Jan. 2, 1923.

K. A. SIMMON ET AL.

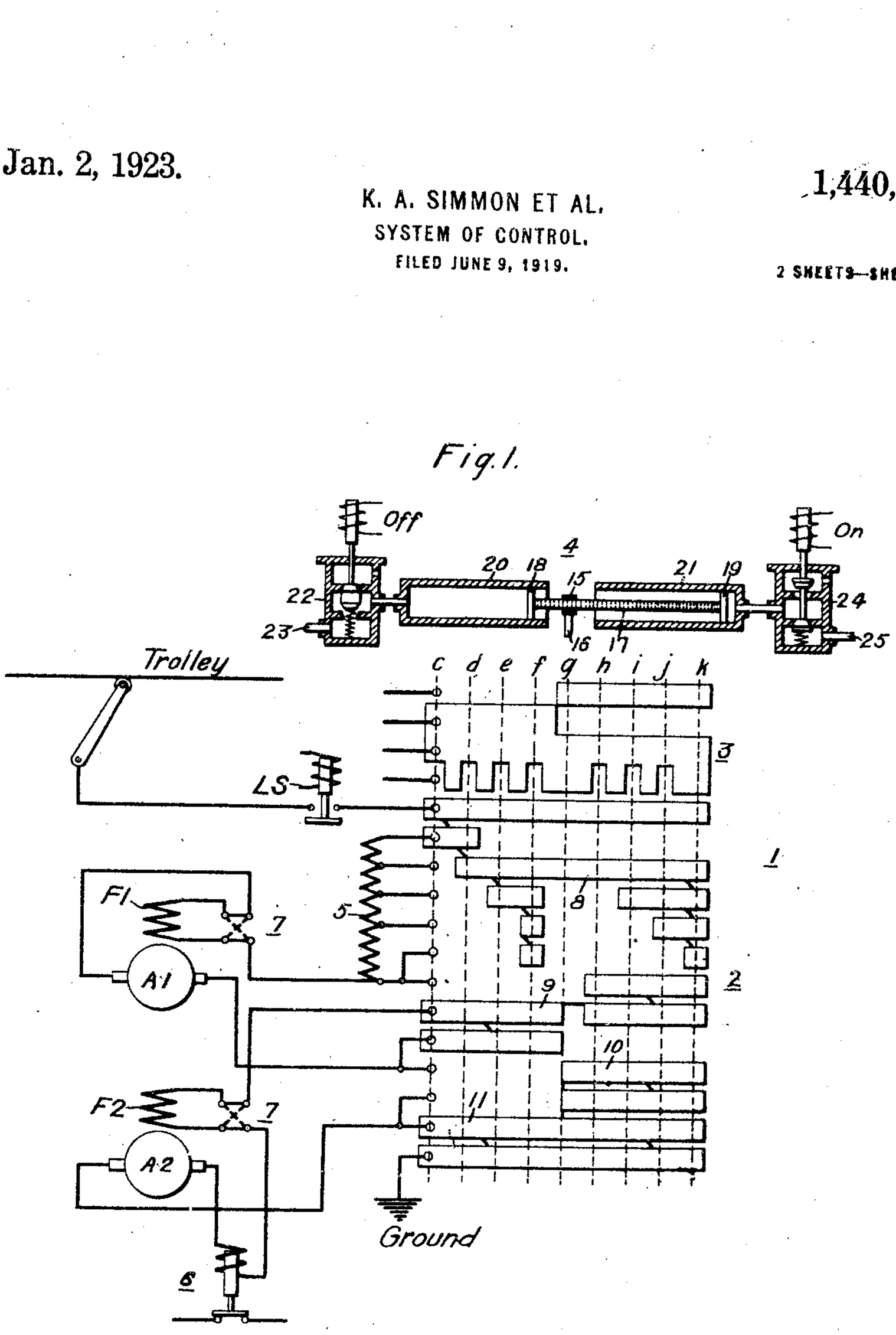
SYSTEM OF CONTROL.

