T. VARNEY.

SYSTEM OF ELECTRIC MOTOR CONTROL.

APPLICATION FILED AUG. 12, 1912.

1,175,321.

Patented Mar. 14, 1916.

2 SHEETS—SHEET 1.

Fig. 1.

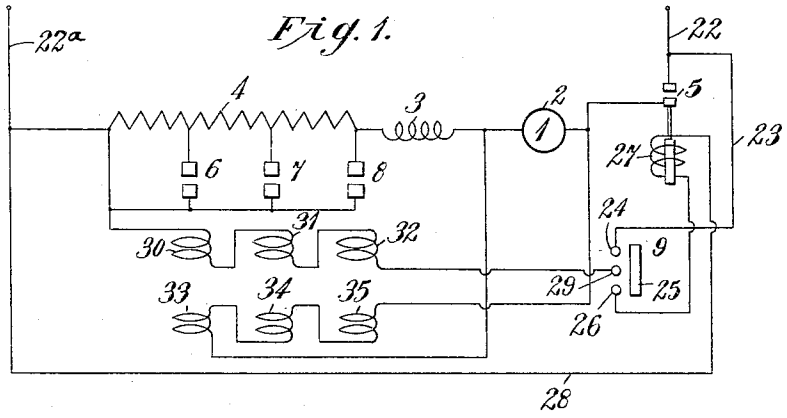


Fig. 2.

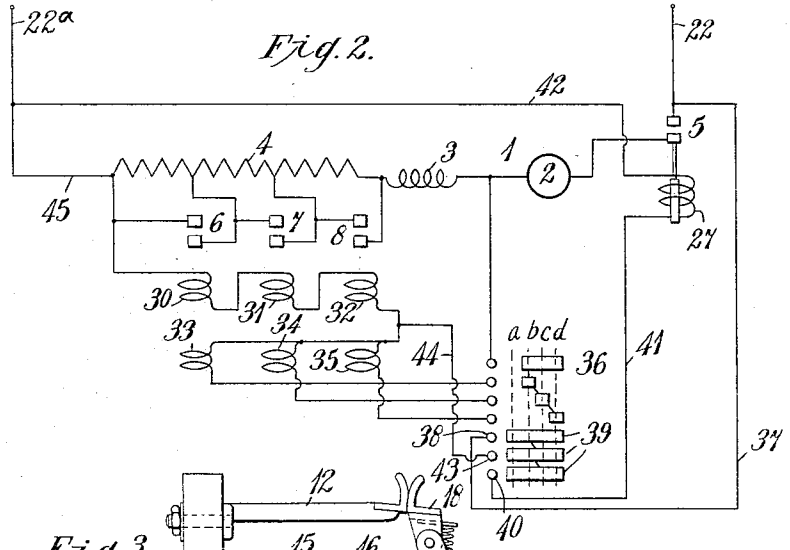
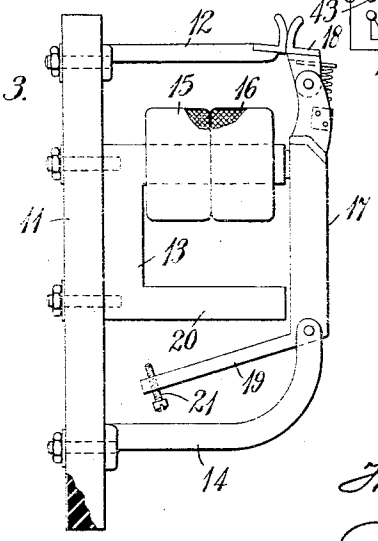


Fig. 3.



