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E. R. CARICHOFF.

MOTOR CONTROL.

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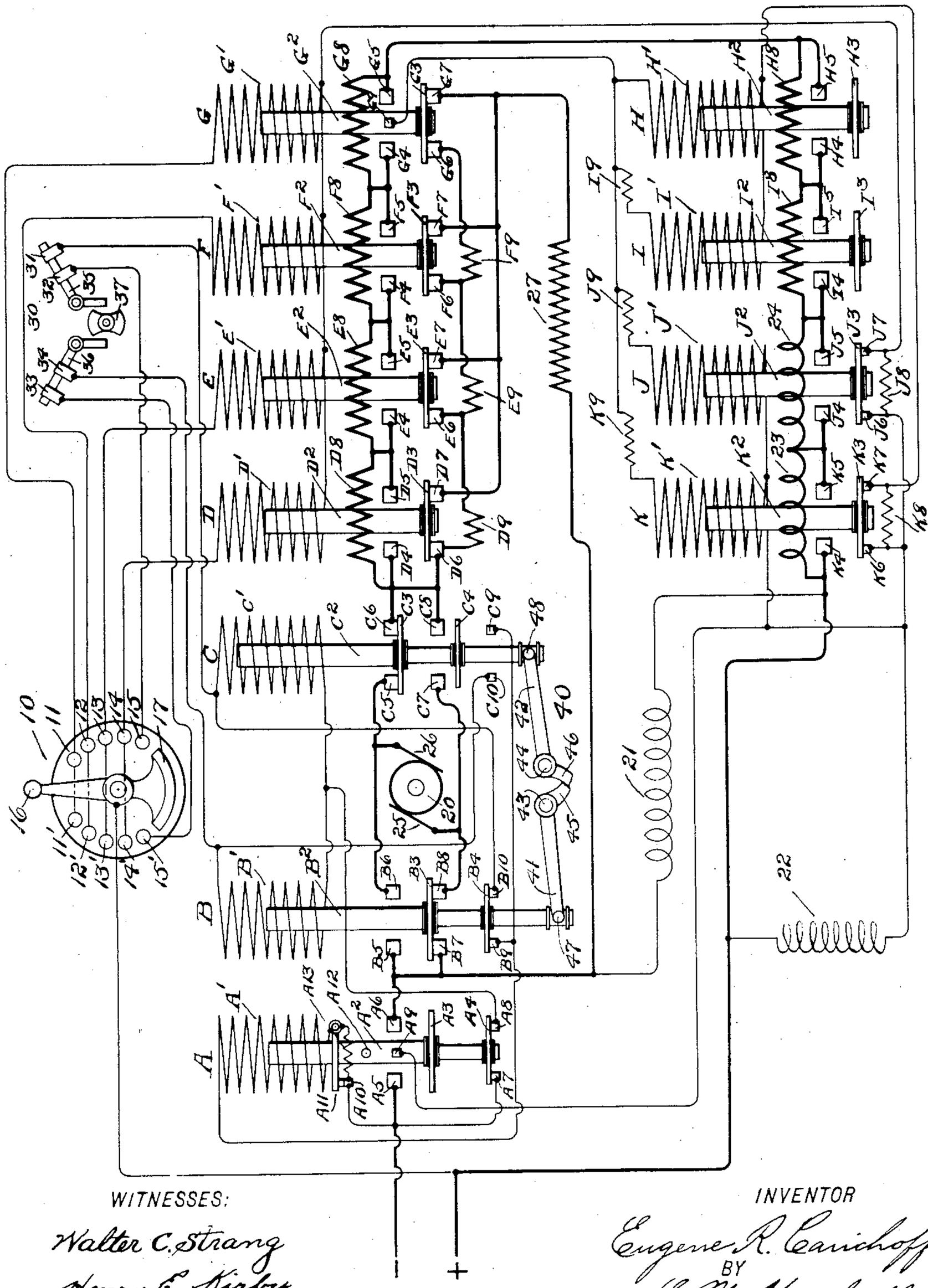

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MOTOR CONTROL.

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To all whom it may concern:

Be it known that I, EUGENE R. CARICHOFF, a citizen of the United States, residing in East Orange, Essex county, New Jersey, have invented certain new and useful Improvements in Motor Control, of which the following is a specification.

My invention relates to a system for controlling electric motors and its object is to improve upon the systems now in use and to provide simple and efficient means for accomplishing this end.