FILED JUNE 9, 1919.

1,440,500.

2 SHEETS—SHEET 1.

Fig. 1.



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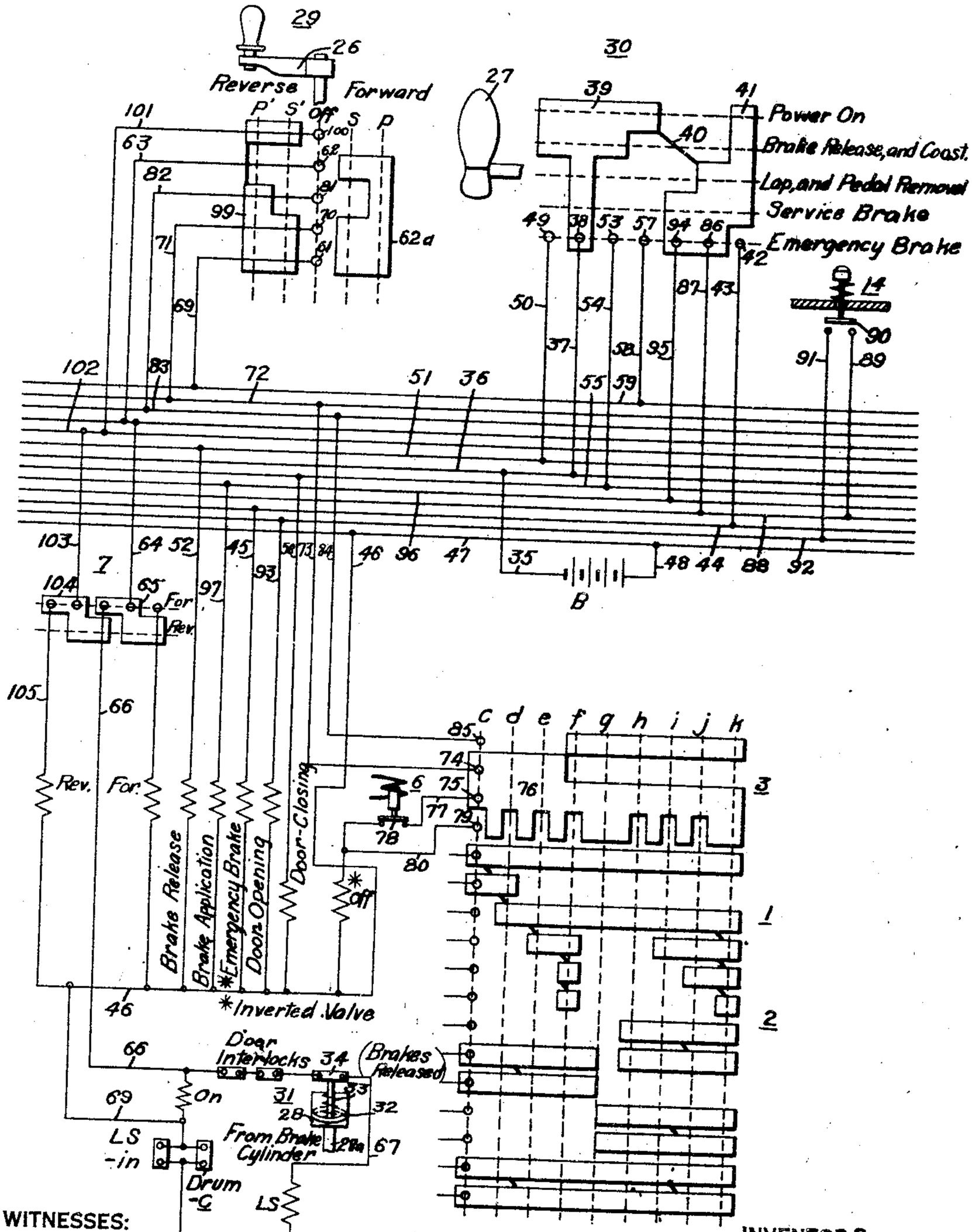
2 SHEETS—SHEET 2.

