J. N. MAHONEY.

ELECTROPNEUMATICALLY OPERATED CONTROLLER.

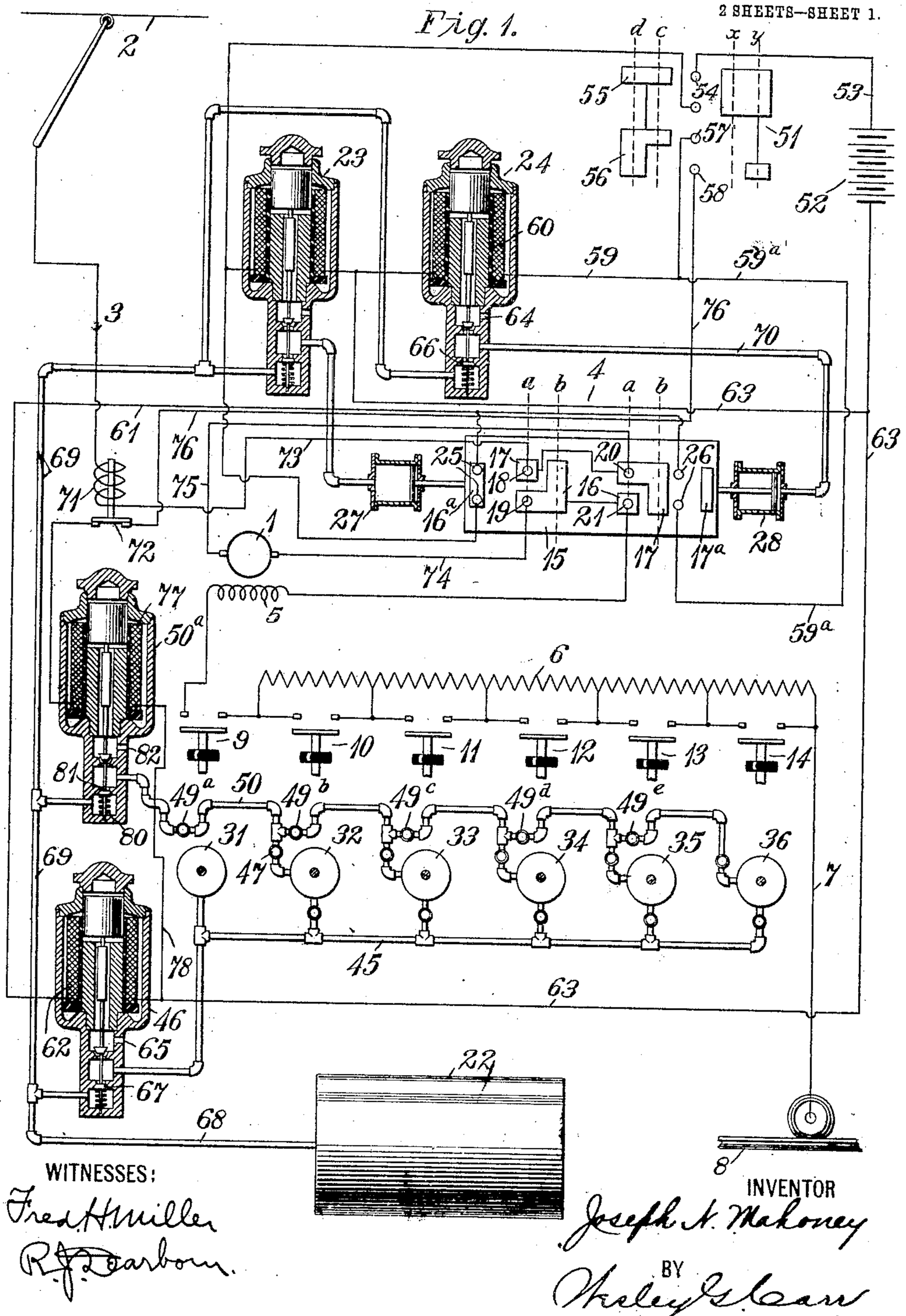
APPLICATION FILED SEPT. 3, 1907.

962,713.

Patented June 28, 1910.

2 SHEETS—SHEET 1.

Fig. 1.



