No. 836,981. PATENTED NOV. 27, 1906.

C. E. LORD.

TRAIN CONTROL SYSTEM.

APPLICATION FILED OCT. 1, 1904.

4 SHEETS—SHEET 1.

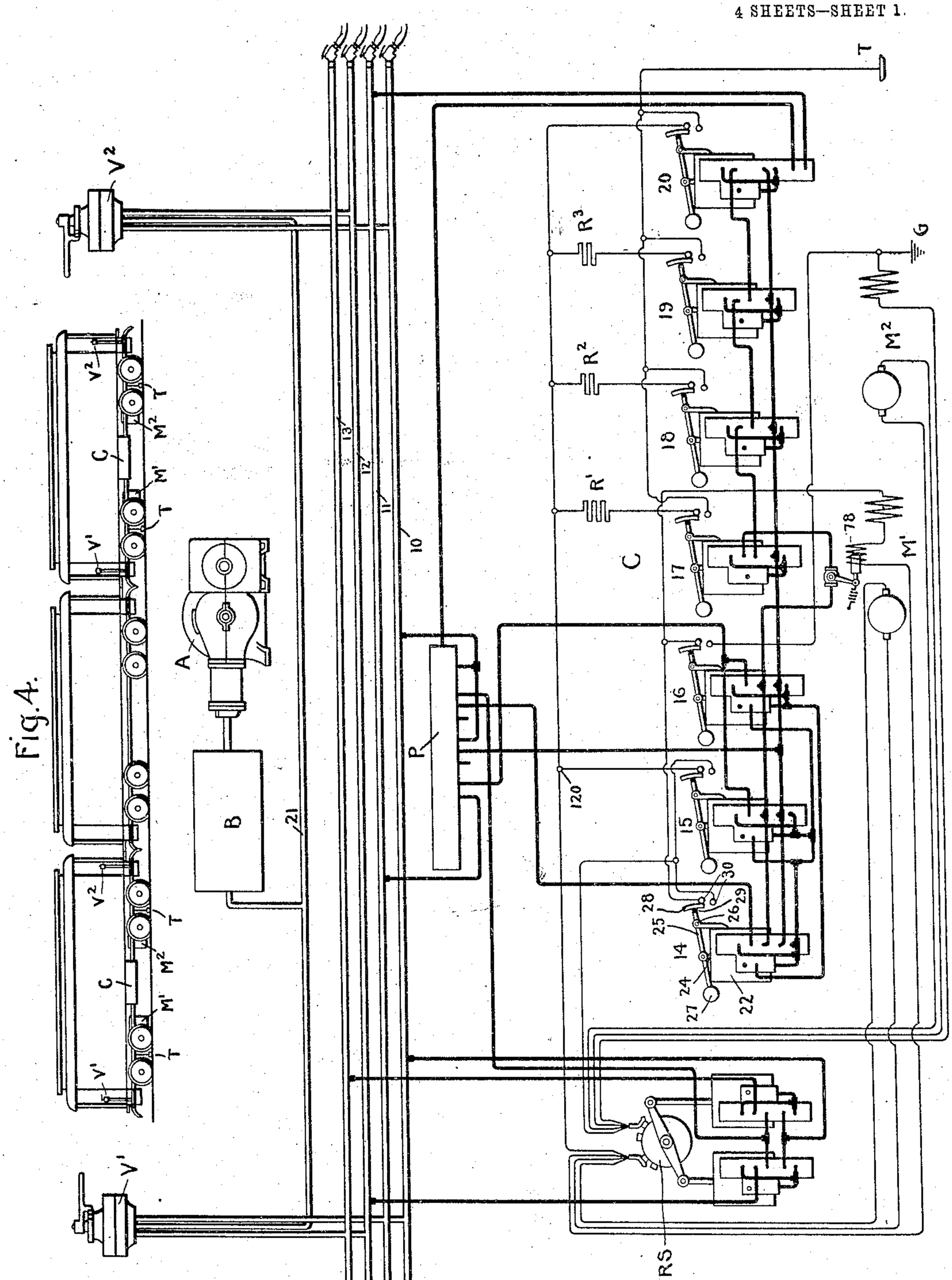

Fig. 4.

Fig. 1.

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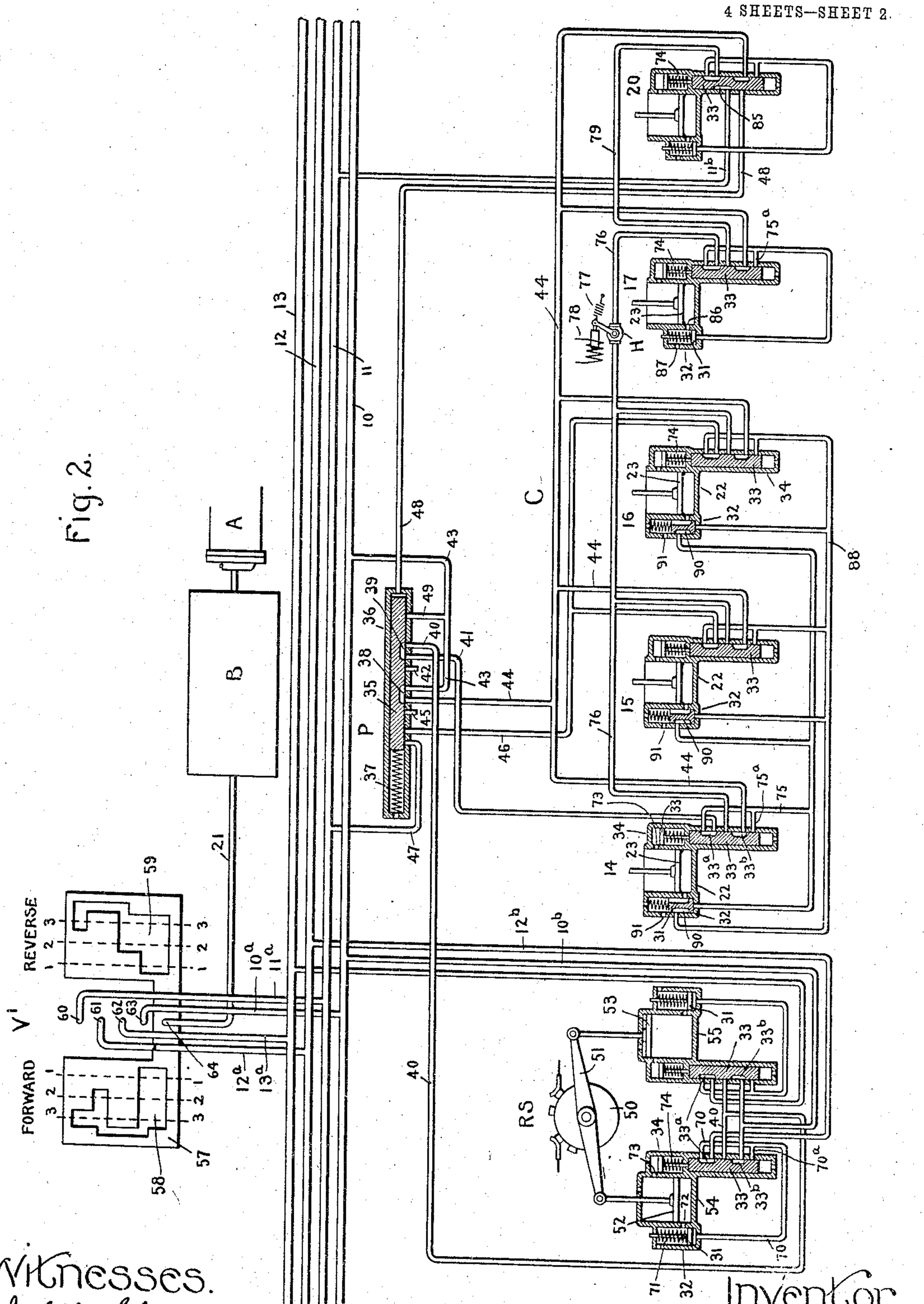
4 SHEETS—SHEET 2.

