M. R. HANNA.

MOTOR STARTER.

APPLICATION FILED SEPT. 12, 1907.

941,412. Patented Nov. 30, 1909.

Fig. 1.

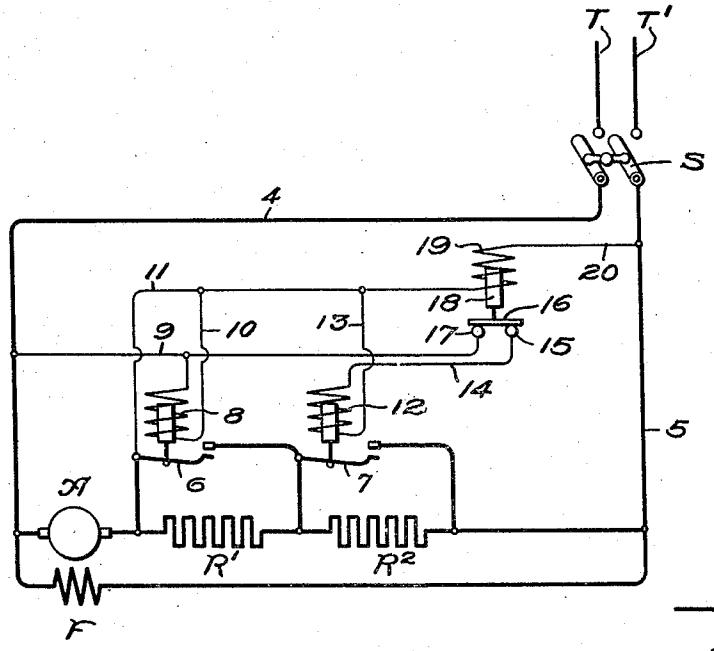
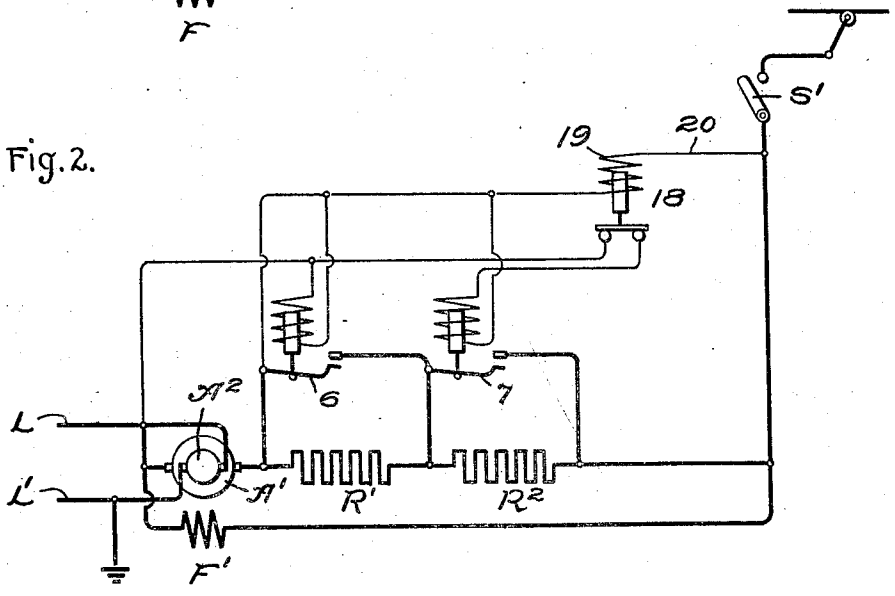


Fig. 2.



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UNITED STATES PATENT OFFICE.

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MOTOR-STARTER.

941,412. Specification of Letters Patent. **Patented Nov. 30, 1909.**

Application filed September 12, 1907. Serial No. 392,423.

To all whom it may concern:

Be it known that I, MAX R. HANNA, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Motor-Starters, of which the following is a specification.

My invention relates to motor controllers and starters and particularly that type of automatic motor starter in which a number of electromagnetic switches or contactors are arranged to close in succession and short circuit sections of resistance in series with the whole motor, or in series with its armature.

One well-known type of such control systems is that in which the operation of the resistance controlling contactors is under the control of a relay responsive to the current in the motor circuit, which relay controls the actuating circuits to the operating coils of the contactors. Such systems are commonly called "current limit control" systems. These systems of control are extensively used but in some connections are open to the objection that the overload responsive device may not become effective, after the closing of the motor circuit, in time to control the operation of the first resistance controlling contactor.

Another well-known type of control system, which is particularly advantageous, owing to its simplicity, is that in which the actuating coils of the resistance controlling contactors are arranged in shunt to the motor or its armature, the contactors being so designed that they will close one after another as the counter electromotive force of the motor increases. Such systems are usually referred to as "counter electromotive force control" systems.