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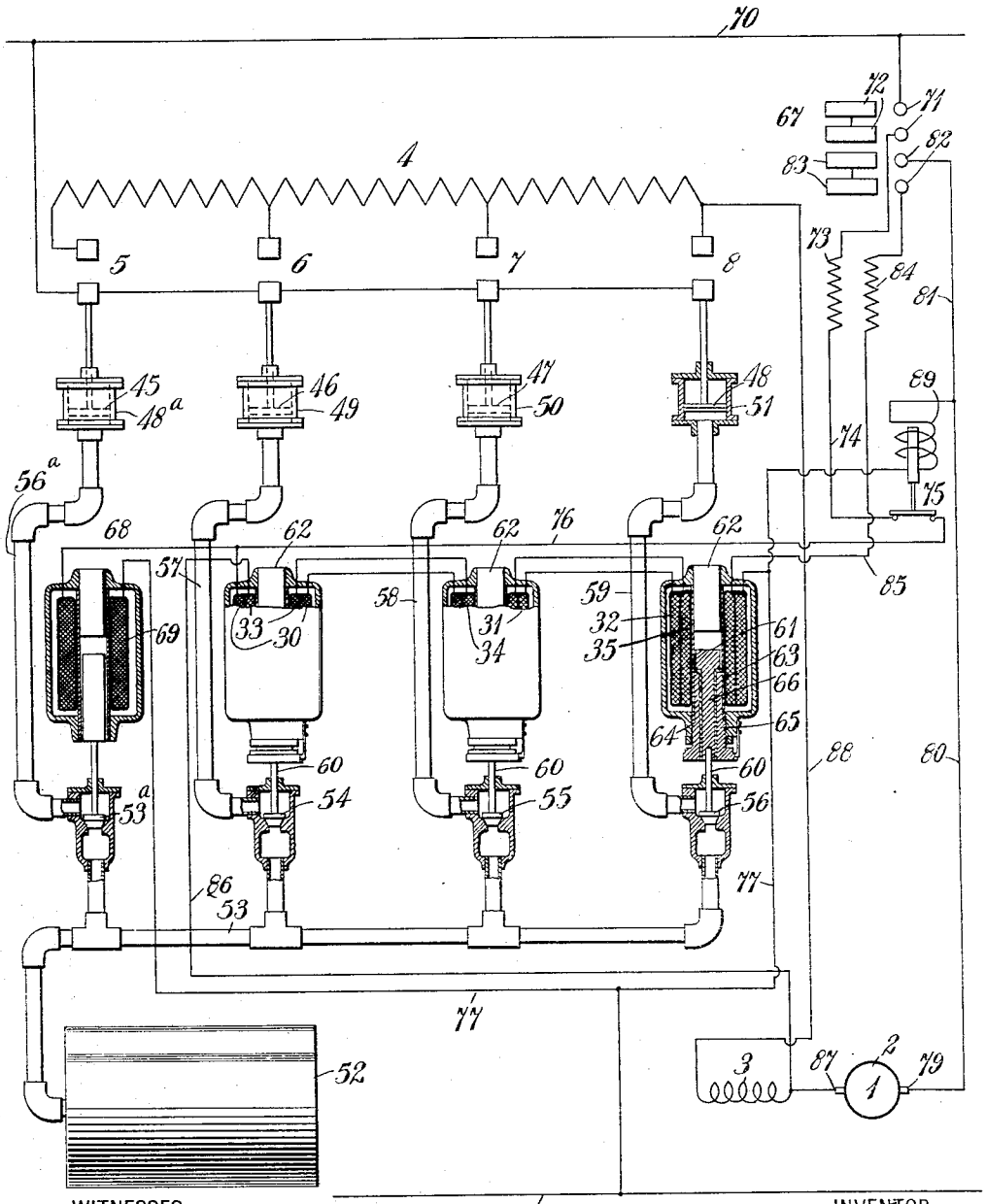
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2 SHEETS—SHEET 2.

Fig. 4.



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SYSTEM OF ELECTRIC-MOTOR CONTROL.

1,175,321. Specification of Letters Patent. Patented Mar. 14, 1916.

Application filed August 12, 1912. Serial No. 714,555.

To all whom it may concern:

Be it known that I, THEODORE VARNEY, a citizen of the United States, and a resident of Pittsburgh, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Systems of Electric-Motor Control, of which the following is a specification.

My invention relates to systems of electric motor control and it has special reference to such systems as embody a plurality of structurally independent switches that are adapted to close in a predetermined sequence.

The object of my invention is to provide a system of the character above specified that shall be simple in arrangement and positive and effective in operation.

Control systems embodying a plurality of independently operated magnet switches have sometimes been made dependent upon the counter-electromotive force generated in the motor armature, in order to insure their closing in a predetermined sequence.