Fig. 2.



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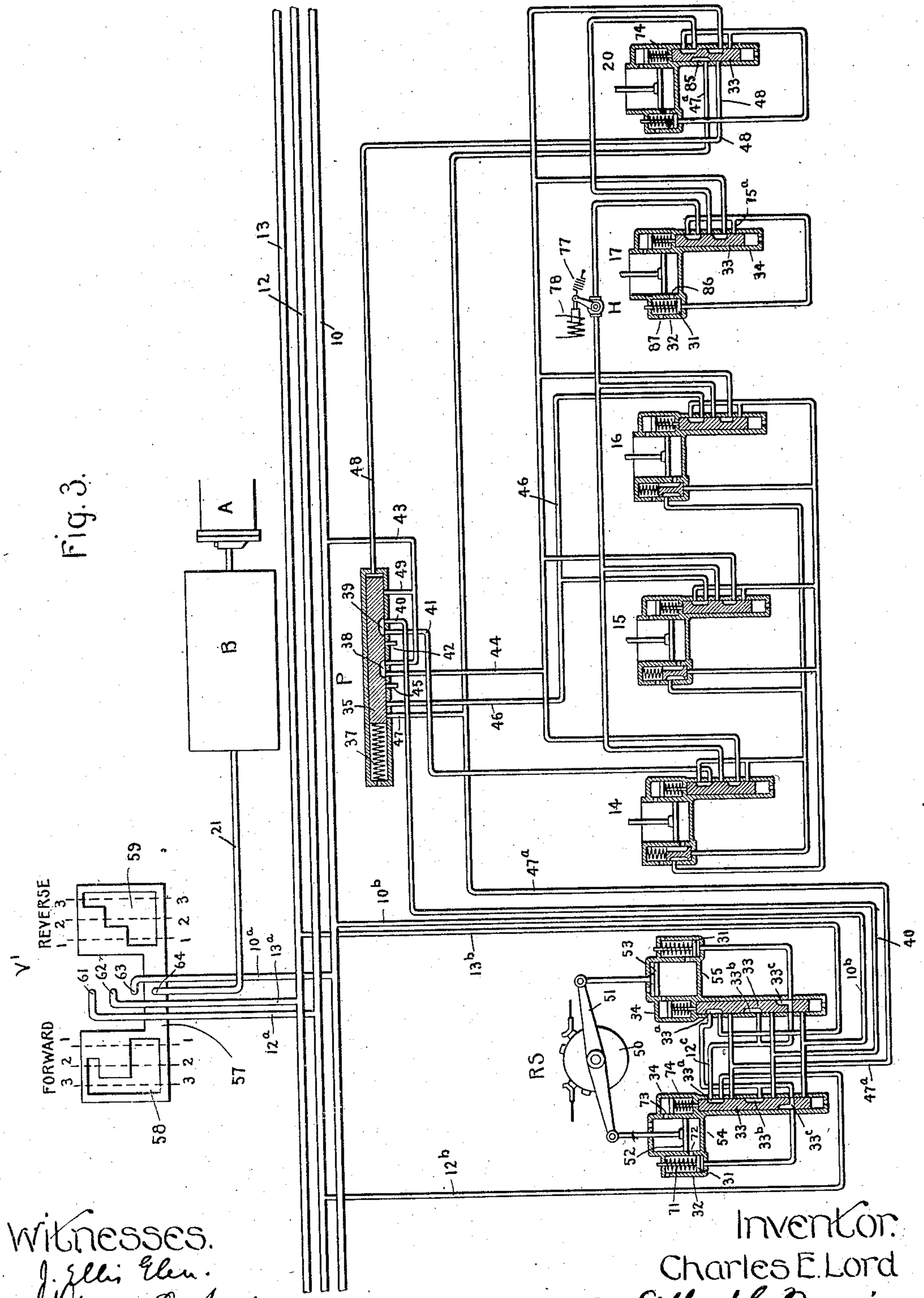
4 SHEETS—SHEET 3.

Fig. 3.



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4 SHEETS—SHEET 4.

Fig. 5.

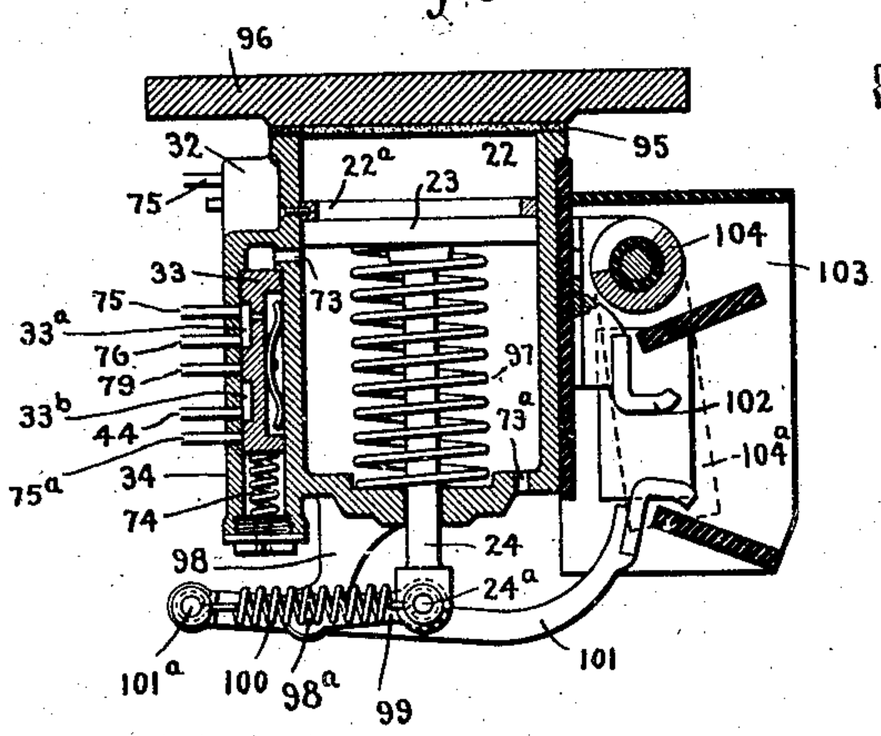


Fig. 6.

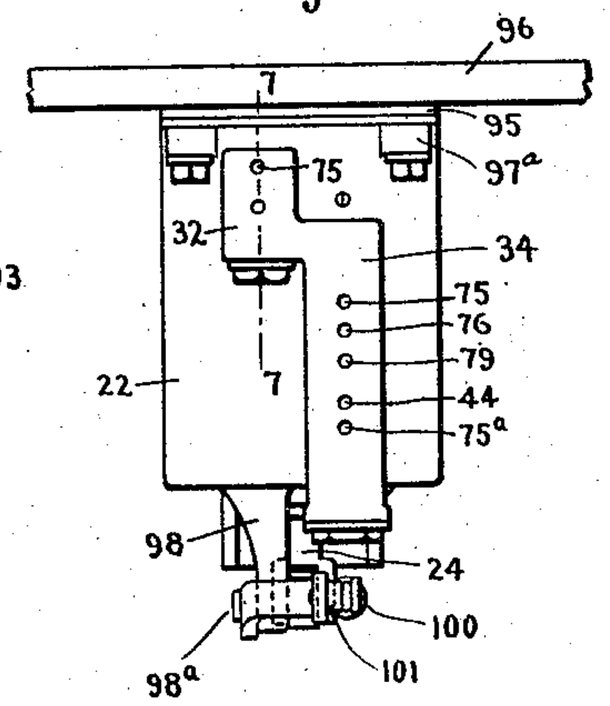


Fig. 7.

