L. BRADLEY.

CURRENT CONTROLLING DEVICE.

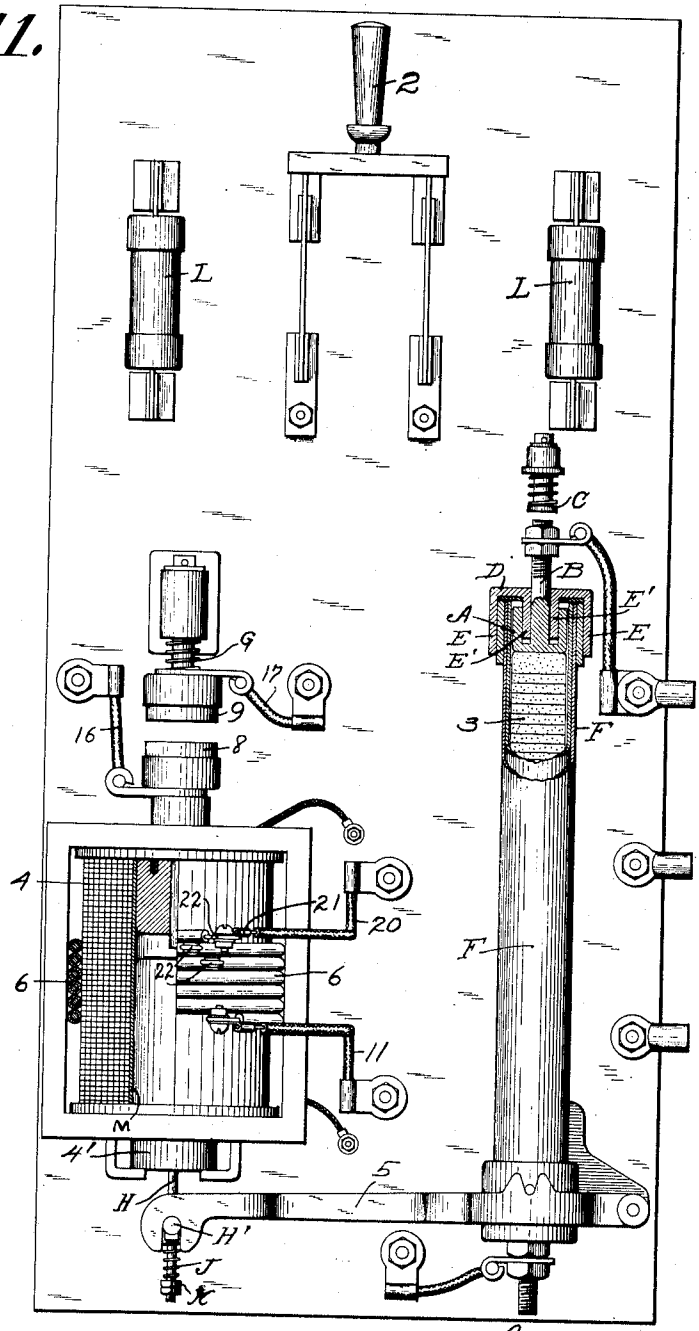
APPLICATION FILED FEB. 12, 1916.

1,361,675.

Patented Dec. 7, 1920.

2 SHEETS—SHEET 1.

Fig. 1.



Witnesses

Inventor

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2 SHEETS—SHEET 2.

Fig. 2.