According to my present invention, I provide a series of accelerating switches of the so-called lock-out type which have the characteristic of remaining open, provided their coils are energized above a predetermined value, and of closing automatically when the energy falls below said predetermined value.

Instead of providing each switch with a series coil, in accordance with the usual arrangement, I provide the switches with shunt or separately excited coils which are normally energized to lock the switches in their open positions and, in addition, I provide opposing coils which are relatively weak and are dependent upon the counter-electromotive force generated in the motor armature. The opposing coils are so proportioned as to partially neutralize the effect of the shunt coils and to permit the shunt coils to close the switches in succession.

My invention is illustrated in the accompanying drawings, in which—

Figures 1 and 2 are diagrammatic views of different control systems embodying my invention. Fig. 3 is an elevation of a preferred form of switch adapted for use in the systems shown in Figs. 1 and 2. Fig. 4 is a partially diagrammatic view of a modification of my invention in which the switches are pneumatically operated and electromagnets are employed for governing the valves through which air is admitted to actuate the switches.

Referring to Fig. 1 of the drawings, the system here shown comprises an electric motor 1 having an armature 2, a field magnet winding 3, a resistor 4, a line switch 5, a plurality of accelerating switches 6, 7 and 8 and a master switch 9. The switches 6, 7 and 8 preferably have the structural characteristics shown in Fig. 3 to which reference will now be had. The switch here shown comprises a stationary base or face plate 11, to which a stationary contact member 12, a U-shaped stationary core member 13 and a bracket 14 are secured, coils 15 and 16, a magnetizable armature 17, which is pivotally supported on the bracket 14 and a movable contact member 18 which is carried by the armature. The armature 17 is adapted to bridge the core member 13 when the switch is closed, and is provided with a projection 19, which is substantially parallel to the lower branch 20 of the stationary core member when the switch is open. The end of the projection 19 is spaced from the stationary core member by an adjusting screw 21 which determines the air gap existing between the members. The branch 20 is smaller in cross sectional area than the body of the core member and, when the flux produced by the coils 15 and 16 is sufficient to saturate the branch 20, the excess traverses the projection 19 of the armature and holds the switch in its open position.

Assuming that switches of this character are utilized in the system shown in Fig. 1, the operation of the system is as follows: If the master switch 9 is closed, a circuit is established from a terminal 22, through a conductor 23 and a contact finger 24 to a contact member 25 of the switch 9. From this point, one circuit is completed through a contact finger 26, a coil 27 of the line switch 5 and a conductor 28 to the opposite terminal 22^a. A second circuit is completed from contact member 25, through a finger 29, shunt coils 32, 31 and 30 of the switches 8, 7 and 6 to terminal 22^a. The switches 6, 7 and 8 are

respectively provided with coils 33, 34 and 35, which are connected in series circuit relation to each other and in shunt circuit relation to the armature 2 of the motor 1. When the coils 30, 31 and 32 and the coil 27 are first energized, no energy is supplied to the coils 33, 34 and 35, inasmuch as the motor is at rest. The energy supplied to the coils 30, 31 and 32 is sufficient to lock open the switches 6, 7 and 8, as already described, and the coil 27, when energized, closes the line switch 5. A circuit is consequently established from the terminal 22, through the switch 5, armature 2, field magnet winding 3 and resistor 4 to terminal 22^a. The motor is thus supplied with energy, and the entire accelerating resistor 4 is included in circuit. As soon as the motor acquires a predetermined speed, its counter-electromotive force so energizes the coil 33, in opposition to the coil 30 of switch 6, as to reduce the flux traversing the stationary core member 13 until the branch 20 is able to carry it without saturation. The flux which predominates in its action upon the armature 17 therefore closes the switch. The switch 6, when closed, short circuits a portion of the resistor 4, in the usual manner, and the motor is still further accelerated. The coils 34 and 35 are so proportioned relative to the coils 31 and 32 as to require a progressively increasing counter-electromotive force in order to permit the switches to close. It is therefore evident that the three switches will be closed in succession with an interval between successive operations which will be dependent upon the load and the rate of acceleration of the motor. The switches, when once closed, will remain closed until the master switch 9 is thrown to its open position. It will be observed that the switches are provided with main contact members only, no interlocks or auxiliary contacts being required to insure their successive operation.