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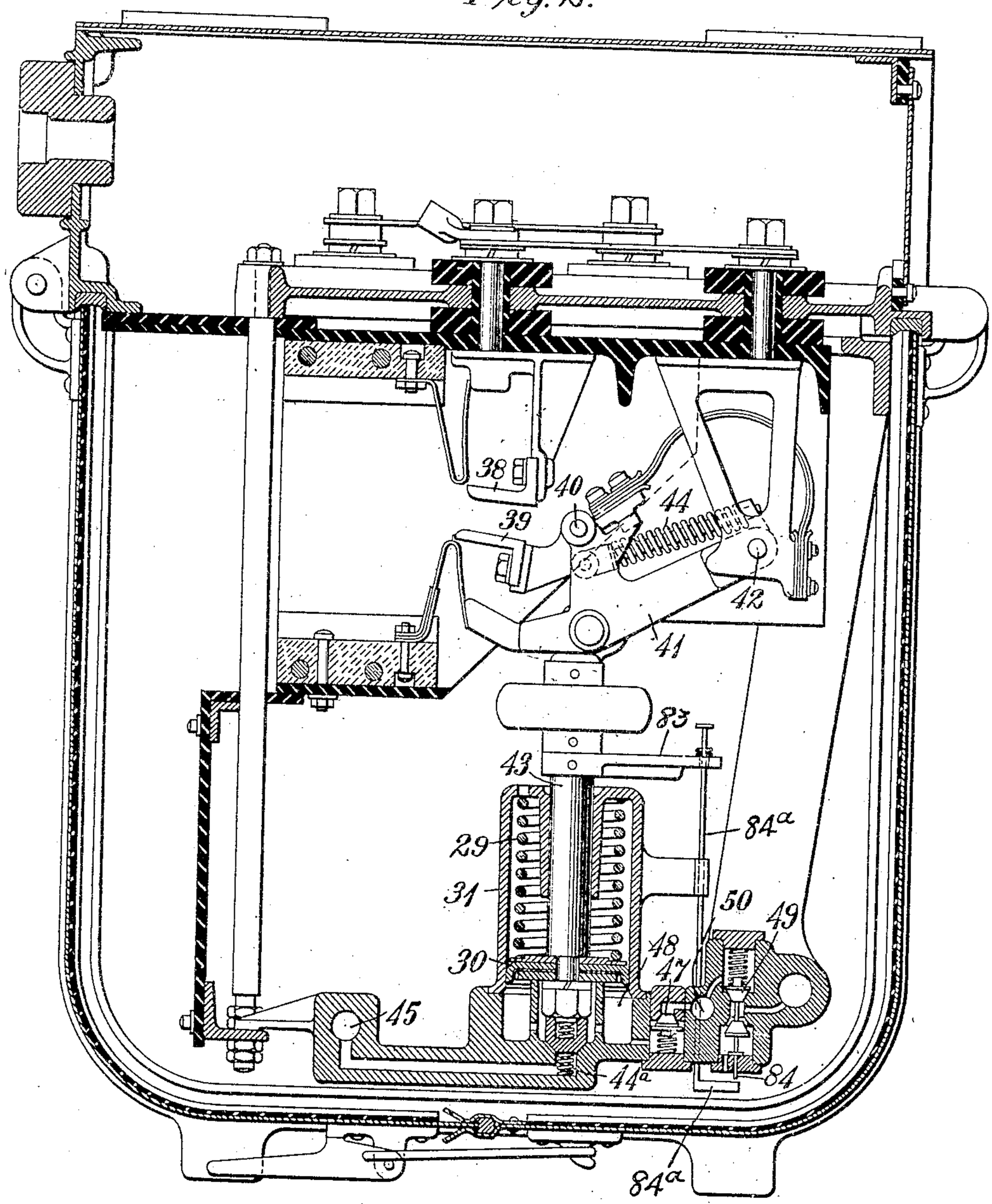
2 SHEETS—SHEET 2.

Fig. 2.



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ELECTROPNEUMATICALLY-OPERATED CONTROLLER.

962,713. Specification of Letters Patent. **Patented June 28, 1910.**

Application filed September 3, 1907. Serial No. 391,238.

To all whom it may concern:

Be it known that I, JOSEPH N. MAHONEY, a citizen of the United States, and a resident of Wilkinsburg, in the county of Allegheny and State of Pennsylvania, have invented a new and useful Improvement in Electropneumatically-Operated Controllers, of which the following is a specification.

My invention relates to systems of electric circuit control and has special reference to systems which embody a plurality of independently operated switches that are adapted to close in a predetermined sequence for effecting the automatic acceleration of electric railway vehicle motors.

The object of my invention is to increase the reliability in operation and simplify the electric circuits of systems in which electric energy and pneumatic energy are associated in the control and actuation of a plurality of switching devices.