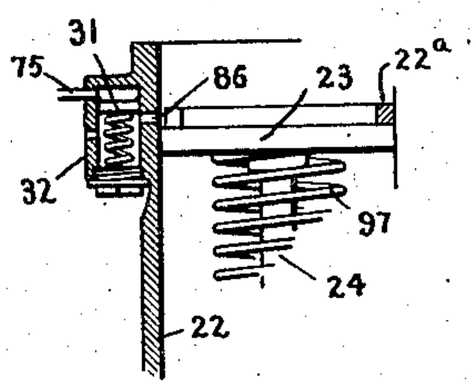
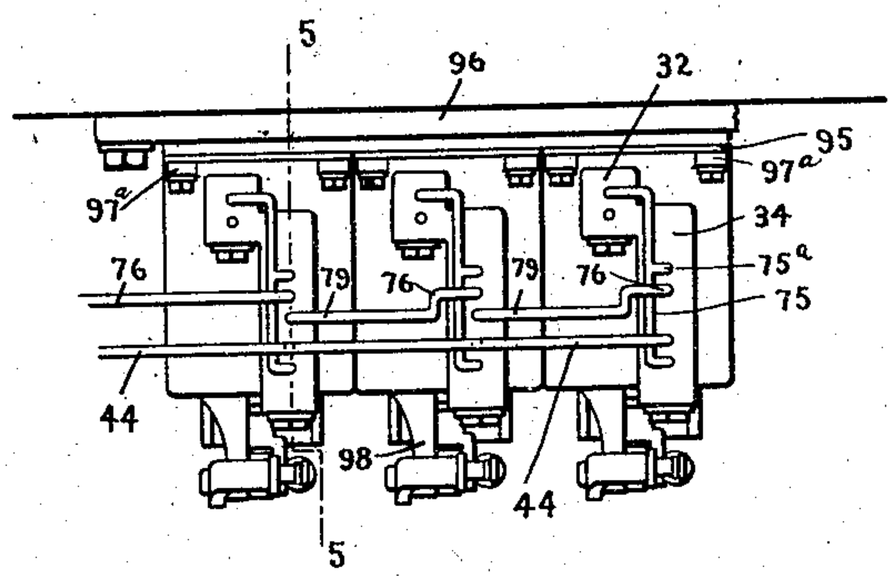


Fig. 8.



Witnesses.
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Helen Alford

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UNITED STATES PATENT OFFICE.

CHARLES E. LORD, OF CINCINNATI, OHIO, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

TRAIN-CONTROL SYSTEM.

No. 836,981. Specification of Letters Patent. Patented Nov. 27, 1906.

Application filed October 1, 1904. Serial No. 226,749.

To all whom it may concern:

Be it known that I, CHARLES E. LORD, a citizen of the United States, residing at Cincinnati, county of Hamilton, State of Ohio, have invented certain new and useful Improvements in Train-Control Systems, of which the following is a specification.

My invention relates to systems of motor control, and more particularly to systems of train control in which a plurality of motors mounted upon the several cars of a train are controlled simultaneously from any desired point on the train.

It has been heretofore customary in systems of train control to employ a plurality of separately-actuated contacts, either electrically or pneumatically operated, and control the operating means through an electric control system having a great number of train-wires connecting the several motor-controllers to the master controller or controllers. In operating electrical systems of train control one must either depend upon the current taken from the trolley or main source of supply or from an auxiliary source of supply carried on the train for power to actuate the parts of the control system. When the main source of supply is depended upon, difficulty is sometimes experienced, due to momentary interruptions of said supply, which tends to derange the control system. When an auxiliary source of supply is depended upon, a bulky, expensive, inefficient, and unreliable storage battery or its equivalent must be employed.

The objects of my invention are to simplify the systems of train control now in use, to reduce the number of connections between the cars of the train, to render the operation of the controller-contacts more positive, to produce an automatic acceleration of the motors by permitting an automatic progression of the controller-contacts, while at the same time retaining complete control from the master-controller of the extent and rate of said progression. To this end I employ a plurality of separately-actuated contacts with pneumatic operating means therefor and a master controlling-valve for controlling the admission of compressed fluid from a source of compressed-fluid supply to said operating means to produce an automatic progressive operation, and means whereby the extent and rate of progression of said contacts may be directly controlled from said master controlling-valve.

More specifically considered, my invention comprises one or more electric motors, a plurality of pneumatically-actuated contacts forming a motor-controller, said contacts being adapted to operate successively in automatic progression, a master controlling-valve, a pneumatic actuating system, and a pneumatic maintaining system connecting the master controlling-valve with the contact-actuating means, whereby the rate and extent of the progression of the controller-contacts may be controlled.

In another aspect my invention comprises a plurality of separate pneumatically-actuated contacts forming a motor-controller, means for producing an automatic progression of said contacts, a master controlling-valve, and means connected with said valve for checking the progression of said contacts without affecting the contacts already operated.

The invention further comprises details of construction and combination of parts of the system which will be hereinafter described, and more clearly set forth in the appended claims.

In the accompanying drawings, which illustrate preferred embodiments of my invention, Figure 1 represents diagrammatically sufficient of the equipment of a single car of a system of train control to illustrate my invention, the pipe connections between the master-controller and the actuating means of the motor-controller contacts being illustrated by heavy lines, while the motor-circuit connections are illustrated by light lines, a series-parallel controller being shown. Fig. 2 illustrates diagrammatically the system shown in Fig. 1, but on a larger scale and with the motor-circuit and motor-controller contacts omitted. Fig. 3 is a diagram similar to Fig. 2, illustrating a modified form of my invention employing three train-pipes instead of four, as shown in Figs. 1 and 2. Fig. 4 illustrates in outline a three-car train equipped with my invention. Fig. 5 is a sectional elevation through the preferred form of my pneumatically-actuated controller-contact, taken on the line 5 5, Fig. 8. Fig. 6 is a rear view in elevation of my improved controller-contact, all piping connections being removed. Fig. 7 is a detail vertical sec-

tion on the line 7 7, Fig. 6, showing the preferred form of quick-acting exhaust-valve and Fig. 8 is a rear elevation of part of the pneumatically-operated controller, showing the method of mounting a plurality of contacts on the same supporting-base.

Referring now to Figs. 1 and 2, which illustrate the modification of my invention which employs four train-pipes 10, 11, 12, and 13, C indicates the motor-controller built up of a plurality of separate pneumatically-actuated contacts 14 to 20, inclusive. RS represents a pneumatically-operated reversing-switch, and M′ and M² represent the motors to be controlled. The master controlling-valves at each end of the car are represented by V′ and V². The series-parallel valve, the function and operation of which will be hereinafter described, is shown at P. The source of supply of compressed fluid for operating the pneumatic control system may be anything desired, though it is here shown as a motor-driven air-compressor A, which is directly connected with the storage-reservoir B, which in turn is directly connected to the supply-pipe 21, leading to the master controlling-valves V′ and V². The invention as illustrated in these figures embodies two cooperating control systems—namely, a pneumatic actuating system, and a pneumatic maintaining system. The reversing-switch and the separately-actuated contacts of the motor-controller are operated by compressed air admitted thereto through the actuating system and are held in their operative positions by compressed air admitted thereto through the maintaining system.