Fig. 2.



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UNITED STATES PATENT OFFICE.

KARL A. SIMMON, OF EDGEWOOD PARK, AND HARRY R. MEYER, OF WILKINSBURG, PENNSYLVANIA, ASSIGNORS TO WESTINGHOUSE ELECTRIC & MANUFACTURING COMPANY, A CORPORATION OF PENNSYLVANIA.

SYSTEM OF CONTROL.

Application filed June 9, 1919. Serial No. 302,813.

To all whom it may concern:

Be it known that we, KARL A. SIMMON, a citizen of the United States, and a resident of Edgewood Park, in the county of Allegheny and State of Pennsylvania, and HARRY R. MEYER, 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 Systems of Control, of which the following is a specification.

Our invention relates to systems of control for dynamo-electric machines, and it has special relation to the use of foot-operated controllers for electric railway-motor systems.

One object of our invention is to provide a system of the above-indicated character wherein a multi-position foot-operated controller is employed for electrically governing the operating circuits of an electric motor and also brake-controlling means therefor.

Another object of our invention is to provide, in conjunction with a foot-operated controller for the purpose just set forth, a hand-operated multi-position controller for effecting predetermined initial re-arrangement of the machine circuits.

A further object of our invention is to provide a foot-operated controller for not only governing the machine and the braking circuits but provided with positions for also controlling door-operating circuits for the vehicle.

Still another object of our invention is to provide means operating in conjunction with a foot-operated controller of the type under consideration for preventing the closure of the motor circuits until the "brake release" operation has been effected, thereby preventing a jerky start of the vehicle and also eliminating the waste of power that necessarily occurs when the vehicle is started before the brakes have been fully released.

A further object of our invention is to provide a system that may be governed by a foot-operated member to readily effect dynamic braking of the vehicle motor or motors under emergency conditions.

Other minor objects of our invention will become evident from the following detailed description, taken in conjunction with the accompanying drawings, wherein

Figure 1 is a diagrammatic view of the main circuits of a system of control that is governed in accordance with our present invention; and

Fig. 2 is a diagrammatic view of an auxiliary control system organized and arranged in accordance with the principles of the present invention.

Referring to Fig. 1 of the drawings, the system here shown comprises suitable supply-circuit conductors such as Trolley and Ground; a plurality of electric motors respectively having commutator-type armatures A1 and A2 and field windings F1 and F2 of the familiar series type; a controller 1 having a main-circuit portion 2 and an auxiliary-circuit section 3, the controller being actuated by means of an electrically-controlled, fluid-pressure-operated mechanism 4; an accelerating resistor 5, the active-circuit value of which may be varied by the controller 1; a line switch LS for connecting the motors to the Trolley; a limit switch or current relay 6 of a familiar type for effecting automatic operation of the motors in a manner to be set forth; and a reversing switch 7 for reversing the electrical relations of the corresponding armatures and field windings. The reversing switch 7 is here shown diagrammatically for the sake of simplicity, but it will be understood that the preferred reversing switch takes the form of the familiar electro-pneumatically operated drum controller with suitable contact fingers.

The main-circuit portion 2 of the drum controller 1 comprises a contact segment 8 for engaging a plurality of control fingers that are suitably connected to various points of the accelerating resistor 5, and other contact segments 9, 10 and 11 that are employed for effecting series-parallel arrangement of the motor circuits.

The actuating mechanism 4 is of a familiar electrically-controlled, pneumatically-operated type comprising a pinion 15 which is mounted upon the operating shaft 16 of the controller 1 to mesh with a transversely movable rack member 17, the opposite ends of which constitute pistons 18 and 19 that travel within suitable operating cylinders 20 and 21. An inverted valve 22, that is normally open to admit fluid pressure from a supply pipe 23 to the operating cylinder

20, is provided with an actuating coil Off, whereby the valve may be closed. A standard valve 24 normally cuts off communication between a supply pipe 25 and the operating cylinder 21, which is normally placed in communication with the atmosphere. An actuating coil On for the valve 24 serves to effect the opening movement thereof. Any suitable source of fluid pressure (not shown), such as the usual air reservoir that is carried upon electric railway vehicles, may be utilized to supply fluid pressure to the inlet pipes 23 and 25.

