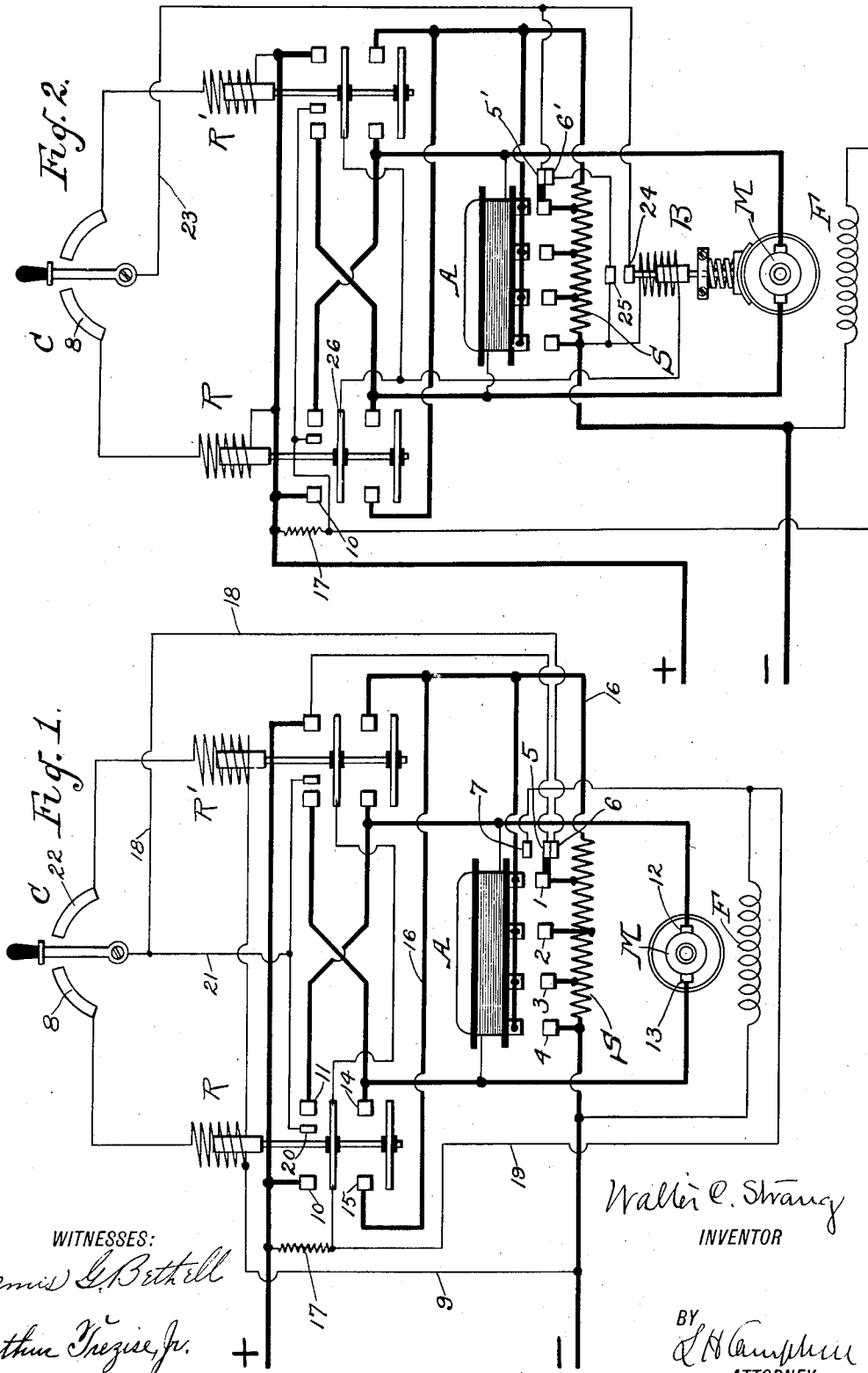


1,264,992.

Patented May 7, 1918.



WITNESSES:

James L. Bethell
Arthur Trezise, Jr.

Walter C. Strang
INVENTOR

BY *L. H. Campbell*
ATTORNEY

UNITED STATES PATENT OFFICE.

WALTER C. STRANG, OF YONKERS, NEW YORK, ASSIGNOR TO OTIS ELEVATOR COMPANY,
OF NEW YORK, N. Y., A CORPORATION OF NEW JERSEY.

MOTOR CONTROL.

1,264,992.

Specification of Letters Patent.

Patented May 7, 1918.

Application filed August 22, 1913. Serial No. 786,072.