Each contact of the motor-controller and its actuating means, as shown diagrammatically in Figs. 1 and 2, embodies a cylinder 22, in which operates a piston 23, connected, through the piston-rod 24, to the arm 25, pivoted at 26 and carrying at one end the weight 27 and at the other end the bridging member 28, insulated from the arm 25 at 29. This bridging member 28 is normally in the position shown in Fig. 1; but when compressed air is admitted below piston 23 said member is moved downwardly to bridge the fixed contacts 30.

The preferred construction of my improved pneumatically-actuated contact will be hereinafter described with reference to Figs. 5 to 8, inclusive. The compressed air is admitted to the cylinder 22 through a quick-acting admission and exhaust valve 31, contained within the valve-casing 32. When the piston 23 has moved into such a position that the contact controlled thereby is completely closed, a pneumatically-actuated valve 33, contained within the casing 34, is operated to disconnect the actuating means of the contact, which has just been closed, from the pneumatic actuating system and connect said contact-actuating means to the pneumatic maintaining system, also to connect the actuating system to the actuating means of the contact next in advance, so as to produce an automatic progression of the contacts of the controller. The contact 14 controls the series connection of the motors M′ and M². The contacts 15 and 16 control the connections of said motors in parallel. The contacts 17 to 20, inclusive, control the resistances R′, R², and R³ in the motor-circuit. The contact 20, in addition to controlling a short circuit around the resistances in the motor-circuit, prevents the operating of the series-parallel valve P regardless of the position of the master controlling-valve until said contact 20 has been completely closed.

The series-parallel valve, as shown in Fig. 2, comprises the slide-valve 35 within the casing 36, normally maintained at the right end of said casing by means of the spring 37. This valve is provided with passage-ways 38 and 39, which are adapted to register with certain of the ports in said casing leading to pipes 40 to 47, inclusive. The pipes 48 and 49 also lead from said casing. The functions of the various ports and passage-ways will be hereinafter stated in the description of the operation of this system.

The reversing-switch RS comprises the customary cylindrical rotating member 50, carrying contact-segments engaging relatively fixed contact-fingers. The member 50 is rotated through the agency of the lever-arm 51, to the ends of which are attached piston-rods connected with the pistons 52 and 53, operating in the cylinders 54 and 55, respectively. The compressed air is admitted to said cylinders 54 and 55 through the valves 31 and 33, which control the connections between said cylinders, and actuating and maintaining control systems in the same manner as the connections to the controller-contacts are controlled. Each valve 33 is provided with passage-ways 33ª and 33ᵇ.

One of the master controlling-valves is shown in development as a slide-valve in Fig. 2 for the purpose of more clearly illustrating the connections to and controlled by said valve. The plate 57 of said valve is provided with the passage-ways 58 and 59, which register with the ports 60 to 64, inclusive, as the valve is moved from its off position, Fig. 2, into its operative positions, (indicated by the vertical dotted lines 1 1, 2 2, and 3 3,) forward and reverse.

The operation of the system shown in Figs. 1 and 2 will now be described. If the master controlling-valve is moved into the position "forward," 1 1, the ports 63 and 64 are brought into register with the passage-way 58 and compressed air is admitted from the storage-reservoir B through the pipes 21 and 10ª into the maintaining train-pipe 10. Said train-pipe and the connections of the pneumatic maintaining system are thus charged

compressed air, but no part of the motor-controller C is operated. When the master controlling-valve is moved into its series forward position, (indicated by 2 2,) the port 61 registers with the passage-way 58, and compressed air is admitted to train-pipe 12 of the pneumatic actuating system through pipes 21 and 12ª, the connections to maintaining system remaining unaffected. The compressed air passes from the train-pipe 12 through pipe 12ᵇ, the passage-way 33ª of valve 33 on reversing-switch cylinder 54, thence through the pipe 70 into the valve-casing 32 on said cylinder, moving valve 31, contained therein, upward against the action of spring 71 until the port 72 is uncovered. The compressed air then enters cylinder 54, forcing the piston 52, contained therein, upward until said piston uncovers the port 73. The reversing-switch 50 is thereby thrown into its forward position and the compressed air enters valve-casing 34, moving the valve 33, contained therein, downward against the action of the spring 74. The passage-way 33ª is thereby moved into register with the ports leading to pipes 12ᵇ and 40 and out of register with the port leading to pipe 70. The pneumatic actuating system is thus cut off from the reversing-switch-actuating mechanism and connected to pipes leading to the contact-operating means of the controller. Simultaneously with this movement the passage-way 33ᵇ in said valve is brought into register with port 70ª, leading to pipe 70. This passage-way maintains its register with pipe 10ᵇ, connected with the maintaining train-pipe 10. Compressed air is then admitted from the maintaining system to the cylinder 54 to hold the reversing-switch in the position into which it has been moved by the compressed air from the actuating system.

The compressed air in the actuating system flows through pipe 40, passage-way 39 in the series-parallel valve, thence through pipe 41, passage-way 33ª, formed in valve 33 of series contact 14, thence through maintaining-pipe 75 into the valve-chamber 32, containing-valve 31 of contact 14, thence to cylinder 22 of said contact, forcing the actuating-piston 23, contained therein, upward to close the motor-circuit at the fixed contacts 30. After said series contact has been closed the compressed air enters the valve-casing 34 of said contact through port 73 and moves the valve 33 so as to bring the port 33ª into register with the pipe 76 and out of register with the pipe 75, thus connecting the operating means of the first resistance-contact 17 with the pneumatic actuating system and disconnecting the operating means of contact 14 from said actuating system. The downward movement of the valve 33 of contact 14 also causes the passage-way 33ᵇ to connect the pipes 44 and 75ª, thus establishing communication between the cylinder 22 of contact 14 and the maintaining train-pipe 10 through pipe 43, passage-way 38 in series-parallel valve, and pipe 44.

The compressed air having been admitted to the pipe 76 of the actuating system flows through the throttle-valve H. This valve is maintained normally open by the spring 77 and is closed when an excessive current flows through the motor-circuit by means of the coil 78, connected in the motor-circuit. The compressed air then enters the actuating-cylinder of the first resistance-contact 17, as before described with reference to series contact 14, and operates the valve 33 of contact 17 to connect the actuating system to the pipe 79, leading, as shown in Fig. 1, to the second resistance-contact 18. As shown in Fig. 2, this pipe 79 leads directly to the last resistance-contact 20, the intermediate resistance-contact being omitted to simplify the diagram of connections. The contact 18 and other resistance-controlling contacts will operate in automatic progression, each contact, as it operates, disconnecting its operating means from the pneumatic actuating system and connecting it to the pneumatic maintaining system and also connecting the operating means of the contact next in advance to the actuating system.

If the automatic progression of the contacts becomes so rapid that an undesirable acceleration of the motors is produced or if for any other reason it is desired to check said automatic progression, the master controlling-valve may be moved back into its first operative position, (indicated by 1 1,) so as to cut the supply of compressed air from the actuating system without disconnecting said supply from the maintaining system. It will thus be seen that the acceleration of the motors or progression of the contacts may be arrested at any desired point for any desired length of time without affecting the contacts already operated or the position of the reversing-switch.