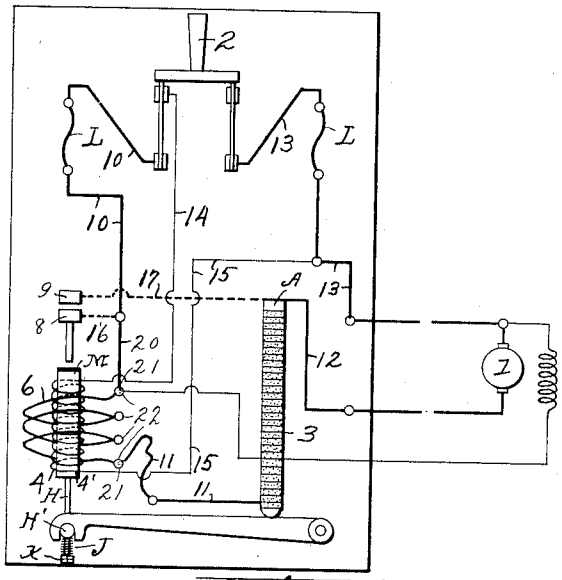
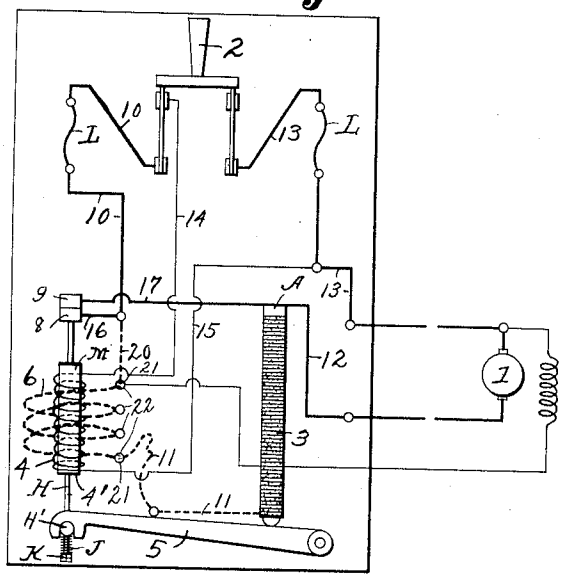


Fig. 3.



Witnesses
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UNITED STATES PATENT OFFICE.

LYNDE BRADLEY, OF MILWAUKEE, WISCONSIN.

CURRENT-CONTROLLING DEVICE.

1,361,675. Specification of Letters Patent. Patented Dec. 7, 1920.

Application filed February 12, 1916. Serial No. 77.873.

To all whom it may concern:

Be it known that I, LYNDE BRADLEY, a citizen of the United States, residing at Milwaukee, county of Milwaukee, and State of Wisconsin, have invented new and useful Improvements in Current-Controlling Devices, of which the following is a specification

My invention relates to improvements in current controlling devices, and pertains especially to that class of devices disclosed in my former Patents, No. 723817, dated March 31, 1903, No. 815317, dated March 13, 1906, No. 821697, dated May 29, 1906, and No. 1161021, dated November 23, 1915.

The general object of such devices is to provide means for progressively reducing the initial protective resistance in the circuit of a motor or other electrically operated machine in inverse proportion to the development of counter-electromotive force. But in the devices heretofore constructed, the reduction of the protective resistance has been accomplished in a series or succession of steps or stages, involving the operation of a rapidly acting interrupter or relay, which delayed the operation of cutting out resistance by repeatedly connecting up and breaking an electrical circuit through the winding of the solenoid or electro-magnet which operates to vary the resistance. Objections have been found to exist to these structures, owing to the fact that under some conditions they require constant attention to keep them in service.

Attempts have also been made to control the action of a resistance varying solenoid or electro-magnet by employing another solenoid in series with the motor and acting in opposition to the resistance varying solenoid by opposing the electro-magnetic force of one to that of the other. But these devices operate substantially the same as those which employ an interrupter or relay, so far as the effect upon the rheostat is concerned, the resistance being reduced step by step, with intervening periods during which the action of the rheostat becomes a constant factor, or in which an actual increase in the resistance is permitted. It is, therefore, desirable that a more stable, uniformly graduated means of controlling the action of the resistance varying magnet should be employed and that some means be provided which are more directly dependent upon and more instantly responsive to variations in current flow of the motor. I have discovered that in utilizing an auxiliary coil to oppose the pull of such a solenoid or electromagnet by electromagnetic force exerted in the opposite direction and variable in proportion to the volume of current in the motor circuit, it is possible to so arrange the coils that the series winding will develop an effective induced electromotive force in the resistance varying winding during periods of varying current flow in the circuit of the motor and thus vary the power of the resistance varying coil in advance, or at least partially in advance, of the mechanical response thereto. This makes the protective resistance afforded by the rheostat more directly responsive to variations in amperage during the motor starting period, and secures a substantially continuous reduction in the resistance under normal starting conditions wherein the motor continuously accelerates in speed.