I will describe a motor control system embodying my invention and point out the novel features thereof in claims.

The drawing diagrammatically represents such a system.

10 designates a manually operated switch by means of which an operator controls the system and the movements of the motor. 11, 12, 13, 14, 15 and 11′, 12′, 13′, 14′, 15′ are the stationary contacts of this hand switch and 17 is its movable contact which is adapted to be moved over these stationary contacts by means of a handle 16.

20 represents the armature of a motor, 21 its shunt field, 22 a brake magnet and 23, 24 its series fields.

A, B, C, D, E, F, G, H, I, J and K are magnetic switches adapted to open and close various circuits which will be fully described later. Briefly each one of the magnetic switches comprises a solenoid, a core, a contact disk or disks attached to the core but insulated from it, stationary contacts with which the disks co-act and certain electrical connections all of which will be specifically pointed out. A is a main line switch, B and C reversing switches and the others are switches for controlling certain resistances and the fields of the motor.

40 is a locking device which operates in conjunction with the magnetic switches B and C and consists of two angular levers 41 and 42 pivoted at 43 and 44, engaging with the lower ends of the cores B^2 and C^2 at 47 and 48 and with each other at 45 and 46. 30 is an automatic stop device. It consists of a cam 37 and two electrical switches with their connections.

Without further description of the drawing, I will proceed to trace out the various electrical circuits and describe the operation of the system. The mains which come from a suitable source of electrical supply are designated by + and —. The positive main is connected to the movable contact 17 of the hand switch. When the movable contact 17 is moved to the right until it touches the stationary contact 15 circuits are established through the solenoids A and C. The current will go through the car switch and to the contact 32 of the automatic stop device 30, through the switch blade 35 and out through the contact 31. Thence it goes to the solenoid C^1 where it branches. One part goes through the solenoid C^1 and out to the negative main through the small contacts A^8 and A^7 and the disk A^4. Another part goes through the small contacts B^{10} and B^9 and the disk B^4 to the solenoid A^1, through the latter and to the negative main through the contacts A^{11} and A^{10}. The solenoids C and A will thus be energized and will draw up their cores C^2 and A^2. C^2 will be drawn up to the position shown in the drawing and will be locked in that position by the lever 42, as the short arm 45 of lever 41 will come up behind the short arm 46 of lever 42 and as the lever 42 is connected at 48 to the core C^2 it will hold the latter up in the position shown. This operation will cause the disk C^4 to be raised from the small contacts C^9 and C^{10}, and the disk C^3 to be raised from the contacts C^7 and C^8 and against the contacts C^5 and C^6. At the same time the core B^2 (if it is not already down) will drop down into the position shown in the drawing because the short arm 46 of the lever 42 will be removed from the back of the short arm 45. The disk B^3 will now rest upon the contacts B^7 and B^8 and the disk B^4 rest upon the contacts B^9 and B^{10}. It will be seen that unless the core B^2 is down or until it has dropped down the circuit to the solenoid A^1 is broken at B^9, B^{10}. When they are closed by the disk B^4 the core A^2 will be drawn up so that the disk A^3 will connect the contacts A^5, A^6 and A^9 and the disk A^4 will be raised from the contacts A^7 and A^8. The latter operation will break the circuit through the solenoid C^1 so that no more current will pass through it while the core A^2 remains up. But the core C^2 will remain up as it is now locked in its up position by the arm 42 as we have already shown. The pin A^{12} will strike upon and raise the pivoted contact A^{11} from the contact A^{10} and this operation will insert the resistance A^{13} into the circuit of the solenoid A^1 and so diminish the current used in A^1 while its core A^2 remains raised. When the disk A^3 connects the contacts A^5, A^6 and A^9 it closes a circuit through the brake magnet 22, one end of which is connected to the positive main and the other end of which is connected to the contact A^9 and through the disk A^3 to the negative main. This magnet is used in a well known way to release when it is excited a brake from the moving part of the motor. The disk A^3 also closes the circuit through the shunt field 21, one end of which is connected to the positive main and the other end of which is connected to the contact A^6, and through the disk A^3 to the negative main. Another circuit is closed at the same time from the positive main through the series fields 23 and 24 and the resistances I^8, H^8, G^8, F^8, E^8 and D^8 the contacts C^6, and C^5, which are connected by the disk C^3, through the armature passing in at the brush 26 and leaving at the brush 25, through contacts B^8 and B^7 connected by the disk B^3, through