The throttle-valve H operates to arrest the flow of compressed air in the actuating system whenever the current in the motor-circuit rises above a predetermined value due to a too rapid acceleration or from any other cause. The operation of this valve checks the progression of the resistance-controlling contacts until the current falls below a definite value without affecting the contacts already operated.

With respect to the motor-circuits when the master controlling-valve is first moved into its second operative position the reversing-switch, the series contact 14, and the first resistance-controlling contact 17 will be closed and an electric circuit completed through the motors connected in series as follows: from the trolley T, through contact 17, resistance R′, reversing-switch RS, arma-

ture of motor M′, reversing-switch RS, coil 78 of the throttle-valve H, field of motor M′, series contact 14, reversing-switch, armature of motor M², reversing-switch, field of motor M², to ground at G. As the automatic progression of the resistance-controlling contacts continues the resistances R² and R³ are successively thrown in parallel with resistance R′ to reduce the resistance of motor-circuit. When the contact 20 is operated, the resistance is short-circuited and the motors are connected directly in series.

By referring to Fig. 2 it will be seen that the valve 33 of contact 20 is provided with an auxiliary passage-way 85, which is adapted to register with ports leading to pipes 11ᵇ, connected with train-pipe 11, and pipe 48, connected with series-parallel valve P. So long as there is no pressure in the parallel train-pipe 11 the progression of the contacts will automatically check itself when the final series position is reached; but if the master controlling-valve is moved into its parallel position (indicated by 3 3) the parallel train-pipe is charged with air from B through the port 64, passage-way 58, port 60, and pipe 11ª. The compressed air then passes from the train-pipe 11 through pipe 11ᵇ, passage-way 85 in valve 33 of contact 20, through pipe 48 into the casing of the series-parallel valve, moving said valve to the left against the action of the spring 37 until the right-hand end of said valve uncovers the port 49. This port communicates with pipe 43, which is connected with maintaining train-pipe 10, and the valve is thus held in its operated position by means of compressed air from the maintaining system. During the forward movement of the series-parallel valve the port 40 is cut off from communication with the pipe 41, thus depriving the contact-operating means of compressed air from the actuating system. The pipe 41, leading to series contact 14, is then exhausted of the air contained therein through the exhaust-pipe 42 and passage-way 39 in said valve. This exhausts all the pipes of the actuating system connected with the contact-operating means. Also during said forward movement the maintaining train-pipe is cut off from that part of the maintaining system connected with contact-operating means, the passage-way 38 moving out of register with pipe 43 and into register with the exhaust-pipe 45 to exhaust the air through pipe 44 from that part of the maintaining system connected with the operating means. During this operation the air is first exhausted from the quick-acting exhaust-valve chamber 32, allowing the valve 31 therein to permit the air within the cylinders 22 to be exhausted through the ports 86 and 87. As the piston 23 moves downwardly the port 73 is opened to the atmosphere and the valve 33 returns to its initial position under the action of spring 74. Thus all the parts of the contact-operating means assume their initial position. It will be noticed, however, that the position of the reversing-switch is unaffected. A further forward movement of the series-parallel valve brings the passage-way 39 into register with pipes 43 and 44, thereby reëstablishing the maintaining system connections. At the same time the passage-way 38 registers with pipes 46 and 47 and the parallel train-pipe 11 is then connected to the parallel actuating system. When this connection is established, the compressed air flows from train-pipe 11 through pipe 47, passage-way 38, pipe 46, through the valve 33 of parallel contacts 15 and 16 in multiple, through pipe 88 into valve-chambers 32 of said contacts 15 and 16, and from thence into the cylinders 22 of said contacts. The parallel contacts are thus closed and the valves 33 of these contacts are then operated to connect the pipe 46 to the pipe 76 and disconnect said pipe 46 of the actuating system from the parallel-contact-operating means and connect said means to the pipe 44 of the maintaining system. The compressed air then passes through the pipe 76 and throttle-valve H to operate the resistance-controlling contacts 17 to 20, inclusive, in automatic progression, as has been hereinbefore described.

The motor-circuit corresponding with the first parallel position of the controller with the contacts 15, 16, and 17 closed may be traced on Fig. 1 as follows: from trolley T through contact 17, resistance R′, reversing-switch, armature of motor M′, reversing-switch, coil 78, field of motor M′, contact 16 to ground at G, also branching at the point 120 through contact 15, reversing-switch, armature of motor M², reversing-switch, field of motor M² to ground at G. As the controller-contacts 18, 19, and 20 successively operate the resistance of the motor-circuit is reduced until the motors are connected in multiple directly across the line.

In order to prevent the simultaneous operation of the series and parallel contacts 14, 15, and 16, I have employed a pneumatic interlock between said contacts, and to this end I provide the quick-acting exhaust-valve of said contacts with an auxiliary passage-way 90, which when the valve 31 is operated to admit air from the pipe 88 or 75 into the cylinders 22 connects the other of said pipes 88 and 75 to atmosphere through port 91. Thus it will be seen that if the series contact 14 is operated by compressed air in the pipe 75 and it is attempted to operate contacts 15 and 16 by admitting air to the pipe 88 the said pipe 88 will be exhausted to atmosphere through the port 91 and passage-way 90 of the quick-acting exhaust-valve of contact 14 and the contacts 15 and 16 will not operate.

In the modification illustrated in Fig. 3 I have reduced the number of train-pipes in

the pneumatic control system from four to three, said pipes being indicated by 10, 12, and 13, the parallel train-pipe 11, Fig. 2, being omitted. The series and parallel connections in forward and reverse direction of movement are controlled through the train-pipes 12 and 13 in a manner which will now be described. To obtain series forward, compressed air is admitted to one train-pipe. To obtain series reverse, the compressed air is admitted to the other train-pipe. To obtain parallel, the compressed air is admitted to both train-pipes 12 and 13, the train-pipe to which the compressed air is first admitted determining the position of the reversing-switch, and hence the direction of movement of the car or train. The actuating and maintaining systems operate substantially the same as before described to produce automatic progression of the contacts of the motor-controller after the reversing-switch has been operated. The main difference between the system before described and the system shown in Fig. 3 lies in the connections to the reversing-switch-actuating means and the series-parallel switch P. In the operation of this modification when the master controlling-valve V′ is moved into the first forward position (indicated by the vertical dotted line 1 1) the compressed air is admitted from the source of supply B through the pipe 21, port 64, passage-way 58 in the valve-seat, port 63, train-pipe 10, thence into the maintaining system of pipe connections through pipes 43 and 10^b. Then the valve V′ is moved into its series-forward position, (indicated by 2 2,) and the compressed air is admitted to the pipe 61 through the passage-way 58, thereby charging the train-pipe 12, pressure being meanwhile maintained in the train-pipe 10. The compressed air then flows through pipe 12^b, passage-way 33^a in valve 33 on cylinder 34 through pipe 12^c, port 33^c of valve 33 in cylinder 55, thence into the latter cylinder through valve 31, forcing the piston 53 into the position shown in Fig. 3, thence into valve-chamber 34, forcing the valve 33 on cylinder 55 downward until the passage-way 33^c registers with the port leading to maintaining-pipe 10^b. The actuating system is thus cut off from the cylinder 55, but is at the same time connected to the operating means for the series contact 14 through pipe 12^c, port 33^b in valve 33 of cylinder 55, pipe 40, passage-way 39 in the series-parallel valve, pipe 41, to the controlling-valves for contact 14. The automatic progressive operation of the controller-contacts then proceeds through the series positions, as before described, until the contact 20 has operated. This progressive action, as before described, may be checked by the operation of the throttle-valve H or by a movement of the master controlling-valve into its first position.