When automatic starting systems of this type are used in connection with a motor driven from a constant potential source, they may be made to increase the potential on the motor by regular and certain amounts. If, however, a system of this kind is used in connection with a source of current, the potential of which varies considerably, the cutting out of the last section of the resistance may result in increasing the potential on the motor by a greater or less amount than desired, depending whether the potential at the source is higher or lower than the normal value for which the system was designed. This will be apparent when it is considered that the operation of the contactors depends altogether on the counter electromotive force of the motor, and is entirely independent of the voltage at the source. All the contactors, except the last one to operate, will, by cutting out the respective sections of resistance, always increase the voltage on the motor by a certain amount. The contactor which cuts out the last section of resistance will, however, when actuated increase the voltage on the motor by an amount which depends upon the voltage at the source. That is, if the voltage is higher than normal, the cutting out of the last section of resistance will result in suddenly increasing the voltage on the motor by an amount in excess of the amount intended to be added on the last step, thereby perhaps overloading the motor while, if the voltage at the source is below normal, the increase in voltage, resulting from the cutting out of the last section of resistance, may be less than the desired amount, or the last resistance controlling contactor may fail to close.

An object of my invention is to provide a control system of the type in which a plurality of contactors close in succession to increase step-by-step the voltage applied to the motor in starting, which will not be open to the objections mentioned above as usually found in "current limit" and "counter electromotive force" control systems. In one aspect my invention may be considered as an improvement on the last mentioned system, although it may be equally well regarded as an improvement on a system of the first mentioned type, since it involves the combination of the principles upon which both types operate.

I have shown my invention as embodied in an automatic motor starter in which the first resistance controlling contactor is rendered responsive to the counter electromotive force of the motor and the last contactor is prevented from closing until the counter electromotive force of the motor has risen to within a certain amount of the potential at the source or, in other words, until the current in the motor circuit has ceased to exceed a certain value. In the particular embodiment shown, I connect the actuating coil of the first resistance controlling contactor in shunt to the motor and provide a

relay having its actuating coil connected across a portion of the starting resistance, the contacts of this relay being located in the control circuit through the actuating coil of the last resistance controlling contactor. This relay is so designed that it will hold its contacts open as long as the fall of potential through the resistance across which it is connected, or, in other words, the current therein exceeds a certain value. This relay will, therefore, prevent the voltage being increased by more than a certain definite amount, irrespective of the voltage at the source, by the cutting out of the last section of resistance. The resistance controlling contactors intermediate the first and the last may have either "current limit" or "counter electromotive force" control, according as one or the other of these types of control is preferred.

My invention obviously may be used in connection with either a series, shunt or compound wound motor, and I have deemed it necessary to describe it in connection with but one of these, since its application to the others will be evident to those skilled in the art. It is also evident that my invention is in no way limited to a starter in which there are a plurality of electro-magnetic switches, since it may equally well be used where but a single contactor cuts out a single section of resistance.

Referring to the drawing, Figure 1 is a diagrammatic representation of a shunt motor with an automatic starter applied thereto, in which is embodied my invention, and Fig. 2 is a diagrammatic representation of a dynamotor or motor generator provided with an automatic starter of my improved type.

Referring to Fig. 1, A represents the armature and F the field of a shunt motor. A source of current is shown at T, T^1 with which the motor is connected by means of a double throw switch S. A starting resistance made up of two sections R^1, R^2 is arranged in series with the armature, as shown. A conductor 4 serves to connect one terminal of both the armature and field to the source T, while a conductor 5 connects the other source T^1 with the other side of the field and with the resistance arranged in series with the armature. Contactors 6 and 7 are arranged, when actuated, to short circuit the resistances R^1 and R^2, respectively. The actuating coil 8 of the contactor 6 is connected on one side through the conductors 9 and 4 with one terminal of the armature, and on the other side through the conductors 10 and 11 with the other armature terminal. The actuating coil 12 of the contactor 7 is similarly connected in parallel with the armature A on one side through the conductors 13 and 11, and on the other side by wire 14, fixed contact 15, movable contact 16 and fixed contact 17 of the relay 18, and wires 9 and 4. The actuating coil 19 of the relay 18 is on one side connected by a wire 20 to the wire 5 running to the source T^1, and on the other side through wire 11 to a point between the starting resistance and the armature A; the coil 19 thus being in parallel with the starting resistance. The relay 18 is so designed that it will pull up immediately when the switch S is closed and will not fall until the current passing through it has been decreased by the reduction to a certain value of the fall of potential through the starting resistance, due to increase in counter electromotive force in the motor.