A^6 and A^5, connected by the disk A^3 to the negative main. When the magnetic switches are in the position shown another circuit is completed through the armature and the resistance 27 as follows: Starting at the brush 25 the circuit goes through contacts B^8, disk B^3 and contact B^7 to the left hand side of the resistance 27, through this resistance to contact D^7, through disk D^3, contact D^6, contact C^6, disk C^3, contact C^5 to brush 26, thence through the armature to the brush 25. Thus it will be seen that the current from the mains is admitted to the armature through the series fields and resistance and that part of it is shunted around the armature through resistance. This will cause the armature to rotate slowly in one direction. As soon as it rotates it generates a counter electro motive force and this will cause an increase of the current through the resistance 27 which causes the latter to act as a brake and prevent an undue acceleration of the armature.

If the movable contact 17 of the hand switch had been moved to the left onto contact 15′ the operation would have been similar but in this case the disks of the reversing switch B would have been raised and those of the reversing switch C would have been dropped, the current would have been sent through the armature in the opposite direction and the armature would have rotated in the opposite direction. If now the movable contact 17 be moved further to the right until it touches the contact 14 a circuit will be closed through the solenoid D^1 of the magnetic switch D. This circuit will be completed from the positive main through the hand switch, the solenoid D^1, thence to the small contact J^7, through the disk J^3, contact J^6, and contact A^9 which as we have already shown is now connected to the negative main. The current flowing through the solenoid D^1 will cause it to be energized and it will attract its core D^2 and draw it up. The disk D^3 will be raised from the contacts D^6 and D^7 and against the contacts D^4 and D^5. In doing this the resistance D^9 will be added to the resistance 27 and at the same time the resistance D^8 which has been in series with the armature will be short-circuited. The effect of this upon the motor will be: first, to decrease the amount of current which is shunted around the armature and decrease the breaking effect thereof, and, second, to increase the current flowing through the armature from the mains by decreasing the series resistance. Both of these actions will have the effect of increasing the rate of rotation of the armature. Similarly, when the movable contact 17 is brought against contacts 13 and 12 the solenoids E^1 and F^1 will be energized, the other cores E^2 and F^2 will be raised respectively from contacts E^6, E^7 and F^6, F^7 and against E^4, E^5 and F^4, F^5, thus adding the resistances E^9 and F^9 to resistance 27 and short-circuiting the resistances E^8 and F^8. In the manner just described, these operations will increase the rate of rotation of the armature. When the movable contact 17 is moved onto the contact 11, the solenoid G^1 will be energized. This will cause the disk G^3 to be raised from the contacts G^6 and G^7, and the shunt around the armature to be broken. When the contacts G^4 and G^5 are connected by the disk G^3, the resistance G^8 is short-circuited. Thus the effect of this operation of the magnetic switch G will be similar to that of the magnetic switches D, E and F. It will also close the circuit through the solenoids H^1, I^1, J^1 and K^1 the effect of which will be presently described. This contact G^9 is now connected through several disks and contacts and their connections to one of the brushes of the armature. It is also connected to the upper side of the solenoids H, I, J and K; to H directly, to the others through resistances I^9, J^9 and K^9. The lower ends of the solenoids H^1, I^1, J^1 and K^1 are connected through various conductors and contacts to the other brush of the armature. Thus these four solenoids are connected in parallel across the brushes of the armature. As the latter accelerates the counter electro-motive force will increase and the current passing through these solenoids will increase in proportion to the acceleration of the armature. The solenoid H^1 is the only one of these four which is connected directly across the armature brushes without the interposition of any external resistance. The solenoid I^1 has a resistance I^9 connected in series with it. J^1 has the resistance J^9 in series with it and K^1 has the resistance K^9 in series with it. The resistance J^9 is greater than the resistance I^9 and the resistance K^9 is greater than the resistance J^9. As the potential across the armature brushes increases these solenoids will become more and more energized until they draw up their respective cores. This they will do step by step beginning with H^1 which has no resistance in series with it, followed by I^1, J^1 and K^1 because of the different amounts of resistance in series with each. When the core H^2 is drawn up, the disk H^3 is brought against the contacts H^4 and H^5 and short-circuits the resistance H^8. This will tend to cause the armature to revolve faster. The core I^2 with its disk I^3 will short-circuit the resistance I^8 at the contacts I^4 and I^5 with a similar result. When the core J^2 is pulled up, its disk J^3 is raised from the small contacts J^6 and J^7 and is brought against the contacts J^4 and J^5. This inserts the resistance J^8 in the circuit with the solenoids D^1, E^1, F^1 and G^1 which prevents them from using excessive current; and it short-circuits the series field 24. Similarly, when the core K^2 is raised, the disk K^3 is lifted from the small contacts K^6 and K^7 and against the contacts K^4 and K^5. This inserts the resistance K^8 in the circuit with the solenoids H^1 and I^1 which prevents them from using excessive current, and it short-circuits the series field 23. The motor will now attain its full speed.