When it is desired to proceed into the parallel positions, the valve V′ is moved into the position indicated by 3 3. This admits compressed air to the train-pipe 13 through the passage-way 58, port 62, and pipe 13^a, pressure being meanwhile maintained in train-pipes 10 and 12. The compressed air then flows through pipe 13^b, passage-way 33^a of valve 33 on cylinder 55, thence since the valve is in its lowest position through the pipe 47^a, passage-way 85 in valve 33 of contact 20, through pipe 48 into the casing of series-parallel valve. The latter valve is then operated, as before described, to disconnect the actuating means of the controller-contacts from the actuating system, then to exhaust that part of the maintaining system leading to said contacts to permit them to assume their initial position, then to reëstablish the connections to the maintaining system and connect the parallel contacts to the actuating systems, the latter connection being made from pipe 47^a through pipe 47, passage-way 38 in the series-parallel valve, through pipe 46 to the valves controlling the actuating means of the parallel contacts 15 and 16.

It will be noted that when the compressed air is admitted to the pipe 13^b from train-pipe 13 there is no tendency for the reversing-switch to be thrown into its reversed position, since the compressed air cannot pass from pipe 13^b through the port 33^a of valve 33 on cylinder 55 because said passage-way is moved out of register with the pipe 13^c when said valve 33 is in its lower position. However, when the master controlling-valve V′ is moved into its series-reverse position (indicated by 2 2) the compressed air is admitted to train-pipe 13 while there is no pressure in the train-pipe 12. The compressed air then flows through pipe 13^b, passage 33^a in valve 33 on cylinder 55, through pipe 13^3, passage 33^c in valve 33 of cylinder 54, thence into said cylinder through valve 31, then by operating the reversing-switch into reversed position and moving valve 33 on cylinder 54 into its downward position. The movement of this latter valve makes pipe connections to the actuating and maintaining systems and series-parallel valve similar to those just described with reference to valve 33 on cylinder 55. These connections may be readily traced on the diagram.

Referring now to the construction of my preferred form of pneumatically-actuated controller-contact, (illustrated in Figs. 5 to 8, inclusive,) the cylinder containing actuating-piston 23 is indicated, as before, by 22. Said piston is maintained normally in a raised position against the stop-ring 22^a by means of the spring 97, thereby maintaining the electrical contact or switch normally open. This cylinder 22 is fastened to the under side of a supporting-plate 96 by means of bolts 97^a, a

strip of compressible material 95 being-placed between the upper edge of cylinder 22 and the lower face of plate 96. These cylinders may be fastened to separate supporting-plates or a large number may be suspended from a single plate in the manner shown in Fig. 8. The valve-casings 32 and 34 are preferably formed integral with cylinder 22 in the manner shown in Figs. 5, 6, and 7. The casing 34 contains the valve 33, the functions and operation of which have been described in detail. The valve-casing 32 contains the quick-acting exhaust-valve 31, which operates to connect the cylinders 22 to atmosphere when the pressure in the supply-pipe 75 falls below a predetermined value. The bracket 98, formed on the lower end of the cylinder 22, has pivoted thereon at 98^a the contact-arm 101, which is connected with the piston-rod 24 by means of the spring 100, attached to the arm 101 at 101^a and to the rod 24 at 24^a, thereby forming a snap-switch action. To take up the strain of the spring 100 on the rod 24 to prevent said rod from sticking in its bearing, I provide the link 99, pivotally connected to the end of rod 24 and to the bracket 98 at 98^a. The contact end of arm 101 engages the fixed contact 102 within the arc-deflector housing 103. A blow-out magnet the coil of which is indicated at 104 and one pole at 104^a in dotted lines in Fig. 5 is provided for the purpose of dissipating the arcs which tend to form at the contacts of the switch. In the operation of this form of pneumatically-actuated controller-contact the compressed air entering the valve-casing 32 forces the valve 31 downward against the action of its spring until the port 86 is uncovered to admit the air into the upper part of cylinder 22. The piston 23 is then forced downward against the action of the spring 97, thereby moving the lower end of the piston-rod 24 below a point in alinement with pivots 98^a and 101^a, so that the spring 100 will exert a downward pull on the left-hand end of arm 101 and move its right-hand end with a snap action into engagement with contact 102, thereby closing the switch. During the downward movement of piston 23 the port 73, leading to valve-casing 34, is uncovered, so as to admit air to the upper end of valve 33, thereby operating said valves to make the connections to the pneumatic actuating and maintaining systems, as before described.

When the pipe 75 is exhausted or the pressure therein reduced below a predetermined value, the valve 31 is moved upwardly by its spring so as to connect the cylinder 22 directly to atmosphere through the port 86. This permits the piston 23 to move upward under the influence of spring 97, throwing the spring 100 over dead-center, so as to exert an upward pull on the left-hand end of arm 101 and open the switch with a snap action. The valve-chamber 34 is also exhausted to atmosphere through ports 73 and 73^a and the valve 33 is returned to its initial position by spring 74.

I aim in the appended claims to cover all modifications and changes in my improved system of pneumatic control for motors and in the construction of the controller-contacts which do not involve a departure from the spirit and scope of my invention.

What I claim as new, and desire to secure by Letters Patent of the United States, is—

1. In a system of motor control, a motor-controller comprising a plurality of separately-actuated contacts with pneumatic operating means therefor, a master controlling-valve for controlling the admission of compressed fluid from a source of supply to said operating means, means associated with the contact-operating means for producing an automatic progressive operation of said operating means, and means whereby the extent and rate of progression of said contacts may be directly controlled from said master controlling-valve.

2. In a system of motor control, a motor-controller comprising a plurality of separately-actuated contacts with pneumatic operating means therefor, a master controlling-valve for controlling the admission of compressed fluid from a source of supply to said operating means, means associated with the contact-operating means for producing an automatic progressive operation of said operating means, and means for checking the automatic progression of said contacts from the master controlling-valve without affecting the contacts already operated.

3. In a system of motor control, a plurality of pneumatically-actuated contacts forming a motor-controller, means associated with the contact-operating means for producing an automatic progressive action of said contacts, a master controlling-valve, and means for checking the automatic progression without affecting the contacts already operated, said means being controlled by a movement of the master controlling-valve.

4. In combination, a plurality of motors, a series-parallel motor-controller of the separately-actuated contact type, means for producing an automatic progressive action of said contacts so arranged that the contacts are required to operate in a definite order, a pneumatically-operated reversing-switch, and a pneumatic control system including a master controlling-valve whereby series and parallel connections of the motors for forward and reverse directions of movement may be obtained and the automatic progression of the contacts checked without affecting the contacts already operated.

5. In combination, a plurality of motors, a motor-controller of the separately-actuated

contact type, pneumatic operating means for the contacts thereof, arranged for automatic progressive action, a pneumatically-operated reversing-switch, a master controlling-valve a pneumatic control system, connected to the master controlling-valve by three pipes, the whole being so constructed and arranged that by a proper manipulation of the master controlling-valve series and parallel in forward and reversed direction may be obtained and the automatic progression of the contacts checked at any desired point without affecting the contacts already operated.

6. In a motor-controller of the separately-actuated contact type, resistance-controlling contacts and series and parallel contacts, pneumatic operating means therefor, a pneumatic control system, including a series-parallel valve, and means for preventing the operating of said series-parallel valve until the final resistance-controlling contact has operated.