Electro-pneumatic control systems, such as are well known and extensively used in connection with electric railway vehicle motors, have usually been arranged with pneumatically operated means for directly effecting the closure of the main circuit switches, electro-responsive devices being employed for governing the action of the pneumatic means.

In order to effect automatic acceleration in a system of the character just mentioned, particularly when the well known form of series multiple control was desired, it was necessary to make use of auxiliary or relay switches for suitably interlocking the main switches and, consequently, a complicated system of control circuits resulted.

The difficulty in properly connecting control circuits of the kind just referred to and the time and labor involved in repairing the same have led me to so modify the pneumatic connections as to enlarge the scope of their usefulness and to materially simplify the electric control circuits.

My invention is illustrated in the accompanying drawings in which Figure 1 is a diagrammatic view of a system arranged in accordance therewith, and Fig. 2 is a sectional elevation of one of the switches, of the group embodied in the system shown in Fig. 1, and its operating and control mechanism.

Referring to the drawings, a motor 1 is supplied with energy from a trolley conductor or other feeder circuit 2, through a conductor 3 and a reversing switch 4, circuit being completed through a field magnet winding 5, a resistance 6 and a conductor 7 to a return circuit or rail conductor 8.

The accelerating resistance 6 is governed by a plurality of control switches 10, 11, 12, 13, and 14 and the motor circuit is established through a line switch 9. The reversing switch comprises a movable contact carrying member 15 which is provided with main contact segments 16 and 17, control or relay contact segments 16^a and 17^a, a plurality of engaging contact fingers 18, 19, 20, 21, 25, and 26 and fluid pressure actuating devices 27 and 28. The movable member is adapted to occupy either one of two positions *a* and *b* and the admission of fluid pressure to the devices 26 and 27 from a storage tank or reservoir 22 is governed by electro-magnet valves 23 and 24.

Each of the switches 9 to 14, inclusive, is normally held in its open position by a spring 29 and is actuated by a piston 30 which operates in a cylinder 31.

In order that the pneumatic circuits may be more readily traced, the cylinders which form parts of the switch operating mechanisms may be designated by reference numerals 31 to 36, inclusive, corresponding to the switches 9 to 14, but, since the switches and operating mechanisms are similar, only one will be described in detail by reference to Fig. 2 of the drawings. The switch, as here illustrated, comprises a stationary contact member 38 and a movable contact member 39 pivotally mounted upon a shaft 40 at the other extremity of an arm 41 which is fulcrumed upon a shaft 42 and is actuated by a piston rod 43. A rolling movement is imparted to the contact member 39 by a spring 44, in order to avoid injuring the contact surface, according to well known practice.

The cylinder 31 is provided with a valve 44^a through which fluid pressure may be admitted from a supply or holding circuit pipe 45 that is controlled by a magnet valve 46. The area of the valve 44^a is so small that the spring 29 holds the port closed until fluid pressure has been admitted through a valve 49, which is governed by the action of the preceding switch, as hereinafter explained, and check valve 47 to a chamber 48 below the piston 30. In this way, the action of the switch is dependent upon the valve

49, which may be designated as a control valve.

The fluid pressure, which initially actuates the switches and is supplied to the cylinders through the valves 49 and 47, is admitted to a control circuit pipe 50 or is exhausted therefrom, by a magnet valve 50^a.

The electric circuits for the valve magnets are governed by a master switch 51 which may occupy positions *c*, *d*, *x*, and *y* and energy for operating these electro-magnets may be supplied from any convenient source, such as storage battery 52.

The operation of the system is as follows: Assuming that the master controller 51 is moved to a position *d*, in which automatic acceleration is permitted, a circuit is established from the battery 52 through a conductor 53, contact finger 54 and contact member 55 to a contact member 56. This contact member is engaged by contact members 57 and 58 and circuits are completed as follows: from contact member 57 through a conductor 59, magnet winding 60 of magnet valve 24, and conductor 63 to the negative terminal of the battery 52. The magnet winding 60, when energized, closes an exhaust port 64 and opens valve 66 so that fluid pressure is admitted from the storage tank 22 through pipes 68 and 69, valve 66 and pipe 70 to the cylinder 28. The admission of fluid pressure to the cylinder 28 moves the reversing switch 4 to the position *b*.