The specific object of this invention is to provide reliable and durable means whereby the protective resistance in such electrical circuits may be automatically reduced and finally cut out entirely in a series of stages which approximate a continuous reduction in inverse proportion to the development of counter-electromotive force in the controlled electrically operated machine. The advantages thus secured reside not only in the fact that the operator is relieved of the necessity of operating a controller lever, but also in the fact that the reduction in the resistance is made so uniformly gradual, with variations of such slight magnitude as to entirely eliminate the tendency to injury or deterioration, such as may result from violent changes in the flow of current to the operated machine. My invention is peculiarly adapted for use in starting motors since it provides means for automatically varying the motor starting interval in proportion to the load. It is of especial importance in connection with resistance columns in which the resistance is varied by pressure electromagnetically applied, for in such cases, if the force of the magnet is overcome by direct counter force of an opposing magnet in series with the motor and dependent for its energy upon abnormal current in the motor circuit, it is difficult to avoid more or less violent fluctuations in pressure upon the column and correspondingly in the protective resistance afforded by

the column. Further, there is a disadvantage in starting and stopping the movement of the solenoid core or plunger since this moving core also induces electro-motive force which cannot be a constant factor in cases where the motion is intermittent.

Much trouble has been experienced in connection with the use of automatic motor starting devices due to the fact that the part of the apparatus, the function of which is to vary the resistance in the motor circuit, is usually governed by some form of interrupter or relay which alternately makes and breaks the energizing circuit of the solenoids or electromagnetic mechanism employed to control the resistance. The contact terminals of these relays or current interrupters almost invariably become insulated by a coating of dirt or oxidized by destructive arcing, or worn away by continued use, and such apparatus therefore requires careful watching to prevent partial or complete failure of the motor starting apparatus. By my invention I completely eliminate this source of trouble and provide an automatic starter for electric motors which can be depended upon for reliable operation under all conditions.

In the drawings—

Figure 1 is a front elevation of an electric motor starter embodying my invention, showing a portion of the differential coil solenoid in central vertical section.

Figs. 2 and 3 are diagrams, respectively illustrating the starting circuit and the final or normal working circuit.

Like parts are identified by the same reference characters throughout the several views.

The circuit of the motor 1 may be closed by any ordinary switch, such, for example, as the switch 2. Initially this circuit includes a variable resistance member, preferably comprising a column of carbon disks 3 similar to those described in my former patents above referred to and in which the resistance is varied by varying the pressure upon the column.

In my improved apparatus, however, I employ a solenoid coil 4 which is connected in shunt to the motor and is adapted to actuate a solenoid plunger 4′ linked to a lever 5, whereby pressure may be applied to the resistance column 3 during the motor starting period. The solenoid is provided with an outer coil 6 which is hereinafter referred to as the dampening coil. It is formed of heavier or coarser wire than the shunt coil 4, and it is either wound in the opposite direction from that in which the coil 4 is wound, or its terminals are reversed. This coil 6 is included in circuit with the resistance column and is therefore also in the circuit of the motor armature. It prolongs the interval of pressure increase upon the resistance column 3 by intermittingly and momentarily inducing an electromotive force in the coil 4, thereby altering the flow of the energizing current through the latter coil and also by inducing a magnetic flux acting upon the solenoid plunger in opposition to that normally produced by the coil 4.

