No. 733,551. PATENTED JULY 14, 1903.

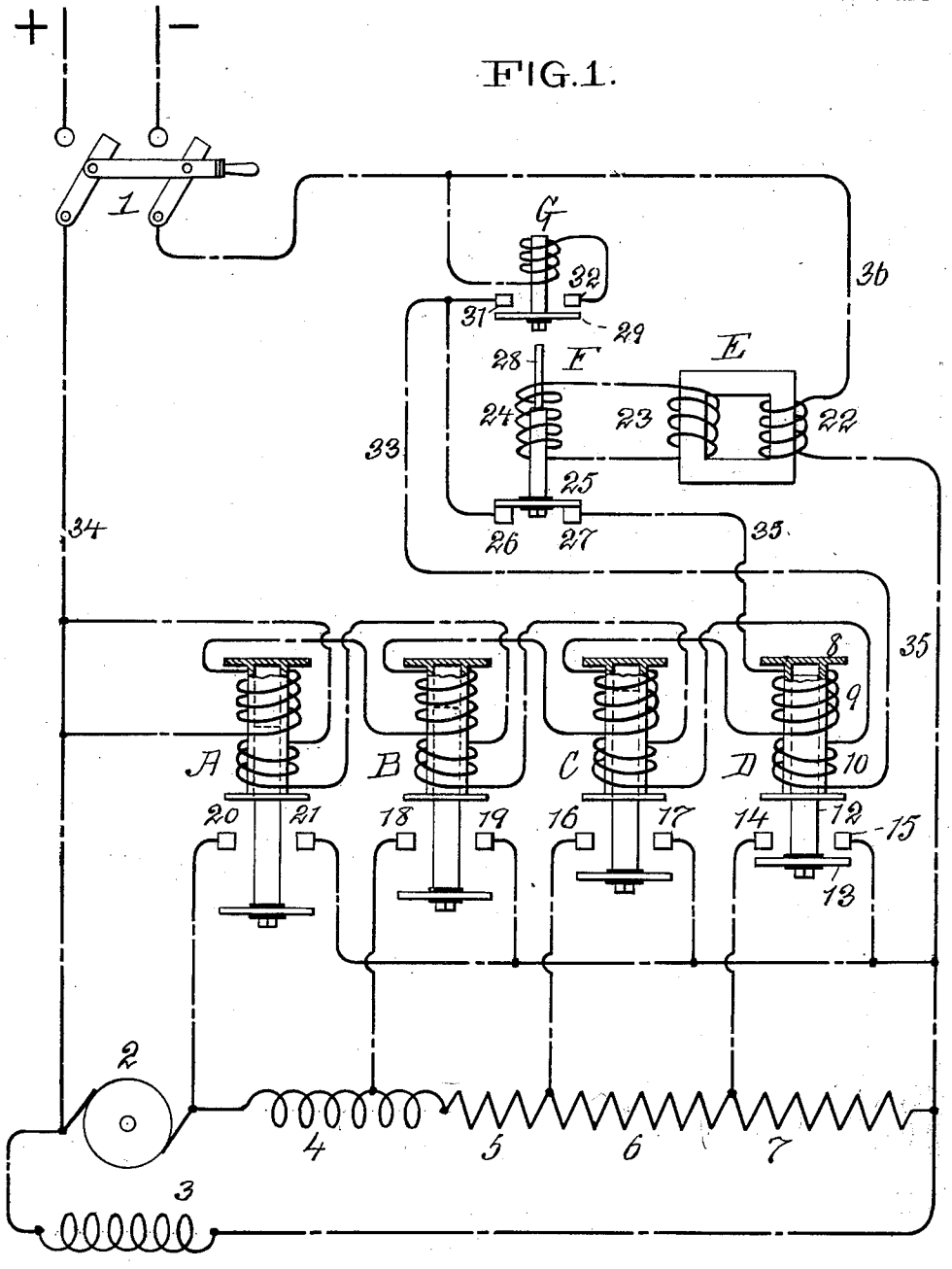
D. L. LINDQUIST.