When it is desired to stop the motor automatically after it has run a predetermined number of revolutions, as when it is directly connected to an electric elevator, the automatic stop device 30 may be used. In such a case a cam 37 is so connected that it is moved by the rotation of the armature until it either opens the switch blade 35 from its contacts 31 and 32 or the switch blade 36 from its contacts 33 and 34 according to the direction of the armature's rotation. This will break the circuit through the main line switch solenoid A^1 and open the main line at A^5 and A^6. All the solenoids of the magnetic switches will be deënergized. This will stop the motor as it will cut off its current supply and connect the resistance 27 across the brushes of its armature which will act as a brake. It will be seen that only one side of the automatic stop device 30 will be opened at a time so that the operator may start the motor rotating in the opposite direction at will. This automatic stop de-

vice has the same effect as the hand switch would have if the operator brought it to center. The operator may, however, if he desires bring the motor to a more gradual stop by moving the hand switch gradually so that its movable contact will leave its stationary contacts one by one. As soon as it leaves contact 11 the circuit through the solenoid G^1 will be broken, its core will drop and this in turn will break the circuit through the solenoids H^1, I^1, J^1 and K^1, put the series fields 23 and 24 and the resistances I^8. H^8 and G^8 into the armature circuit and connect the resistances 27, F^9, E^9 and D^9 in shunt with the armature. This will retard the rotation of the armature. The braking effect of the current which flows through the resistances 27, F^9, E^9 and D^9 will of course depend upon its amount and this will depend upon the amount of the resistance. This the operator may decrease and thus increase the braking effect by removing step by step, the resistances F^9, E^9 and D^9 by causing the movable contact 17 to leave respectively the contacts 12, 13 and 14. When at last he causes it to leave the contact 15 the main line will be opened at the magnetic switch A and the motor will come to a stop. The shunt field 21 remains connected across the brushes of the armature so that it will receive current as long as the armature rotates.

It is to be noted that in this system the motor is controlled partly by hand and partly automatically in that the switches A, B, C, D, E, F and G are directly under the control of the operator, while the switches H, I, J and K are operated automatically by the acceleration of the motor armature. It is also to be noted that the magnetic switches D, E, F and G which are directly under the control of the operator perform a double function. They control two resistances one of which is in series with the armature and the other of which is in shunt with the armature. While the series resistance is decreased the shunt resistance is increased. As both of these operations have a tendency to increase the rate of rotation of the armature the effect is doubled. Likewise when the series resistance is increased the shunt resistance is decreased. In this way the operator has a positive control over the rate of rotation of the armature.

Having described my invention what I claim is:

1. In a motor-controlling system, the combination with an electric motor, of two starting resistances, a switch for controlling said resistances to remove one from in circuit with the motor armature, and insert the other in shunt thereto, or to insert one in circuit with said armature and remove the other from in shunt thereto, in starting the motor in either direction, an electro-magnet for operating said switch against the action of gravity which automatically restores said switch to normal when said electro-magnet is deënergized, and a main-line switch for closing a circuit for said armature and for both of said resistances.

2. In a motor controlling system, the combination with an electric motor, of two variable starting resistances, one in series and the other in shunt to the motor armature, a switch for controlling said resistances to increase or diminish the amount of one and substantially at the same time decrease or increase, respectively, the amount of the other of said variable resistances, in starting the motor in either direction, and an electro-magnet operating said switch from one position to the other against the action of gravity which automatically returns said switch to normal when said electro-magnet is deënergized, and a main-line switch for closing a circuit for the motor armature and both of said resistances.

