energized and the circuits controlled by this relay will cause the relay F and mechanism *y* to control the motor so that it will move the receptacle A to the same extent as when the contact arm was on contact 7, assumed to be 120°. The motor will then stop and the motor N will operate to complete circuits to the relay G and mechanism *z* which will cause the motor M to operate receptacle A through a further angle, assumed in the prior description to be 20°.

Thus, contact 8 is connected by conductors 120 and 121 to coil of magnet 122 of relay J and thence to conductor 60 which is connected to supply wire L. When the relay J closes its insulated contact 123 connects conductor 88, leading from supply wire L', to conductor 116, and the operation is then the same as when conductor 116 was connected to supply wire L' through the contact 7 of the master switch,—that is, relay F will cause the motor M to start and the mechanism *y* will cause it to stop by interrupting the circuit of the magnet of relay F. The clutch magnet 55d will remain energized, however, as long as the relay J is closed, and the switch 56c will be held open after the motor stops. The opening of the relay F while the relay J is closed completes circuits to the auxiliary motor N and slip-switch mechanism *w*, as follows: From supply wire L' through conductor 88 to upper insulated contact 124 of relay J, thence through conductor 125 to insulated contact 126 of relay F, thence to conductor 103 to which conductors 104, 108 and 106 leading to the motor N, mechanism *w* and clutch magnet 55b are connected, as before explained. Hence, when the motor M is stopped by the opening of the relay F, the relay J remaining closed, the motor N will operate the mechanism *w* to close the magnet circuit of the relay G, and the closure of this relay will cause the motor M to start and it will continue in operation until the mechanism *z* interrupts the circuit of the magnet of relay G, when this relay will open and the motor M will stop. Thus, when the master switch contact arm is moved onto contact 8, two successive movements will be given to the motor M and when the arm engages any contact connected to contact 8, such as contacts 12 and 28, similar successive movements will be given to the motor.

Certain contacts on the master switch are

shown not connected to any circuits, and when the contact arm is on any one of these, no operation of the motor M or rotation of the receptacle A will take place.

Contacts 16, 32 and 36 are shown connected together by a conductor 130, and when the contact arm is on any one of these, the relay G and the mechanism *z* will be operative to control the motor M, giving the short movement, assumed, for the purpose of illustration, to be 20°. As shown, the conductor 130 is connected by connection 131 to conductor 108 which leads to clutch magnet 55c and the magnet of relay G. The details of these connections have been heretofore described. The closure of relay G causes the motor M to start, and the mechanism *z* causes it to stop after the predetermined movement by interruption of the circuit to the magnet of relay G. When the contact arm *d* moves off of contact 16, 32 or 36, the circuit from the arm to the clutch magnet 55c and the magnet of the relay coil will be broken.

What I claim is:

1. The combination with an electric motor and a load to be moved thereby, of a starter for the motor, a plurality of normally open relay switches adapted to independently control the operation of the starter, a master switch having a plurality of contacts and a contact member adapted to engage said contacts, step by step, in succession, means for operating said switch intermittently, independent circuits for the magnets of said relays connected to independent contacts on said switch, and a plurality of slip-switch mechanisms operated by the motor, each adapted to open a separate one of said circuits.

2. The combination with an electric motor and a load to be moved thereby, of a starter for the motor, a plurality of normally open relay switches each adapted to independently control the operation of the starter, a master switch having a plurality of contacts and a contact member adapted to engage said contacts, step by step, in succession, means for operating said switch intermittently, independent circuits for the magnets of said relays connected to independent contacts on said switch, and a plurality of slip-switch mechanisms operated by the motor, each adapted to open a separate one of said circuits, each mechanism having an adjustable part adapted to vary the time of opening the circuit.

3. The combination with an electric motor and a load to be moved thereby, of a starter for the motor, a plurality of normally open relay switches each adapted to independently control the operation of the starter, a master switch having a plurality of contacts and a contact member adapted to engage said contacts, step by step, in succession, means for operating said switch intermittently, independent circuits for the magnets of said relays connected to independent contacts on said switch, clutch magnets having circuits connected to said contacts, and a plurality of slip-switch mechanisms controlled by the latter magnets and operated by the motor for opening the circuits of the relay magnets.

4. The combination with an electric motor and a load to be moved thereby, of a starter for the motor, a plurality of normally open relay switches each adapted to independently control the operation of the starter, a master switch having a plurality of contacts and a contact member adapted to engage said contacts, step by step, in succession, means for operating said switch in-

- termittently, independent circuits for the magnets of said relays connected to independent contacts on said switch, clutch magnets having circuits connected to said contacts, and a plurality of slip-switch mechanisms controlled by the latter magnets and operated by the motor for opening the circuits of the relay magnets, each mechanism comprising a switch operating member movable by frictional means to open a circuit and which resets in normal position when the clutch magnet is de-energized.
5. The combination with an electric motor and a load to be moved thereby, of a starter for the motor, a plurality of normally open relay switches each adapted to independently control the operation of the starter, a master switch having a plurality of contacts and a contact member adapted to engage said contacts, step by step, in succession, independent circuits for the magnets of said relays connected to means for operating said switch intermittently, independent contacts on said switch, clutch magnets having circuits connected to said contacts, and a plurality of slip switch mechanisms controlled by the latter magnets and operated by the motor for opening the circuits of the relay magnets, each mechanism having an adjustable part adapted to vary the time of opening the circuit.
6. The combination with an electric motor and a load to be moved thereby, of a master switch having a contact member and a plurality of contacts, means for operating said switch intermittently to cause said member to engage said contacts in succession, step by step, and means controlled by said switch, when said member engages one of said contacts, adapted to cause said motor to start and operate through a predetermined movement, then stop, and then start and operate through a further predetermined movement.
7. The combination with a load motor, of a starter for the motor, a master switch, a relay having a magnet circuit adapted to be closed by said switch, a second relay having a magnet circuit adapted to be closed by said first mentioned relay, said second relay adapted to control the operation of the starter, a clutch magnet having a circuit adapted to be closed by said first mentioned relay, a slip-switch mechanism controlled by the clutch magnet and operated by the load motor for opening the magnet circuit of the second relay to stop the load motor after a predetermined movement of the latter, means for operating the load motor through a further predetermined movement comprising a third relay, adapted to control the operation of the starter, a slip-switch mechanism for closing the magnet circuit of said third relay, an auxiliary motor and a clutch magnet for operating the latter mechanism, circuits for said latter motor and magnet adapted to be closed by said second relay when its magnet circuit is de-energized, and a slip-switch mechanism operated by the load motor for opening the magnet circuit of the third relay.
8. The combination with an electric motor and a load to be moved thereby, of a starter for the motor, a master switch having a series of spaced contacts and a contact member, means for operating said switch intermittently to cause said member to engage said contacts, step by step, in succession, a relay controlling the operation of the starter, a clutch magnet, a circuit for the magnet of the relay and a circuit for the clutch magnet, both connected to certain contacts on the master switch whereby, when the latter switch is operated, said magnets will be energized simultaneously, and a slip-switch mechanism operated by said motor and controlled by the clutch magnet for opening the circuit of the relay magnet after a predetermined movement of the motor.
- WILLIAM H. NEVILLE.

45	120
50	125
55	130
60	135
65	140
70	145
75	150