The operation of the actuating mechanism 4 may be briefly set forth as follows. By reason of the normally open position of the inverted valve 22, the pistons 18 and 19 are biased to the illustrated position, corresponding to the initial position *c* of the controller 1. Upon concurrent energization of the actuating coils Off and On, fluid pressure is exhausted from the cylinder 20 to the atmosphere through the valve 22 and is admitted through the other valve 24 to the operating cylinder 21. In this way, the normal unbalanced relation of fluid pressures in the actuating mechanism is reversed to cause a movement of the pistons 18 and 19 and, therefore, of the controller 1 toward the left through the successive positions or notches *d* to *k*, inclusive.

To arrest such movement at any time, it is merely necessary to de-energize the off coil, whereupon balanced high-fluid-pressure conditions obtain in the mechanism and a positive and reliable stoppage thereof is secured.

To produce a return movement of the apparatus, the actuating coils Off and On are concurrently deenergized, whereby fluid-pressure conditions in the mechanism revert to the original unbalanced state, and the desired backward movement is effected.

Inasmuch as the particular main-circuit connections employed are not material to our present invention, it is not deemed necessary to trace, in detail, the series-parallel circuits that are formed by movement of the controller 1 through its successive positions. It will be sufficient to state that position *f* corresponds to full series relation of the motors and position *k* to full parallel relation thereof, transition of the motors being effected between position *f* and position *h* by means of the familiar "shunting" type of transition.

Referring to Fig. 2, the auxiliary system here shown comprises, in addition to the auxiliary-circuit portion 3 of the controller 1 and the actuating coils for the fluid-pressure mechanism 4 and the line switch LS, a plurality of other actuating coils that are designated by descriptive legends such as "Brake release" and "Door-opening", together with a hand-operated selective switch 29, a foot-operated controller 30, a pneumatic relay 31, a door-opening push-button 14 and a battery B, or other suitable source of energy, for the various illustrated actuating coils.

The selective switch 29 is provided with a handle 26 of a familiar type and is placed in a position corresponding to that of the customarily employed master controller. The selective switch may thus be readily reached by the motorman in either a standing or a sitting position, for the purpose of effecting either forward or reverse operation of the motors in either series or parallel relation. The illustrated right-hand side of the controller corresponds to forward operation and positions *s* and *p* correspond to series and parallel relation of the motors, respectively. The reverse side of the selective switch is provided with corresponding positions *s'* and *p'*.

The foot-operated controller 30 is located upon the platform floor of the vehicle and is provided with a pedal or foot-lever 27 for actuating the controller from the illustrated "emergency brake" position through the other positions designated as "Service brake", "Lap and pedal removal", "Brake release, and coast" and "Power on". The preferred construction of the foot-operated controller, including means for biasing it to the illustrated "emergency brake" position, is fully set forth in our copending application, Serial No. 283,474, filed March 19, 1919.

It will be understood that any well-known type of braking system may be employed in the present instance to be governed by the foot-operated controller 30 jointly with the control of the motor circuits, but we prefer to employ the familiar air-brake system, electrically controlling it through the agency of three valves, the actuating coils for which are respectively marked "Brake release" and "Brake application", such valves being of the standard type, such as 24 shown in Fig. 1, and "emergency brake", the associated valve being of the inverted type, as noted in Fig. 2, such as the valve 22 illustrated in Fig. 1. Thus, the emergency brake valve is normally open, that is to say, an emergency braking application is made whenever the foot-operated controller 30 occupies its biased illustrated position. On the other hand, the brake-release and the brake application valves are actuated to perform the corresponding operation only when the foot-operated controller 30 occupies certain other positions, as subsequently described in detail.