3. In a motor control system, the combination with the armature of the motor, of two resistances, a switch held in normal position by gravity, electric means for operating said switch to remove one of said resistances from the circuit of the armature and insert the other in shunt to the armature, or to insert one of said resistances in circuit with the armature and remove the other from in shunt thereto, reversing switches for the motor, mechanical interlocking mechanism for said switches, and a main line switch for closing the circuit through said armature and both of said resistances.

4. In a motor controlling system, the combination with the armature of the motor, of two variable resistances, one in series with the armature and the other in shunt thereto, both being starting resistances for the motor in starting in either direction and the shunt resistance being also a stopping resistance, a plurality of electro-magnet switches for controlling said resistances, and a manual switch for effecting the operation of said switches to vary the speed of the motor; said speed being dependent upon the position of said manual switch.

5. In a motor control system, the combination with the armature of the motor, of two variable resistances, one in series and one in shunt with said armature, both being starting resistances and the latter also a stopping resistance, a plurality of magnetic switches for controlling said resistances so connected that they will increase or diminish step-by-step the amount of one of said resistances and at the same time decrease or increase the other of said resistances in the operation of the motor in either direction, a manually operated switch for controlling the magnetic switches, and a single switch for closing the motor circuit including the armature and said resistances.

6. In a motor control system, the combination with the armature of the motor, of two variable resistances, one in series and one in shunt with said armature, a plurality of magnetic switches for controlling said resistances so connected that they will increase or diminish step by step the amount of one of said resistances and at the same time decrease or increase the other of said resistances, and other magnetic switches automatically operated by the acceleration of the armature for controlling a part of the series resistance.

7. In a motor control system, the combination with the armature of the motor, of two resistances, one in series and the other in shunt to the armature, a plurality of electromagnetic switches for controlling said resistances to vary the speed of the motor, additional resistance in circuit with the armature, additional switches for controlling said additional resistance, and circuits and connections to effect the operation of said additional switches after the first-named electromagnetic switches have operated.

8. In a motor control system, the combination with the armature of a motor, of resistance in series and parallel with the armature, additional resistance in series with the armature, manually controlled electromagnetic switches for controlling said first-named resistances, and other electromagnetic switches for automatically controlling said additional resistance after said first-named electromagnetic switches have operated.

9. I a motor control system, the combination with starting resistances connected to the armature, of electromagnetic switches for controlling said resistances, a manual switch for operating said switches in successive order, additional starting resistances, other switches for controlling the latter resistances, and automatic means for successively operating said other switches after the said electromagnetic switches have been operated.

10. In a motor control system, the combination with starting resistances connected to the motor armature, of a series of electromagnetic switches for controlling one portion of said resistances, another series of electromagnetic switches for controlling the other portion of said resistances, and means operated by the second series for reducing the current consumed by both series.

11. In a motor control system, the combination with sectional starting resistances for the motor armature, of manually controlled electromagnetic switches for gradually varying said resistances, additional sectional starting resistance, and a series of automatic electromagnetic switches successively operated to control said last-named resistance.

12. In motor-controlling apparatus, the combination with an electric motor, of armature-current reversing mechanism comprising two electric switches, electric means for operating said reversing mechanism, a main line switch, an auxiliary switch co-acting with the main line switch to cut off the current from said electric-operating-means, and an interlocking device for holding one of said first-named electric switches in upper position and the other in lower position.

13. In motor-controlling apparatus, the combination with an electric motor, of reversing switches therefor, electro-magnets for operating said switches, a main line switch, an auxiliary switch controlling the circuit of either of said electro-magnets and normally closed, an additional electro-magnet for operating said main line switch, and said auxiliary switch, the former to closed position and the latter to open position, and a mechanical interlocking device for holding one of the reversing switches in closed position even after the current has been cut off from its operating magnet.

14. In current-controlling apparatus, the combination with current-reversing mechanism comprising two independently operated switches, of electro-magnets for changing the relative positions of said switches, and mechanical means for positively locking one switch in closed position until the other is moved a predetermined distance toward closed position.

15. In current-controlling apparatus, the combination with two electro-magnetic switches for controlling the direction of current through a circuit, of a pivoted lever connected to a moving part of each of said switches, and interlocking lugs on the inner ends of said levers and movable in arc, to mechanically lock one switch in closed position until the other is operated to a predetermined degree.

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

EUGENE R. CARICHOFF.

Witnesses:

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