7. In a motor-controller of the separately-actuated contact type, pneumatically-operated series and parallel contacts, pipes leading to the actuating means for said contacts, and means associated with the series contact for exhausting the pipes leading to the parallel contacts when the series contact is operated and vice versa.

8. In combination, one or more electric motors, a plurality of pneumatically-actuated contacts forming a motor-controller, means for producing an automatic progressive operation of said contacts, a master controlling-valve, a pneumatic actuating system, and a pneumatic maintaining system connecting the master controlling-valve with the contact-actuating means, whereby the rate and extent of the progression of the controller-contacts may be controlled.

9. In combination, a motor-controller of the separately-actuated contact type, pneumatic actuating means for the contacts thereof, a pneumatic actuating system, and a pneumatic maintaining system, said actuating system being normally connected to one or more of said contacts, and means for disconnecting the contact-operating means from the actuating system and connecting it to the maintaining system as the contact operates.

10. In a system of motor control, a motor-controller of the separately-actuated contact type, having pneumatic operating means for the contacts thereof, a pneumatic actuating system, a pneumatic maintaining system, and means for connecting the contact-operating means successively to the actuating and maintaining systems.

11. In a system of motor control, a motor-controller of the separately-actuated contact type, having pneumatic operating means for the contacts thereof, a pneumatic actuating system, a pneumatic maintaining system, and means for shifting the operating means of each contact as it operates from the actuating to the maintaining system.

12. In a system of motor control, a motor-controller of the separately-actuated contact type, having pneumatic operating means for the contacts thereof, a pneumatic actuating system, a pneumatic maintaining system, and means for shifting the operating means of each contact as it operates from the actuating to the maintaining system and for connecting the actuating means of the contact next in advance to the actuating system.

13. In a system of motor control, a motor-controller of the separately-actuated contact type, having pneumatic operating means for the contacts thereof, a pneumatic actuating system, a pneumatic maintaining system, and automatically-actuated valves for connecting the operating means of a contact to the actuating system and after said contact has operated disconnecting said operating means from the actuating system and connecting it to the maintaining system.

14. In a system of motor control, a motor-controller of the separately-actuated contact type, having pneumatic operating means for the contacts thereof, a pneumatic actuating system, a pneumatic maintaining system, and automatically-actuated valves for connecting the operating means of a contact to the actuating system and after said contact has operated disconnecting said operating means from the actuating system and connecting it to the maintaining system and for connecting the actuating system to the next contact-operating means.

15. In a system of motor control, a motor-controller of the separately-actuated contact type having pneumatic operating means for the contacts thereof, a pneumatic actuating system, a pneumatic maintaining system, and means for connecting the operating means of the contacts to the actuating system in a manner to produce an automatic progressive operation of said contacts and for disconnecting the operating means of each contact as it operates from the actuating system and for connecting it to the maintaining system.

16. In a system of motor control, a motor-controller of the separately-actuated contact type, having pneumatic operating means for the contacts thereof, a pneumatic actuating system, a pneumatic maintaining system, and means for connecting the contact-operating means successively to the actuating and maintaining systems, and means for rendering the actuating system inoperative to check the automatic progression of said contacts.

17. In a system of motor control, a motor-controller of the separately-actuated contact type, having pneumatic operating means for the contacts thereof, a pneumatic actuating

system, a pneumatic maintaining system, means for connecting the contact-operating means successively to the actuating and maintaining systems, a throttle-valve in said actuating system, and means for operating said throttle-valve to check the progression of said contacts when the current in the motor-circuit rises above a predetermined value.

18. In a system of motor control, a motor-controller of the separately-actuated contact type, having pneumatic operating means for the contacts thereof, a pneumatic actuating system, a pneumatic maintaining system, and means for connecting the contact-operating means successively to the actuating and maintaining systems, and a master controlling-valve adapted to cut off the supply of compressed fluid to said actuating system to arrest the progressive operation of said contacts without affecting the maintaining system.

19. In a motor-controller of the separately-actuated contact type, resistance-controlling contacts, series and parallel contacts, a pneumatic system for actuating said contacts, and a pneumatic system for maintaining said contacts after they have been actuated.

20. In a motor-controller of the separately-actuated contact type, resistance-controlling contacts and series and parallel contacts, pneumatic operating means for said contacts, a pneumatic actuating system, a pneumatic maintaining system, and means for rendering said actuating system inoperative without affecting the maintaining system.

21. In a motor-controller of the separately-actuated contact type, series, resistance-controlling and parallel contacts, pneumatic operating means therefor, and an actuating system for said contacts including means controlled by the series and resistance controlling contact operating means for rendering the actuating system operative with relation to the resistance controlling and parallel contacts, respectively.

22. In a motor-controller of the separately-actuated contact type, series, resistance controlling and parallel contacts, pneumatic operating means therefor, an actuating system and a maintaining system, and means controlled by the operating means of a resistance-controlling contact for rendering said actuating and maintaining systems inoperative as to said series and resistance controlling contacts but operative as to said parallel contacts.

23. In a motor-controller of the separately-actuated contact type, series and parallel contacts, pneumatic operating means therefor, a source of compressed-fluid supply, an actuating system including independent connections between said source of supply and the respective pneumatic operating means, and a maintaining system including a common connection between the source of supply and the pneumatic operating means.

24. In combination, a series-parallel motor-controller of the separately-actuated contact type, pneumatic operating means therefor, a pneumatic actuating system, and an automatic valve controlled by the operating means of one of said contacts for rendering said actuating system inoperative as to the series contacts and operative as to the parallel contacts.

25. In combination, a series-parallel motor-controller of the separately-actuated contact type, pneumatic operating means therefor, a pneumatic actuating system, a maintaining system, and an automatic valve for rendering said actuating and maintaining systems inoperative as to the series contacts and then operative as to the parallel contacts.

26. In a motor-controller of the separately-actuated contact type, series, parallel and resistance controlling contacts, pneumatic operating means therefor, a pneumatic actuating system, and an automatic valve controlled by the operating means of one of said contacts for rendering said system inoperative as to the series and operative as to the parallel contacts.

27. In a motor-controller of the separately-actuated contact type, series, parallel and resistance controlling contacts, pneumatic operating means therefor, an actuating system and a maintaining system, and an automatic valve for rendering the actuating and maintaining systems inoperative as to the series contacts and then operative as to the parallel contacts.

28. In combination, a series-parallel controller of the separately-actuated contact type, a reversing-switch, pneumatic operating means therefor, a pneumatic actuating system, means controlled by the reversing-switch-operating means for rendering said actuating system operative as to the series contacts, and an automatic valve controlled by the operating means of one of said contacts for rendering said actuating system operative as to the parallel contacts.

29. In combination, a series-parallel controller of the separately-actuated contact type, a reversing-switch, pneumatic operating means therefor, a pneumatic actuating system, means controlled by the operating means for the reversing-switch for rendering the actuating system operative as to the series contacts, and an automatic valve for rendering said actuating system inoperative as to the series contacts and operative as to the parallel contacts.

30. In combination, a series-parallel controller of the separately-actuated contact type, a reversing-switch, pneumatic operating means therefor, pneumatic actuating and maintaining systems, and means controlled

by the operating means of the reversing-switch for rendering said systems operative as to the series contacts.

31. In combination, a series-parallel controller of the separately-actuated contact type, pneumatic operating means therefor, pneumatic actuating and maintaining systems, means controlled by the operating means of the reversing-switch for rendering said systems operative as to the series contacts, and an automatic valve for rendering said systems operative as to the parallel contacts.