The door-opening and the door-closing apparatus is also preferably of a familiar electro-pneumatic type, embodying standard valves, as 24, which are alternatively actuated to effect the desired operation of the vehicle doors. In the present case, the

doors are opened through the agency of the push-button 14 and are closed in the "brake-release" position of the foot-operated controller 30.

The pneumatic relay 31 is employed for the purpose of ensuring that the vehicle brakes are released before the motor circuits can be closed. The relay is shown as comprising an operating cylinder 28, which is placed in communication with the brake cylinder of the vehicle by means of a pipe 28ª, together with a flexible diaphragm 32 that is biased to the illustrated lower position by means of a helical spring 33 within the cylinder 28. The spring 33 acts in opposition to fluid pressure that is admitted to the lower end of the cylinder 28 whenever fluid pressure is present in the brake cylinder or, in other words, whenever an application of the brakes, either service or emergency, is being made.

Whenever the brakes are released, as evidenced by the exhaust of fluid pressure from the brake cylinder, a contact segment or electrical interlock 34 occupies the illustrated closed-circuit position to permit energization of the actuating coil for the line switch LS, as hereinafter more fully set forth. In this way, complete release of the vehicle brakes is ensured before the vehicle may be operated, the advantages of which arrangement have already been set forth.

Assuming that it is desired to effect acceleration of the motors when the various pieces of apparatus occupy the illustrated normal positions, the selective switch 29 is first actuated to the desired position,—in the first place, to produce the proper direction of operation, and, secondly, to predetermine the final motor speed to be automatically attained, as about to be described. In other words, in congested districts, it may be well to actuate the selective switch to series position *s*, so that the motors will not be automatically connected in the higher-speed parallel relation, whereas, in thinly populated districts, the selective switch 29 may be initially thrown to its parallel position *p*, and automatic acceleration of the motors to full speed may then be effected.

Such actuation of the selective switch 29 to any desired position does not complete any controlling circuits until the foot-operated controller 30 has been actuated. In this way, the motorman may place the selective switch 29 in the desired position at the beginning of a trip and no further attention need be paid thereto until it is desired to change the setting thereof, full control of the vehicle being generally secured by means of the foot-operated controller 30 alone.

Assuming that the foot-operated controller 30 is actuated from its illustrated biased position, designated as "Emergency brake", to the other extreme position "Power on", a circuit is first completed, as the controller passes through its "service brake" position, from the positive terminal of the battery B, through conductor 35, train-line conductor 36, conductor 37, control finger 38, contact segment 39, conductor 40, contact segment 41 and control finger 42 of the foot-operated controller, whence circuit is continued through conductor 43, train-line conductor 44, conductor 45, actuating coil of the Emergency Brake valve, conductor 46, train-line conductor 47 and conductor 48 to the negative battery terminal. In this way, the emergency brake valve, which, as previously stated, is of the inverted or normally open type, is closed to discontinue the emergency-braking operation.

The service brake application is also made under normal conditions, that is to say, whenever the vehicle is stopped and the foot-operated controller occupies its illustrated position, by reason of the energization of control finger 94 from the contact segment 41, whence circuit is continued through conductor 95, train-line conductor 96, conductor 97, actuating coil of the brake-application valve, and thence to the negative battery terminal, as already described. The circuit just traced is interrupted as soon as the foot-controller reaches its position "Lap, and pedal removal" by reason of the disengagement of the control finger 94 from the contact segment 41. Thus, both the emergency and the service-brake-application valves are operated to prevent further brake application as soon as the foot-operated controller 30 reaches its "lap" position, thereby corresponding to the familiar "lap" position of the engineer's valve for straight air-brake systems.

In the "brake release, and coast" position of the controller 30, a new circuit is continued from the contact segment 39 through control finger 49, conductor 50, train-line conductor 51, conductor 52, and the actuating coil for the brake-release valve. In this way, the brake-release operation is performed, thus effecting exhaust of fluid pressure from the brake cylinder to remove the brake-shoe from the vehicle wheels and also to permit actuation of the pneumatic relay 31 to the illustrated closed-circuit position.