Fig. 2 is similar to Fig. 1, except that the coils 33, 34 and 35 are arranged in multiple circuit relation and are dependent, for their circuit connections, upon a master switch 36 that is substituted for the switch 9. In this arrangement, the master switch is provided with a plurality of positions *a*, *b*, *c* and *d* and is manually advanced step-by-step.

The operation of the system is as follows: Assuming that the switches occupy the positions in which they are shown, if the master switch 36 is moved from its off position, to its position *a*, a circuit is established from the terminal 22, through a conductor 37 and a contact finger 38 to contact members 39. From this point, one circuit is completed through a contact finger 40, a conductor 41, the coil 27 of line switch 5 and a conductor 42 to the terminal 22^a. A second circuit is completed through a finger 43, a conductor 44, the coils 32, 31 and 30 in succession and a conductor 45 to the terminal 22^a of the line switch 5. The coils 30, 31 and 32 are thus energized as in Fig. 1, the switches 6, 7 and 8 being locked open. The line switch 5 is closed by reason of the energization of coil 27, and the motor circuit is established as before. The acceleration, however, is not automatic and the resistor 4 will remain in the motor circuit until the master switch 36 is advanced to occupy its successive positions *b*, *c* and *d*. The coils 33, 34 and 35 will then be successively included in multiple relation to each other in a shunt connection to the armature 2 of the motor. As each coil is included in this circuit, it sufficiently opposes the action of the other coil of the switch to permit the switch to close. In order to stop the motor and open the switches, it is only necessary to throw the master switch to its off position.

Referring to Fig. 4 of the drawings, the switches 5, 6, 7 and 8 are respectively actuated by a plurality of pistons 45, 46, 47 and 48 which act in cylinders 48^a, 49, 50 and 51. Pneumatic pressure is supplied from a tank or reservoir 52, through a pipe 53, valves 53^a, 54, 55 and 56, and pipes 56^a, 57, 58 and 59 to the cylinders. The valve 53^a, which governs the switch 5, is controlled by a magnet 68 having a coil 69 which, when energized, opens the valve in opposition to gravity or a spring, in a well known manner, and admits air through the valve to the cylinder 48^a. Each of the valves 54, 55 and 56 is provided with a valve magnet having a movable core member 61 to which a stem 60 is secured. The valve magnet further comprises a stationary core member 62, and coils which are designated by reference characters corresponding to the actuating coils of the switches 6, 7 and 8 of Figs. 1 and 2. The stationary core member 62 of each valve magnet comprises a shell 63, a magnetizable sleeve 64 through which the movable core member 61 operates, in addition to the body of the core member to which the movable member is attached. The sleeve 64 is provided with a bushing 65, of non-magnetizable material, which provides a material air gap between a projection 66 of the movable core member and the sleeve. A slightly larger air gap is provided between the body of the movable core member 61 and the end of the sleeve 64, so that, under normal conditions, when the magnet is energized below a predetermined value, the flux traversing the stationary and movable members tends to open the valve 56. If, however, the magnet is energized above a predetermined value, the projection 66 of the movable core member becomes saturated and the flux passes directly from the body 61 across the air gap into the sleeve 64, producing such an attraction between these members as to

prevent movement of the core member 61 and the opening of the valve. The valve magnet operates in accordance with well known lockout switch principles and serves to hold the valve closed if energized above a predetermined value and opens the valve as soon as the energy has decreased to said value.