ELECTRIC CONTROLLER.

APPLICATION FILED APR. 10, 1903.

NO MODEL. 2 SHEETS—SHEET 1.

FIG. 1.




WITNESSES:

J. A. Van Wart

A. Henderson.

INVENTOR

David L. Lindquist

BY Paul Synnestvedt

His ATTORNEY

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

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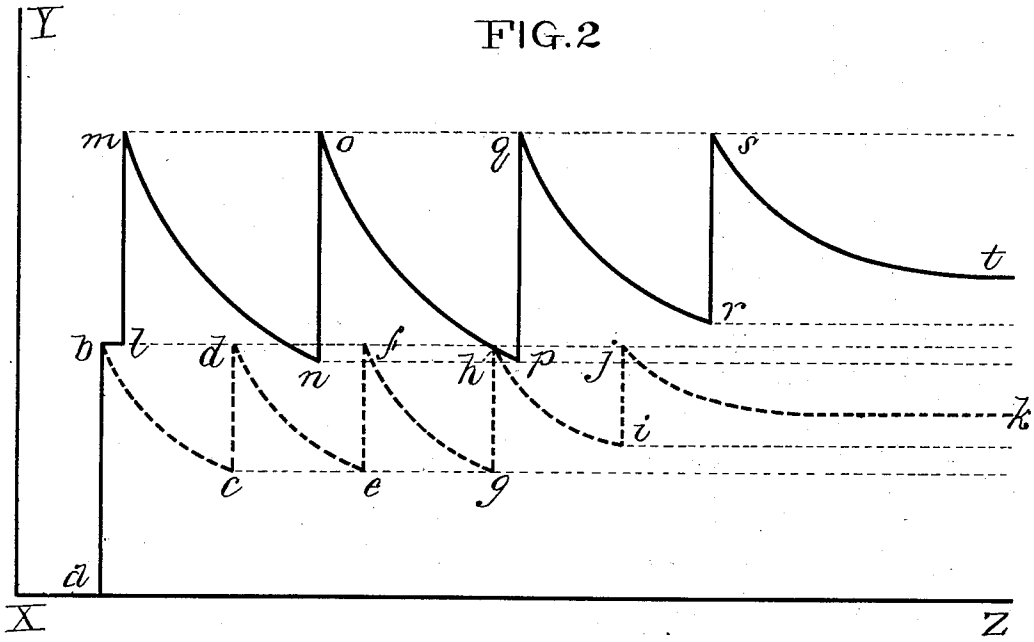
D. L. LINDQUIST.

ELECTRIC CONTROLLER.

APPLICATION FILED APR. 10, 1903.

NO MODEL. 2 SHEETS—SHEET 2.

FIG. 2




WITNESSES:

J. A. Van Wart

A. Henderson

INVENTOR

David L. Lindquist

BY

Davis Benjamin

His ATTORNEY.

THE NORRIS PETERS CO., PHOTO-LITHO., WASHINGTON, D. C.

No. 733,551. Patented July 14, 1903.

# UNITED STATES PATENT OFFICE.

DAVID LEONARD LINDQUIST, OF YONKERS, NEW YORK.

## ELECTRIC CONTROLLER.

SPECIFICATION forming part of Letters Patent No. 733,551, dated July 14, 1903.

Application filed April 10, 1903. Serial No. 152,042. (No model.)

*To all whom it may concern:*

Be it known that I, DAVID LEONARD LINDQUIST, of Yonkers, Westchester county, New York, have invented a new and useful Improvement in Electric Controllers, of which the following is a specification.

The invention is a device for causing a direct-current electric motor automatically to start and control itself by its own current.