To all whom it may concern:

Be it known that I, WALTER C. STRANG, a citizen of the United States, residing in Yonkers, in the county of Westchester and State of New York, have invented a new and useful Improvement in Motor Controls, of which the following is a specification.

My invention relates to the control of an electric motor, and has for an object the provision of automatically operated means for preventing the too sudden reversal of the motor.

A further object of the invention is to prevent the closing of the motor circuit, unless and until the starting resistance is inserted in the armature circuit.

Other objects of the invention will appear hereinafter, the novel combinations of elements being pointed out in the annexed claims.

Figures 1 and 2 of the drawing represent motor controlling systems containing an embodiment of my invention.

In the control of an electric motor where it is required that the motor be reversed, such for example as in an electric hoist or elevator, it is essential that the motor be safeguarded against a too sudden reversal by a careless operator. Various schemes have been proposed from time to time to overcome this danger, and, while such schemes will operate more or less satisfactorily they are as a rule complicated and liable to get out of order, and are expensive to install. I propose to attain the desired object in a very simple and practical manner and without resorting to complicated or expensive apparatus.

Referring to Fig. 1, I show a hand controller C, operative to effect the closure of either of the reversing switches R or R', to close a circuit to the motor M. A starting resistance S is gradually short circuited by an accelerating magnet A and the motor is automatically run up to full speed in either direction of rotation. The accelerating magnet A is substantially like that shown in Patent No. 677,359, issued to John D. Ihlder, July 2, 1901, and comprises the contacts 1, 2, 3 and 4, which are arranged to operate successively in the order named to short circuit the starting resistance according to the varying potential of the motor armature. The contact 1, or rather the arm which carries the contact, is preferably made of less

weight than the other contacts 2, 3, and 4, so that it will be the last one to fall out when the magnet is deenergized. Movable with the contact 1 is an insulated contact 5 which normally engages a stationary contact 6 when the magnet A is completely deenergized, and is moved upwardly into electrical engagement with a stationary contact 7 when the contact 1 operates to short circuit the first portion of the starting resistance.

The operation of the device shown in Fig. 1 may best be shown by assuming the operator has moved the lever of the master switch C until the contact 8 is in electrical engagement therewith. A circuit may now be traced from the + main through the contacts 5 and 6 to the switch lever, switch contact 8, magnet winding of reversing switch R, and by the conductor 9 to the - main. The reversing switch operating circuit being complete, the switch operates to raise its core and connected contact disks, thereby closing a circuit to the motor. The motor circuit may be traced from the + main, through the reversing switch contacts 10 and 11, armature brush 12, through the motor armature to brush 13, reversing switch contacts 14 and 15, conductors 16, starting resistance S, to the - main. The circuit to the motor field F is always closed through the high resistance 17 so that the motor field may be partially magnetized when the motor armature is disconnected from the line. As soon as the reversing switch R closes, this resistance 17 is short circuited and the motor field at once attains full strength with its terminals connected across the mains.

The circuit being now closed, the motor starts, and as its counter-electro-motive force rises, the accelerating magnet A being connected across the armature brushes, gathers strength and successively operates the contacts 1, 2, 3 and 4, in the order named, gradually to short circuit the starting resistance S and allow the motor to reach full speed. As soon as the contact 1 operates to short circuit the first step of the starting resistance the contact 5 is moved out of engagement with the contact 6 and is carried into engagement with the contact 7. In separating the contacts 5 and 6, it will be observed that the conductor 18 leading to the master switch lever is open-circuited, while the clos-

ing of the contacts 5 and 7 establishes a circuit from the right hand terminal of the field winding F to the + main which circuit is in parallel to the circuit closed from this same field terminal to the + main via the conductor 19 and reversing switch contact 10. While it might appear that the open circuiting of the contact 6 and conductor 18 would open circuit the magnet of the reversing switch, such is not the case, since when the reversing switch operated, an additional circuit was closed from the + main to the lever of the master switch through the reversing switch contacts 10 and 20, and the conductor 21 and hence the reversing switch remains in closed position.

If the operator attempts suddenly to reverse the motor by reversing the master switch C, the motor will first come gradually to rest with its field fully excited from the mains via the contacts 5 and 7, and then, and not until then, can a circuit be closed to the motor in the reverse direction to effect a reversal. The reason for this is as follows: As soon as the master switch lever leaves the contact 8, the circuit to the magnet of the reversing switch R is interrupted and this switch immediately drops, thereby opening the motor armature circuit at the contact 10, and rendering the contact 20 and conductor 21, which feeds the master switch, dead. Since the motor is still in motion a current continues to pass from the motor, acting in the capacity of a separately excited generator, to the accelerating magnet A and the contact 5 of said magnet remains out of engagement with the contact 6. Such being the case, both the conductors 21 and 18 which alternately serve as feed wires for the master switch are dead and it will be impossible to close a circuit to either of the reversing switch magnets as long as the motor possesses any appreciable speed. As soon as the motor substantially comes to rest, its generated electro-motive force falls to such an amount that the accelerating magnet no longer has sufficient strength to maintain the contacts 5 and 7 in closed position and the contact 5 falls away from the contact 7, and engages the contact 6, whereupon a circuit may again be closed through the conductor 18 to the magnet of reversing switch R or reversing switch R' as desired.