There is a transformer action constantly taking place between the voltage and series coils. A sudden variation in one is partially counteracted by the other until the current valve becomes more nearly steady, at which time this inductive action ceases and the pull upon the plunger becomes the difference between the steady pulls of the two coils. For instance, a rapidly increasing current in the series coil would induce a voltage tending to aid the voltage impressed upon the voltage coil thereby increasing the current flowing in the voltage coil and consequently increasing its magneto motive force thereby temporarily offsetting the effect of this increased series coil current. When the current became more nearly constant in the series coil the original value of the current in the voltage coil would exist. The pull on the plunger would be the difference in the now steady pull of the series and shunt coil resulting in a slowing down of the speed with which the resistance is cut out. In other words, a change in one coil (which if no mutual induction existed would act only upon the plunger) directly produces a change in the other coil, and in such a direction and of such magnitude that there is a gradual shifting of a part of the control from one coil to the other. Thus, a lessening of the effect of the series coil produces a momentary lessening of the effect of the shunt coil. As soon as the current in the series coil becomes more nearly constant, the shunt coil regains its original power or pull and, due to the lessened counteracting effect of the series coil, assumes more of the control of the plunger.

The effect of this electromotive force induced in coil 4 by coil 6, together with the reduction of its effective magnetic flux by the opposition of coil 6, is sufficient at certain values of the motor current, (predetermined by the number of turns and character of the respective coils), to reduce the pull upon the plunger 4′ and thereby delay the column compressing operation. This reduction in the plunger pull may be sufficient to cause a cessation in the movement of the plunger and lever 5, in which case the resistance of the starter will not be additionally decreased until the increasing speed of the motor and its development of counter-electromotive force has reduced the current flow through coil 6 to a point where its dampening action upon coil 4 will be less effective. Coil 4 will then have sufficient power to still further compress the resistance

column. This dampening action of coil 6 upon solenoid coil 4 may be continuous, and while it may at times cause an intermittent movement of the plunger and thus produce step by step variations in the reduction of the resistance in column 3, yet these steps will be of such slight magnitude that the solenoid plunger will appear to be in continuous and comparatively slow motion and the effect upon the resistance column and upon the circuit of the motor will be substantially the same as that of a gradual or steady increase of pressure and reduction in resistance inversely proportioned to the development of counter electromotive force in the motor.

During the final upward movement of the solenoid plunger, the pressure upon the column 3 reaches a maximum and the resistance of said column to the current flow reaches a minimum. At this point a switch member 8, connected with the plunger, comes into circuit closing relation with a contact member 9, thereby cutting out both the resistance column 3 and the dampening coil 6. This, however, does not take place until the motor is substantially at full speed. The shunt circuit may persist through coil 4 until an interruption of the power circuit occurs, whereupon the shunt circuit will be interrupted, the solenoid deënergized, the solenoid plunger will drop by gravity, and all the parts will be restored to normal position.

In the construction shown, the resistance column 3 is supported by lever 5 and lifted bodily thereby to compress it against head block A, having a stem B, which is adapted to bear against a stop C. A cap D covers the top of the column and is provided with depending annular flanges E, E'. The outer flange E embraces the upper end of the column inclosing casing F and the inner flange E' fits an annular channel in the cap block, thus preventing free passage of air to the interior of the casing without completely sealing the casing to such an extent that the escape of air or gas from the interior may not be permitted when the column is heated. The contact member or terminal 9 is resiliently cushioned by a spring G in order to avoid shocks. For the same reason the solenoid plunger 4' is connected with the forked end of lever 5 by a vertical rod H which extends through the fork in lever 5 and is provided with a sliding cross head H' supported by a coiled spring J, which is located between the cross head and a head or nut K on the lower end of the rod H. L are fuses of ordinary construction. These structural features are, however, not essential to my invention.

As above stated, the coil 6 is wound for a pre-determined amperage and is included in the circuit of the column 3, so that when the resistance of the column is reduced by pressure, the increased amperage may eventually become sufficient to counteract both the impressed electromotive force and the magnetic flux in coil 4 sufficiently to completely stop the action of the solenoid plunger 4' as soon as the current volume reaches the pre-determined limit. It is therefore impossible for the amperage to exceed the limit imposed by the coil 6.

Initially, the circuit of the motor is from the switch 2, through lines 10 and 20, winding of the dampening coil 6, line 11, column 3, line 12, the motor 1, and line 13 to the switch 2. The circuit of the shunt coil 4 is from the switch through line 14, coil 4, line 15, to line 13. When the solenoid plunger 4' has been lifted to a point where the switch 8 contacts with terminal 9, the circuit of the motor armature will be as shown in Fig. 3, from switch 2 through lines 10 and 16, contact 8, switch member 9, lines 17 and 12, the motor and line 13 to the other side of the switch 2.