32. In combination, a series-parallel controller of the separately-actuated contact type, a reversing-switch, pneumatic operating means, pneumatic actuating and maintaining systems, means controlled by said reversing-switch-operating means for rendering said systems operative as to the series contacts, and an automatic valve for rendering said systems inoperative as to the series contacts and operative as to the parallel contacts.

33. In a system of train control, each of a plurality of cars having a motor-controller comprising a plurality of separately-actuated contacts with pneumatic operating means therefor and means for producing an automatic progressive operation of said operating means, and a pneumatic train system including a master-valve and means whereby the extent and rate of progression of said contacts may be directly controlled from said master-valve.

34. In a system of train control, each of a plurality of cars having a motor-controller comprising a plurality of separately-actuated contacts with pneumatic operating means therefor, and means for producing an automatic progression of said operating means, train-pipes, and a master-valve for connecting said train-pipes to a source of compressed-fluid supply, the arrangement of parts being such that the rate and extent of automatic progression of said contacts may be controlled directly from said master-valve.

35. In a system of train control, each of a plurality of cars having a motor-controller comprising separately-actuated contacts with penumatic operating means therefor and means for producing an automatic progression of said operating means, and a pneumatic train system including a master-valve and means whereby the rate and extent of progression of said contacts may be controlled directly from said master-valve without affecting the contacts already operated.

36. In a system of train control, each of a plurality of cars having a plurality of pneumatically-actuated contacts forming a motor-controller, means for producing an automatic progressive action of said contacts, and a pneumatic train system including a master-valve, the arrangement being such that the progressive action of the contacts may be checked from the master-valve without affecting the contacts already operated.

37. In a system of train control, each of a plurality of cars having a motor-controller comprising separately-actuated resistance-controlling and series and parallel contacts, pneumatic operating means therefor and means controlled by the last resistance-contact for preventing the operation of the parallel contacts until after the closing of the last resistance-contact, train-pipes, and means for connecting said train-pipes to a source of compressed-fluid supply.

38. In a system of train control, each of a plurality of cars, having a plurality of pneumatically-actuated contacts forming a motor-controller, means for producing an automatic progressive action of said contacts, a pneumatic actuating system and a pneumatic maintaining system, and a pneumatic train system operatively related to said actuating and maintaining systems.

39. In a system of train control, each of a plurality of cars having a plurality of pneumatically-actuated contacts forming a motor-controller, means for producing an automatic progressive operation of said contacts, a pneumatic actuating system and a pneumatic maintaining system, a pneumatic train system operatively related to said actuating and maintaining systems, said pneumatic train system including a master-valve and the arrangement of the parts being such that the rate and extent of progression of the contacts may be controlled directly from the master-valve.

40. In a system of train control, each of a plurality of cars having a plurality of pneumatically-actuated contacts forming a motor-controller, a pneumatic actuating system and a pneumatic maintaining system, and a pneumatic train system operatively related to said actuating and maintaining systems.

41. In a system of train control, each of a plurality of cars having a motor-controller of the separately-actuated contact type, pneumatic actuating means for the contacts thereof, a pneumatic maintaining system, said actuating system being normally connected to one or more of said contacts, and means for disconnecting the contact-operating means from the actuating system and connecting it to the maintaining system as the contact operates, train-pipes operatively related to said actuating and maintaining systems, and means for supplying said train-pipes with compressed fluid.

42. In a system of train control, each of a plurality of cars having a motor-controller of the separately-actuated contact type, pneumatic operating means for the contacts thereof, a pneumatic actuating system, a pneumatic maintaining system, and means for connecting the contact-operating means suc-

cessively to the actuating and maintaining systems, train-pipes operatively related to said pneumatic actuating and maintaining systems, and means for supplying said train-pipes with compressed fluid.

43. In a system of train control, each of a plurality of cars having a motor-controller of the separately-actuated contact type, pneumatic operating means for the contacts thereof, a pneumatic actuating system, a pneumatic maintaining system, and means for shifting the operating means of each contact as it operates from the actuating to the maintaining system, train-pipes operatively related to said actuating and maintaining systems, and a master-valve for connecting said train-pipes to a source of compressed-fluid supply.

44. In a system of train control, each of a plurality of cars having a motor-controller of the separately-actuated contact type, pneumatic operating means for the contact thereof, a pneumatic actuating system, a pneumatic maintaining system, and means for shifting the operating means of each contact as it operates from the actuating to the maintaining system and for connecting the actuating means of the next contact in advance to the actuating system, train-pipes connected to said actuating and maintaining systems, and a master-valve for connecting said train-pipes to a source of compressed-fluid supply.

45. In a system of train control, each of a plurality of cars having a motor-controller of the separately-actuated contact type, pneumatic operating means for the contacts thereof, a pneumatic actuating system, a pneumatic maintaining system, and an automatic actuating-valve for connecting the operating means of the contacts to the actuating system and after said contact has operated, disconnecting said operating means from the actuating means and connecting it to the maintaining system, train-pipes connected to said actuating and maintaining systems, and a master-valve for connecting said train-pipe to a source of compressed-fluid supply.

46. A system of train control, each of a plurality of cars having a motor-controller of the separately-actuated contact type, pneumatic operating means for the contacts thereof, a pneumatic actuating system, a pneumatic maintaining system, an automatic actuating-valve for connecting the operating means of the contact to the actuating system, and after said contact has operated disconnecting said operating means from the actuating system and connecting it to the maintaining system and for connecting the actuating system to the next contact-operating means, train-pipes connected to said actuating and maintaining systems, and a master-valve for connecting said train-pipes to a source of compressed-fluid supply.

47. In a system of train control, each of a plurality of cars having a motor-controller of the separately-actuated contact type, pneumatic operating means for the contacts thereof, a pneumatic actuating system, a pneumatic maintaining system, and means for connecting the operating means of the contacts to the actuating system in a manner to produce an automatic progressive operation of said contacts and for disconnecting the operating means of each contact, as it operates, from the actuating system and for connecting it to the maintaining system, train-pipes connected to said actuating and maintaining systems, and a master-valve for admitting compressed fluid from the source of fluid-supply to said train-pipes.

48. In a system of train control, each of a plurality of cars having a motor-controller of the separately-actuated contact type, pneumatic operating means for the contacts thereof, a pneumatic actuating system, a pneumatic maintaining system, and means for connecting the contact-operating means successively to the actuating and maintaining systems, train-pipes connected to said actuating and maintaining systems and a master-valve for connecting said train-pipes to a source of compressed-fluid supply, the arrangement being such that the actuating systems may be rendered inoperative from the master-valve without affecting the maintaining systems.

49. In combination, a plurality of pistons, contacts operated thereby, supply-pipes between successive pistons, valves adjacent the pistons for closing the supply-pipes to succeeding pistons, and means for opening the valves upon the operation of the respective pistons.

50. In combination, a contact, a piston for operating it, two supply-pipes operatively related to said piston, a pneumatically-actuated valve constructed and arranged to close one pipe when the other is opened, and means whereby compressed fluid is applied to said valve to move it to one position, and means for moving it to the other position.

51. In combination, a piston or diaphragm, two supply-pipes operatively related thereto, a valve constructed and arranged to close either supply-pipe when the other is open, means for operating the valve to close one of the supply-pipes after the piston has been operated to open the other pipe, whereby the piston is maintained in position by pressure supplied by the latter pipe.

In witness whereof I have hereunto set my hand this 27th day of September, 1904.

CHARLES E. LORD.

Witnesses:
SANFORD KLINE,
FRED J. KINSEY.