As the contacts 5 and 7 become separated, the right hand terminal of the field F is no longer connected directly to the + main, but is connected to the + main through the conductor 19 and the high resistance 17. Hence the field strength becomes weakened and a substantial saving in current consumption is the result.

The chief function of the contact 7 in the motor field circuit, is to insure that the motor field will always be strongly excited when the armature circuit to the mains is

open and the motor is running. As long as the field is excited the motor can always be depended upon to generate sufficient potential to maintain the accelerating magnet contacts 5 and 6 in open relation even at very low motor speeds. From this it follows that a reversing switch cannot be moved to effect a reversal of the motor until the latter has substantially come to rest. Furthermore the motor cannot be reversed nor can it again be started in the same direction unless and until the entire starting resistance first be reinserted in the armature circuit. The reason for this lies in the fact that the accelerating contact 1 being of lighter construction than the contacts 2, 3 and 4, is the last one to drop out as the motor comes to rest, hence the contacts 5 and 6 cannot close to permit the operator to establish the motor circuit in either direction until after all of the contacts 4, 3, 2 and 1 first have effected the open circuiting of the starting resistance.

While I have shown the contact 7 arranged to maintain the field circuit of the motor at one strength while the motor is rotating, this contact may in certain cases be dispensed with and the field may be permanently connected to receive current at the full line potential. Or if desired, the field circuit may be broken at the reversing switches and one may depend upon the uncertain and variable residual magnetism of the motor field to excite the motor in slowing down and stopping. Whether the contact 7 is used or not depends upon the varying conditions found in practice, but in general I prefer to use said contact, since its use insures of a certain constant field strength while the motor is acting as a generator and hence the motor may be depended upon to generate an appreciable potential and current at very low speeds, so that a reversal of the motor cannot possible be effected unless and until the motor first be substantially at rest, or at the very least, rotating at such a slow speed that a reverse circuit may safely be closed to the motor from the mains without any danger to the motor or parts driven therefrom.

In Fig. 2 the arrangement is somewhat different than that just described and is particularly adapted to the control of the motor of an electric elevator wherein an electric brake is employed to assist the motor in stopping and holding the elevator car against movement when the motor circuit is cut off. Referring to this view, it will be seen that the magnets of both reversing switches are connected to the + main and to the master switch, while the feed wire 23 of the master switch may be connected through the accelerating magnet contacts 5' and 6' to the - main or by the normally open contacts 24 and 25 controlled by the brake. In starting the motor, the magnet of reversing switch R receives current via the

contacts 5' and 6' one of which, the contact 6', is connected to the — main. As soon as the reversing switch R operates the motor circuit is completed, as before described in connection with Fig. 1, and the high resistance 17 in the field circuit is short circuited to permit of full field strength and the brake circuit is closed at the contact 10 and contact disk 26. As soon as the brake lifts the brake contact 24 and 25 are brought together, thereby establishing a short circuit around the contacts 5' and 6' of the accelerating magnet and maintaining a circuit for the magnet of the reversing switch after these latter contacts are separated by the automatic operation of the accelerating magnet A. If the operator attempts to reverse the motor, the circuit of the reversing switch R is immediately opened and this switch operates to cut off the supply to the motor and brake and the latter at once opens its contact 24 and 25, thereby rendering the feed wire 23 of the master switch dead; the contacts 5' and 6' being previously separated by the motor acting through the accelerating magnet during the period of starting. The feed wire 23 of the master switch being dead it is obviously impossible again to operate either of the reversing switches. As the motor, assisted by the brake, slows down to practically zero speed, the accelerating magnet allows the contacts 5' and 6' to engage each other and then, and not until then, can a circuit to either of the reversing switches be closed from the master switch.

In Fig. 2 it will be observed that the field is only partially excited during the slowing down or stopping period, since the field circuit includes the high resistance 17 when the reversing switches are in open circuit position, and this resistance not only effects an economy of current consumption while the motor is disconnected from the supply main, but it also insures a field of predetermined strength during the slowing down and stopping period so that the motor must first substantially be brought to rest before the control of the motor can be restored to the master switch.