It will be observed that my invention is adapted to automatically vary the interval of progressive resistance column compression in proportion to the time required for developing full speed in the motor, and therefore the interval depends indirectly upon the load. This is true because the dampening coil 6 will continue to hold back or delay the movement of the solenoid plunger 4' until the speed of the motor reaches a point where its counter-electromotive force will develop sufficiently to prevent the amperage from exceeding the predetermined limit set by the dampening coil 6. The plunger 4' is preferably fitted to the tubular guideway M in which it travels in such a manner that an air cushion is provided within said guideway, the latter being substantially closed. The air cushion checks the momentum of the plunger in either direction, when the solenoid is subject to sudden current changes, and prevents injurious pounding.

In my improved starter, however, the air cushion is not needed under ordinary conditions for the reason that sudden changes in the volume of current to the motor, of such magnitude as to require a variation in the movement of the starting lever or a stoppage or reversal of said lever, would invariably develop considerable induced electromotive force in the shunt coil. This induced electro-motive force will be developed only during the period in which the volume of the current is changing but it will be instantly effective to vary the power of the shunt magnet before any mechanical response is secured by means of the series magnet. Therefore, instead of developing a sudden jerk upon the rheostat lever 5 the motion of the latter is gradually checked

before it is entirely brought to rest and ordinarily it is not necessary that it should be brought entirely to rest since the motor will normally tend to accelerate and reduce the amperage in the main circuit by its own counter electro-motive force. This reduction in current volume tends to increase the strength of the shunt solenoid or magnet and therefore the pressure exerted upon the column commences to increase even before the counter pull developed by the series coil has materially decreased. This also tends to prevent injurious jerks in the operation of the lever 5, and makes the movement of said lever substantially continuous.

Means for adjusting the starter to operate at different amperages are preferably employed. This may be simply accomplished by connecting line 20 with the dampening coil 6 at intervals along the length of the wire composing said coil. The line 20 may be provided with a suitable lug 21 adapted to be connected with any one of the terminal projections 22 formed on or secured to the wire composing coil 6 at intervals, or to successive turns in the coil, thereby cutting out a portion of the coil, the degree of cut-out being determined by the point at which the lead wire 20 is connected.

I claim—

1. In a motor starter system, the combination of a motor, a variable resistance for controlling the current supplied said motor, electromagnetic means for directly decreasing said resistance, and additional electromagnetic means for both modifying and delaying the operation of said first electromagnetic means.

2. In a motor starter system the combination of a motor, a variable resistance for controlling the current supplied said motor, electromagnetic means for directly decreasing said resistance, and additional electromagnetic means for modifying the operation of said first electromagnetic means, each of said electromagnetic means having a delaying or dampening action upon the other by mutual induction.

3. In a motor starter system the combination of a motor, a movable resistance varying member, a coil connected in shunt with said motor for directly actuating said members to reduce said resistance, a second coil inductively associated with and opposing said first mentioned coil connected in series with said motor, whereby sudden surges in the motor circuit are suppressed and smooth starting of the motor is secured.

4. In a motor starter having a compressible resistance column, and a column compressing lever, the combination with said lever of an electro-magnetic mechanism provided with a plurality of opposing coils, one of said coils being in shunt with the motor circuit and adapted to actuate said lever in a column compressing direction, the other of said coils being in series with the motor and arranged to develop opposing magnetic flux, and also to have a delaying and dampening action upon the first mentioned coil during periods of variation in the flow of current to the motor, said series coil being normally weaker than the other and adapted to vary the power of the electro-magnetic device for a compressing operation while allowing it to continuously move the lever in the same direction at different speeds.

In testimony whereof I affix my signature in the presence of two witnesses.

LYNDE BRADLEY.

Witnesses:
LEVERETT C. WHEELER,
IRMA D. BREMER.