The operation of the system is as follows: When the switch S is closed current from the source T, T^1 passes in parallel through the field F and through the sections of starting resistance R^1, R^2 and armature A. Armature A then begins to rotate and as its speed increases the counter electromotive force builds up. When this has reached a certain value sufficient current will pass through the actuating coil 8 of the contactor 6 to operate the same, which will result in short circuiting the section of resistance R^1 and increasing the voltage applied to the armature. The armature continues to speed up and the counter electromotive force increases, but no current can yet pass through the coil 12 of the contactor 7 since its circuit is interrupted at the contacts of the relay 18 which pulled up immediately after the switch S was closed. The coil 19 of this relay 18 is now, owing to the closing of the contactor 6, connected in shunt to the section of resistance R^2 and depends for its current on the fall of potential in this section of resistance. When the increasing counter electromotive force of the motor has cut down the fall of potential through the resistance R^2 to a certain amount, the current through the actuating coil 19 of the relay 18 will be insufficient to maintain this relay in its raised position and it will drop thereby bridging the fixed contacts 15 and 17 by the movable contact 16. Current is now permitted to flow through the actuating coil 12 of the contactor 7 and the same will be actuated. This results in cutting out the last section of resistance R^2 and in increasing the voltage impressed on the armature by a certain amount.

In Fig. 2 I have shown my invention as applied to a dynamotor intended to be used on a railway car or locomotive to reduce the voltage on the line (from say 1200 volts to 600 volts) for use in the auxiliary circuits of the train. In this figure the motor armature is indicated at A^1 and the generator armature at A^2, while the field, which may be common to both armatures, is shown at F^1. The armatures A^1 and A^2 are connected

together, as shown, and supply the auxiliary circuit through the leads L, L^1 in a well known manner. The sections of starting resistance R^1 and R^2, the contactors 6 and 7 and the relay 18 are arranged exactly as shown in Fig. 1 above described. Closing of the switch S^1 starts the dynamotor which is brought up to speed by the conjunctive operation of the contactors 6 and 7 and the relay 18, as above described in connection with the system shown in Fig. 1.

What I claim as new and desire to secure by Letters Patent of the United States, is,—

1. In a motor control system, a motor to be controlled, a plurality of switches intended for operation in succession to increase step-by-step the voltage applied to the motor in starting, means for rendering the first switch responsive to the counter electromotive force of the motor, and means for rendering the last switch responsive to the current in the motor circuit.

2. In a motor control system, a motor to be controlled, a plurality of electrically controlled switches intended for operation in succession to increase step-by-step the voltage applied to the motor in starting, means for connecting the actuating coil of the first switch in shunt to the motor, and means responsive to the current in the motor circuit for controlling the energization of the actuating coil of the last switch.

3. In a motor control system, a motor to be controlled, a starting resistance in the motor circuit, a plurality of electrically controlled switches intended for operation in succession to short circuit said resistance section by section, means for connecting the actuating coil of the first switch in shunt to the motor, and a relay having its actuating coil connected across a portion of said resistance arranged to control the circuit through the actuating coil of the last switch whereby the same will be prevented from closing while the current in the motor circuit exceeds a certain value.

4. In combination, a source of current, a motor connected thereto, a starting resistance for said motor, an electro-magnetic switch having its actuating coil connected across the armature of said motor for cutting out said resistance, and a relay having its actuating coil connected across said resistance and its contacts arranged to interrupt the circuit through the actuating coil of the electro-magnetic switch while the counter electro-motive force of the motor is more than a certain amount below the potential at the source.

5. In combination, a source of current supply, a motor connected thereto, a starting resistance for said motor, a plurality of electro-magnetic switches having their actuating coils connected across the armature of said motor and arranged to operate successively as the counter electromotive force of the motor increases, and a relay arranged to interrupt the circuit through the actuating coil of the last switch while the counter electromotive force is more than a certain amount below the potential at the source.

6. In combination, a source of current supply, a motor connected thereto, a resistance in series with said motor, electro-magnetic switches having their actuating coils connected across the armature of said motor and arranged to successively operate as the counter electromotive force of the motor increases, and a relay having its actuating coil connected across said resistance and its contacts arranged to interrupt the circuit through the actuating coil of the last electro-magnetic switch while the voltage at the source is more than a certain amount above the counter electromotive force of the motor.

7. In combination, a source of current supply, a shunt motor connected thereto, a resistance in series with the armature of said motor, electro-magnetic switches having their actuating coils connected across the armature of said motor and arranged to operate successively as the counter-electromotive force of the motor increases, and a relay having its actuating coil connected across said resistance and its contacts arranged to interrupt the circuit through the actuating coil of the last electro-magnetic switch while the counter electromotive force of the motor is more than a certain amount below the potential at the source.

In witness whereof, I have hereunto set my hand this 10th day of September, 1907.

MAX R. HANNA.

Witnesses:
BENJAMIN B. HULL,
MARGARET E. WOOLLEY.