The operation of this system is as follows: Assuming that the valves are closed, as shown in the drawing, and that the switches are open, if the master switch 67 is closed, a circuit is established from a line conductor 70 through contact fingers 71, which are bridged by contact segments 72 of the master switch, resistor 73, a conductor 74, a relay switch 75, which is normally closed, a conductor 76, the coil 69 of the valve magnet 68 and a conductor 77 to opposite line conductor 78. Another circuit is also established from the conductor 76, through the coil 30 of the valve magnet 54, the coil 31 of the valve 55 and the coil 32 of the valve 56 to the conductor 77. When the master switch is closed, another local circuit is established from one terminal 79 of the motor armature 2, through a conductor 80, a control conductor 81, contact fingers 82 which are bridged by contact segments 83 of the master switch, a resistor 84, a conductor 85, the coils 35, 34 and 33 of the magnets 56, 55 and 54 and a conductor 86 to an opposite terminal 87 of the motor armature. The coil 69, when energized, immediately opens the valve 53^a and admits air to the cylinder 48^a, thereby closing the line switch 5. Although the coils 33, 34 and 35 are connected across the terminals of the motor armature, no current is supplied to them until the motor accelerates sufficiently to build up its counter-electromotive force. The coils 30, 31 and 32 are sufficiently energized to magnetically saturate the projections 66 of the movable core members of the magnets associated with the valves 54, 55 and 56 and to lock the valves in their closed positions, as hereinbefore explained.

When the line switch 5 is closed, a main circuit is completed from the conductor 70, through the line switch 5, the resistor 4, a conductor 88, the field magnet winding 3, the armature 2, the conductor 80 and a coil 89 of the relay switch 75 and the conductor 77 to the opposite line conductor 78. As the motor accelerates and its counter-electromotive force increases, the coils 33, 34 and 35 will be increasingly energized, their design being such that the coil 33 first exerts such an influence, in opposition to the coil 30 of the same magnet, as to reduce the flux until the projection 66 of the core member is able to carry it without saturation. Under these conditions, the leakage flux which held the valve closed is very much reduced or is entirely overcome and, consequently, the valve is opened. The opening of the valve 54 admits fluid pressure to the cylinder 49, thereby causing the switch 6 to close and to short circuit a portion of the resistance 4. As the motor continues to accelerate, the coil 34 and then the coil 35 are successively energized to a sufficient degree to permit the opening of the valves 55 and 56. As these valves are opened, the switches 7 and 8 are closed and the resistor 4 is short circuited. If the current traversing the motor circuit becomes excessive, the coil 89 of the relay switch 75 will be sufficiently energized to open the switch. Since this switch is included in the control circuit above described, it automatically permits the valves 53^a, 54, 55 and 56 to close and to exhaust the air from the cylinders 48^a, 49, 50 and 51. The switches 5 to 8, inclusive, are thus opened.

Variations in size and arrangement of parts and in the circuit connections of the control systems may be effected within the spirit and scope of my invention, and I desire that only such limitations shall be imposed as are indicated in the appended claims.

I claim as my invention:

1. The combination with an electric motor, of a controlling switch therefor having a coil which tends to close it but is adapted, when normally energized, to hold it open, and means dependent upon the operation of the controlled motor for so opposing the action of the coil as to permit the switch to close.

2. The combination with an electric motor, of a controlling switch therefor having a coil which tends to close it but is adapted, when normally energized, to hold it open, and means dependent upon the counter-electromotive force of the controlled motor armature for so opposing the action of the coil as to permit the switch to close.

3. The combination with an electric motor, of a controller therefor comprising voltage-reducing means, a plurality of governing switches having coils that tend to close them but adapted, when normally energized, to hold them open, and means dependent upon the acceleration of the controlled motor for successively reducing the forces exerted by said coils, whereby said switches are closed in a predetermined sequence.

4. A controller for an electric motor comprising an accelerating resistance, a plurality of governing switches having coils that tend to close them but adapted, when normally energized, to hold them open, and opposing coils that are adapted to successively oppose the first named coils and to permit the switches to close in a predetermined sequence.

5. A controller for an electric motor comprising a plurality of accelerating switches that are adapted to close in a predetermined

sequence and are provided with coils that tend, when energized within predetermined limits, to close the switches but are adapted, when normally energized, to hold them open, and additional coils acting in opposition to the first named coils to permit the switches to close in succession.

In testimony whereof, I have hereunto subscribed my name this 31st day of July, 1912.

THEODORE VARNEY.

Witnesses:
F. D. HALLOCK,
B. B. HINES.

Copies of this patent may be obtained for five cents each, by addressing the "Commissioner of Patents, Washington, D. C."