Controlling devices which cut out resistance from the motor-circuit without the use of a dash-pot are known. With those which depend for operation upon the armature speed—as, for example, when a governor is used—if the motor happens to be overloaded it may not start, and as the resistance remains in circuit injurious overheating follows. If magnet-coils are connected across the lines, some being provided with an induction ("hold-back") coil in series the current is retarded to give the motor a definite period in which to start; but the conditions here are similar to those which prevail when dash-pots are used—that is, no matter what the load is on the motor the resistance will be cut out in a constant time, which will be too quick or too slow.

My present invention involves an entirely novel principle whereby I cause a direct-current motor automatically to start itself by the agency of the current due to its own operation, and the said principle is to control the motor by the fluctuations in its own main current, thereby producing a positive step-by-step action which operates to cut out resistance at exactly the proper moment when the motor speed, voltage, and current correspond to the load. This I do independently of the line and motor voltage, the maximum and minimum value of the current, the armature speed, and the load on the motor.

My invention consists in means whereby my aforesaid principle may be carried into practical and useful effect, and one embodiment of said means is hereinafter fully described. I do not limit myself to the particular construction of the said embodiment; but, on the contrary, assert my present invention is wholly new and pioneer in the art and desire that my claims shall be given the broadest interpretation consistent with law.

In the accompanying drawings, Figure 1 is an electrical diagram showing the arrangement of my controller in connection with a direct-current motor. Fig. 2 is a time-current diagram.

In Fig. 1 the current-supply for the mains is controlled by the hand-switch 1. 2 is a direct-current motor, the shunt-field of which is shown at 3 and the series field at 4. In series with the series field are resistances 5 6 7. At A B C D are solenoids, each having an internal cylinder 8, closed at its upper end. On each cylinder are two coils 9 and 10, the coil 9 on each cylinder being stronger than the coil 10. Within each cylinder is the movable core 12, which carries a circuit-closing bar 13. Each bar 13 is constructed to close contact with terminals in its proximity, the solenoid D thus controlling circuit at the terminals 14 15, the solenoid C at terminals 16 17, the solenoid B at terminals 18 19, and the solenoid A at terminals 20 21. The construction of the circuit-closing devices is to be such that the bars 13 of the several solenoids when all are disengaged will drop to different distances from their respective pairs of terminals 14 15, 16 17, &c., so that when said solenoids are excited the closing of circuit by the bars 13 through their associated terminals will be successive. Any other means of securing this result may be employed instead of the adjustment of the bars 13, above noted. E is a converter, on the magnetic core of which are wound the primary coil 22 and secondary coil 23. F is a solenoid having its coil 24 in closed circuit with the secondary coil 23. The solenoid-core carries a bar 25, which establishes circuit between the terminals 26 27. The core has an upward prolongation 28, which when said core is raised strikes a circuit-closing bar 29, carried by the core of a solenoid G. Said bar 29 is arranged to close circuit between the terminals 31 32. Terminal 31 connects by branch wire 33 to the lower coils 10 of solenoids A B C D and so to the wire 34, which leads through switch 1 to the positive main and also by branch wire 35 to the upper

coils 9 of said solenoids, which also connect to said wire 34. Said wire 34 also leads to the motor.