What I claim as new and desire to have protected by Letters Patent of the United States is:—

1. The combination with an electric motor of reversing switches therefor, a resistance in the circuit of the motor armature, a device controlled by the motor for cutting out said resistance in starting, and means controlled by said device for preventing the operation of either of said reversing switches until the motor substantially comes to rest.

2. The combination with an electric motor, of electro-responsive reversing switches for the motor, an operating circuit for said

switches, a motor starting resistance, a device controlled by the speed of the motor for short circuiting said starting resistance, and means controlled by said device for opening the operating circuit of the reversing switches while the motor is rotating.

3. The combination with an electric motor, of electro-responsive motor reversing switches, an operating circuit for said switches, and means actuated by the motor while starting for maintaining said operating circuit open until the motor substantially comes to rest.

4. The combination with an electric motor, of reversing switches therefor, a circuit for effecting the operation of said switches, and means actuated by the counter-electromotive force of the motor in starting for opening said operating circuit and maintaining said circuit open until the motor substantially comes to rest.

5. The combination with an electric motor, of reversing switches therefor biased toward open position, a circuit for effecting the initial operation of said switches, an additional circuit for maintaining said switches in closed position, and automatic means controlled by the motor for opening said first named circuit to prevent the closing of either of said reversing switches after said additional circuit is opened and the motor is rotating.

6. In a system of motor control, the combination with an electric motor, of electro-responsive apparatus for effecting the reversal of the motor, and means dependent upon the motor in starting for controlling the operating circuit of said electro-responsive apparatus to prevent reversal of the motor before substantial reduction in speed thereof.

7. In a system of motor control, the combination with an electric motor, of electro-responsive apparatus for effecting the reversal of the motor, and means dependent upon the speed of the motor in starting for controlling the operating circuit of said electro-responsive apparatus to prevent a reversal of the motor before substantial reduction in the speed thereof.

8. In a system of motor control, the combination with an electric motor, of reversing switches therefor, an electromagnet for operating each switch, and means operated by the motor in starting for controlling the circuit of said electromagnets to prevent energization of the latter immediately after one of said switches opens.

9. In a system of motor control, the combination with an electric motor, of reversing mechanism therefor, electric means for actuating the reversing mechanism, and a device controlled by the speed of the motor in starting for interrupting the circuit of said electric means to prevent a sudden

change in the direction of rotation of the motor armature.

10. In a system of motor control, the combination of an electric motor, reversing switches therefor, a circuit for effecting the closing of one of said switches, a circuit for maintaining said switch closed, and means for maintaining said first named circuit open during the period that the motor armature is rotating.

11. In a system of motor control, the combination of an electric motor, reversing switches therefor, a circuit for effecting the closing of one of said switches, a circuit for maintaining said switch closed, and means controlled by the motor for maintaining said first named circuit open while the motor is in motion.

12. In a system of motor control, the combination of an electric motor, electroresponsive reversing switches, a starting resistance for the motor, a magnet arranged automatically to control said resistance, a circuit to the magnets of the reversing switches, a self holding circuit to the magnets of the reversing switches controlled by said switches, and means for opening said first named circuit and for maintaining the same open while the motor armature is in motion, and the said self holding circuit is open to prevent a too sudden reversal of the motor.

13. The combination with an electric motor, of a resistance in the motor circuit, a device for controlling said resistance, and means operated by said device for controlling a circuit to the field of the motor and for preventing a too sudden reversal of the motor.

14. The combination with an electric mo-

tor, of electroresponsive reversing switches therefor, and a device controlled by the motor in starting for controlling the operating circuit of said switches and a circuit to the field winding of the motor for preventing a too sudden reversal of the motor.

15. The combination with an electric motor, of electro-responsive reversing switches therefor, an operating circuit for said switches, and means controlled by the motor in starting for maintaining said operating circuit open and the motor field at a predetermined strength while the motor is coming to rest.

16. The combination with an electric motor, of electro responsive reversing switches therefor, an operating circuit for said switches, and means operated by the motor in starting for maintaining said operating circuit open and the motor field at a predetermined strength while the motor is coming to rest.

17. The combination with an electric motor, of electro-responsive reversing switches therefor, an operating circuit for said switches, a resistance in the motor circuit, an automatic device for controlling said resistance, and means operated by said device for preventing the operation of said reversing switches and for maintaining the motor field of predetermined strength while the motor is coming to rest.

In testimony whereof, I have signed my name to this specification in the presence of two subscribing witnesses.

WALTER C. STRANG.

Witnesses:

ERNEST L. GALE, Jr.,

ARTHUR TREZISE, Jr.