In position *b*, the motor circuit is completed from conductor 2 through conductor 3, a magnet winding 71 of a limit switch 72, conductor 73, contact fingers 18 and 19 (which are bridged by contact member 16 when reversing switch occupies position *b*), conductor 74, armature of the motor 1, conductor 75, contact fingers 20 and 21 (which are bridged by contact member 17), and field magnet winding 5 to the switch 9, which is now open. A control circuit is also established from contact finger 58 through conductor 76, limit switch 72, magnet winding 77 of valve 50^a and conductor 78 to the negative terminal 63 of the battery 52. Thus, the position of the valve is changed so that the exhaust port 82 is closed and the port 81 is opened in opposition to a spring 80, admitting fluid pressure from pipe 69 to the control circuit pipe 50. As soon as the reversing switch occupies position *b*, a second control circuit is established from contact finger 57 through conductor 59^a, contact fingers 26 (that are bridged by contact member 17^a), conductor 61, magnet winding 62 of valve magnet 46 and conductor 63 to the negative terminal of the battery. When energized, the magnet valve 46 closes an exhaust port 65 and opens a port 67 through which fluid pressure is admitted to the holding circuit pipe 45. The cylinders 31 to 36 are connected to this pipe in multiple circuit but fluid pressure is directly admitted only to the cylinder 31 since all the other cylinders are equipped with valves 44^a which cannot be opened until a corresponding control valve 49 is actuated. The closure of the switch 9 is thus effected and the motor circuit connections are established for rotation in one direction with the entire resistance 6 included in the circuit. If the first rush of current exceeds a predetermined amount, the magnet winding 71 will be energized sufficiently to open the switch 72, then, as the speed of the motor increases, the switch 72 will drop and a control circuit will be completed from contact finger 58 through conductor 76, switch 72 and magnet 77 of the magnet valve 50^a and conductor 78 to the negative conductor 63.

As long as the limit switch is open, the control circuit pipe 50 is exhausted through a port 82 and, consequently, although the closure of the switch 9 has effected the opening of a control valve 49^a which corresponds to the valve 49 of Fig. 2, fluid pressure is not supplied through check valve 47 to the chamber 48 of the cylinder 32 until the limit switch is closed.

As illustrated in Fig. 2, when pressure is admitted through the check valve 47 to the chamber 48, the piston 30 will be raised, permitting the fluid pressure from the holding circuit pipe 45 to enter through the port 44^a and to hold the switch 9 closed. When the switch 9 is closed, a section of the resistance 6 is short-circuited in a well known manner.

If the current traversing the motor circuit again exceeds a predetermined amount, the limit switch 72 will be opened, permitting the pipe 50 to again exhaust through the port 82 and thereby preventing the closure of the switch 10 until the limit switch is again closed. The closure of the switches 11, 12, 13 and 14 is dependent upon the limit switch 72, as above indicated for switch 10.

The acceleration may be suspended at any point at the will of the attendant by moving the master controller 51 from the position *d* to the position *c* in which contact finger 58 is disengaged from the contact member 56. This disengagement interrupts the same circuit as that interrupted by the limit switch 72 and, consequently, it is possible to indefinitely delay the acceleration of the motor, and the limit switch protects the motor from injury by preventing the too rapid exclusion of the resistance from the circuit. A time limit device may, of course, be employed for delaying the action of the accelerating switches, in addition to or in lieu of the current limiting device.

The control valves 49^a and 49^e may be actuated in any suitable manner by the final action of the piston of the adjacent switches, a convenient arrangement being illustrated

in Fig. 2, which shows a projection 83 from the piston rod 43, a stem 84 which projects from the valve 49 and an intermediate release pawl 84ª which is resiliently connected to the projection 83 and is adapted to engage the stem 84 to open the valve 49 just as the piston 30 approaches the ends of its travel.

It will be readily understood that the principles involved in the system illustrated are applicable to, and suitable for, motor control systems which employ a rheostatic or a series of multiple form of control and, while I have illustrated a single motor, I do not wish to restrict my invention thereto.

I claim as my invention:

1. In a control system for electric motors, the combination with a series of independently operated switches, of an elastic fluid interlocking means therefor, and electro-responsive means for initiating the action of the switches.

2. In a control system for electric motors, the combination with a plurality of independently operated switches, of means for pneumatically interlocking the switches to insure their closure in a predetermined sequence, and electro-responsive means for initiating the sequential action of the switches.

3. In a control system for electric motors, the combination with a series of automatically and independently operated switches, of pneumatic interlocking means for confining their closure to a predetermined sequence, and electro-responsive means for initiating the action of the series of switches.