The operation of the device is as follows: The switch-lever 1 being closed, circuit is established by wire 34 to the motor, the series field, and all the resistances 5 6 7, and thence by wire 35 to primary coil 22 of the converter, and so by wire 36 to the negative main. The rise of current in the motor and converter primary induces a current in the secondary 23, which energizes the solenoid F, causing it to lift its core, and so break circuit at terminals 26 27. As the core of F rises the prolongation 28 moves the bar 29 of solenoid G into contact with the terminals 31 32. Circuit is then established from wire 34, through the lower coils 10 of solenoids A B C D, to terminal 31, bar 29, terminal 32, and so through the coil of solenoid G to negative main. Solenoid G now being excited holds up its core, and so keeps circuit closed between 31 and 32. The motor now starts, developing a counter electromotive force, which gradually reduces the current to uniform value, with the result that as this is established the converter induces no further current in its secondary. The solenoid F thus becomes deënergized, drops its core, and establishes circuit between terminals 26 27. The weak coils 10 of solenoids A B C D are not strong enough to lift the cores of said solenoids. When the coils 9, however, are energized, they are sufficient for this purpose. Inasmuch as the core of solenoid D has dropped to the minimum distance below its terminals 14 15, it follows that the bar 13 of that solenoid will first be lifted by its coil 9, and thus circuit will be closed between terminals 14 15 before the other bars 13 meet their associated terminals. Thus resistance 7 will become short-circuited. The current in the motor will then again rise, energizing the converter, as before, breaking circuit at solenoid F. Again the counter electromotive force will operate to reduce the current to uniformity, and again the converter will cease to induce current on its secondary. Meanwhile, although the solenoid F has opened circuit through the strong coil 9 of solenoid D, the weak coil 10 still remains energized, and that coil, while, as already stated, not strong enough to lift its core, is sufficiently strong to retain the bar 13 in contact with terminals 14 15. Now when circuit is again closed by the solenoid F the solenoid C operates, in the manner already described, to cause the bar 13 to close circuit between terminals 16 17, and thus the resistance 6 also becomes short-circuited. The same cycle repeated operates solenoid B to cut out resistance 5 and part of the series coil of the motor, and, finally, solenoid A, operated in like manner, cuts out the rest of the series coil, and the motor reaches its regular running speed.

Turning now to Fig. 2, in which the line X Y represents current and the line X Z time, both functions, augmenting from the point of origin X, the current and time conditions above described are here graphically illustrated, first, under circumstances of light and, second, of heavy load. Under light load current rises in the motor until it overbalances the resistances. This rise is indicated by the line *a b*. The counter electromotive force now gradually reduces the current to uniformity, the current, therefore, falling, as indicated by the dotted curve *b c*. At *c* the first solenoid D cuts out its resistance 7, when the current rises to *d* and again gradually descends to the point *e*, when the second resistance 6 is cut out by solenoid C. Another rise to *f*, followed by a gradual descent to *g*, succeeds when the solenoid B cuts out resistance 5 and part of the series field. The current now rises to *h* and drops to point *i*. Solenoid A then cuts out the rest of the series field, when the current rises to *j* and then goes down to the line *k*, which represents the normal running conditions under light load. Under heavy load current rises, as before, in the motor from *a* to *b*, but, being unable to start, the motor becomes uniform from *b* to 1. Then solenoid F drops its core, with the result, as already explained, of causing solenoid D to cut out resistance 7. As a consequence of this the current rises to the point *m*, at which it can start the motor. The counter electromotive force, as before, now reduces the current, reducing it to point *n*, when the second solenoid C acts to cut out resistance 6. Current then rises to *o*, descends to *p*, and solenoid B cuts out resistance 5 and part of the series coil of the motor. Lastly, current rises to *q* and descends to *r*, when solenoid A acts to cut out the remainder of the series coil. The current then rises to *s*, and finally descends to normal running strength, (represented by line *t*.)

I claim—

1. In an electric controlling device for a direct-current motor, a plurality of resistances in circuit, a plurality of solenoids constructed and arranged to cut said resistances successively out of circuit and means for energizing said solenoids controlled by fluctuations in the motor-current.

2. In a controlling device for a direct-current motor, means for inducing a current from the current fluctuations in said motor, and means for controlling said motor by said induced current.

3. In a controlling device for a direct-current motor, a converter having its primary in the motor-circuit and means for controlling said motor governed by the secondary of said converter.

4. In a controlling device for a direct-current motor, a resistance in the motor-circuit, a converter in said circuit and a circuit-closer controlled by the secondary of said converter

and operating to cut said resistance out of circuit.

5. In a controlling device for a direct-current motor, a plurality of resistances in the motor-circuit, a converter in said circuit, and a plurality of circuit-closers controlled by the secondary of said converter and operating successively to cut said resistances out of circuit.

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

DAVID LEONARD LINDQUIST.

Witnesses:
I. A. VAN WART,
WM. H. SIEGMAN.