4. In a control system for electric motors, the combination with a series of automatically and independently operated switches, of pneumatic interlocking means for confining their closure to a predetermined sequence, electro-responsive means for initiating the sequential closure of the switches and electro-responsive means for suspending the closure of the switches at any point in the sequence.

5. In a control system for electric motors, the combination with a plurality of independently operated switches pneumatically interlocked to effect their closure in a predetermined sequence, of electro-responsive means for initiating the sequential closure of the switches and means for suspending the closure of the switches at any point in the sequence.

6. In a control system for electric motors, the combination with a plurality of independently operated switches pneumatically interlocked to effect their closure in a predetermined sequence, of electrically controlled means for governing the switches and means dependent upon the current traversing the motor circuit for automatically suspending the closure of the switches at any point in the sequence.

7. The combination with a series of pneumatic cylinders and pistons operating therein, of pneumatic means for confining the operation of said pistons to a predetermined sequence, and magnet valves for governing the pneumatic means.

8. In a control system for electric motors, the combination with a plurality of independently operated switches, pneumatic cylinders, and pistons operating therein to actuate the switches, of admission valves for the cylinders, a series of interlocked control valves for governing the action of the admission valves, and magnet valves for controlling the supply of actuating fluid to the admission valves.

9. In a control system for electric motors, the combination with a plurality of independently operated switches, pneumatic cylinders, and pistons operating therein to actuate the switches, of admission valves for the cylinders, a series of interlocked control valves for governing the action of the admission valves, and electro-magnet valves for independently controlling the fluid pressure supplied to the control valves and to admission valves.

10. In a control system for electric motors, the combination with independently operated switches, pneumatic cylinders, and pistons operating therein to actuate the switches, of admission valves for the cylinders and a series of interlocking control valves for governing the action of the admission valves to confine the closure of the switches to a predetermined sequence, electro-magnet valves for independently controlling the fluid pressure supplied to the admission valves and to the control valves, and means for suspending the closure of the switches at any point in the sequence.

11. In a control system for electric motors, the combination with independently operated switches, pneumatic cylinders, and pistons operating therein to actuate the switches, of admission valves for the cylinders and a series of interlocking control valves for governing the action of the admission valves to confine the closure of the switches to a predetermined sequence, electro-magnet valves for independently controlling the fluid pressure supplied to the admission valves and to the control valves, and means for cutting off the supply of fluid pressure to the control valves to suspend the closure of the switches at any point in the sequence.

12. In a control system for electric motors, the combination with independently operated switches, pneumatic cylinders, and pistons operating therein to actuate the switches, of admission valves for the cylinders and a series of interlocking control valves for governing the action of the admission valves to confine the closure of the switches to a predetermined sequence, elec-

tro-magnet valves for independently controlling the fluid pressure supplied to the admission valves and the control valves, and automatic means dependent upon the current traversing the motor circuit for cutting off the supply of fluid pressure to the control valves at any point in the closure of the switches.

13. In a control system for electric motors, the combination with a plurality of independently and pneumatically operated switches that are adapted to close in a predetermined sequence, of a control circuit pipe, a holding circuit pipe, magnet valves for each pipe and means dependent upon the closure of one of the switches for admitting fluid-pressure to actuate the next switch in the series.

14. In a control system for electric motors, the combination with a plurality of independently operated switches that are adapted to close in a predetermined sequence, pneumatic cylinders, and pistons operating therein, of a holding circuit pipe, electro-responsive valves interposed between the cylinders and the pipe, a control circuit pipe, a series of valves located therein, taps connecting the control circuit pipe with the cylinders, and check valves in the taps, the operation of one of said switches serving to open the control valve for the next switch in the sequence, and the operation of the control valves serving to complete a fluid connection from the holding circuit pipe to the cylinders.

15. In a control system for electric motors, the combination with independently operated switches, pneumatic cylinders, and pistons operating therein to actuate the switches, of a holding circuit pipe, a magnet valve for governing the fluid supplied thereto, valves interposed between the cylinders and said pipe, a control circuit pipe, a series of valves located therein that are adapted to confine the closure of the switches to a predetermined sequence, and check valves interposed between the cylinder and the control circuit pipe for preventing the fluid-pressure in the holding pipe from escaping into the control pipe.

In testimony whereof, I have hereunto subscribed my name this 28th day of August, 1907.

JOSEPH N. MAHONEY.

Witnesses:
G. M. Eaton,
Birney Hines.