Another circuit is completed, in the brake-release position of the foot-operated controller 30, from the contact segment 39 through control finger 53, conductor 54, train-line conductor 55, conductor 56 and the actuating coil of the door-closing valve. Thus, the vehicle doors are closed without requiring any manual manipulation upon the part of the motorman, and such closure

is necessary to permit operation of the vehicle, by reason of the inclusion of the familiar door interlocks in the governing circuit for the line switch, as about to be described.

When the foot-operated controller 30 has reached its final position "Power on", a new circuit is completed from the contact segment 39 through control finger 57, conductor 58, train-line conductor 59, conductor 60, control fingers 61 and 62, which are bridged by contact segment 62^a, in series position *s*, for example, of the selective switch 29, whence circuit is continued through conductors 63 and 64, contact segment 65, of a familiar form, that is placed upon the main-circuit reversing switch 7, conductor 66, the above-mentioned door interlocks, interlock 34 of the pneumatic relay 31 in its closed position, conductor 67, the actuating coil for the line switch LS, conductor 68, contact segment Drum-*c*, (whereby the circuit being traced can be completed only when the controller 1 occupies its initial position *c*), circuit being completed through conductor 69 to the negative conductor 46. The line switch LS is thus closed to complete the initial connection of the motors through the accelerating resistor 5 across the supply circuit, as will be understood without detailed description.

The closure of the line switch causes an interlock LS-in of the usual type to bridge the contact segment Drum-*c*, thus ensuring the continued closure of the line switch when the drum controller 1 leaves its initial position, as about to be set forth.

The actuating coil On for the operating mechanism 4 is also energized under initial operating conditions, that is, as soon as the foot-operated controller 30 reaches its "power on" position, by reason of the permanent connection of the coil between the positively-energized conductor 66 and negative conductor 69.

As soon as the foot-operated controller 30 occupies its "power on" position, a further circuit is completed from the thereby energized contact segment 62^a of the selective switch 29, through control finger 70, conductor 71, train-line conductor 72, conductor 73, control fingers 74 and 75, which are bridged by contact segment 76, comprising the auxiliary-circuit section 3 of the controller 1, whence circuit is continued through conductor 77, contact disk 78 of the limit switch or current relay 6, whenever occupying its lower position, and actuating coil Off of the mechanism 4 to the negative conductor 46.

Since both the on and the off coils for the actuating mechanism 4 are thus concurrently energized whenever the limit switch 6 occupies its low-current position, forward movement of the controller 1 occurs in a step-by-step manner responsive to the movements of the limit switch, as will be understood by those skilled in the art.

To prevent the controller 1 from sticking in a position intermediate the illustrated notches, the contact segment 76 is provided with a plurality of depending tongues that engage a control finger 79 between the successive pairs of notches, whereby energy is led directly through conductor 80 to the actuating coil Off. The contact disk 78 of the limit switch 6 is thus short-circuited between controller notches to insure the continuous movement of the controller from notch to notch under the control of the limit switch.

In case the selective switch 29 occupies its position *s*, as in the assumed case, the main controller 1 stops in its full-series position *f*.

However, if the selective switch 29 has initially been moved to its position *p* or is moved to that position when the motors have attained their full series relation, provided the motorman maintains the foot-operated controller 30 in its "power on" position, further step-by-step movement of the main controller 1 to its final position *k*, corresponding to full-parallel relation of the motors, is automatically effected under the control of the limit switch 6.

If, at any time, an emergency stop of the vehicle is desired to prevent accident, or for any other reason, the motorman merely removes his foot from the pedal 27, and the foot-operated controller 30 returns to its biased illustrated position to effect the emergency braking operation, by reason of the disengagement of the control finger 42 from the contact segment 41.

However, to effect a service-brake application, the motorman operates the pedal 27 to return the controller 30 to its service-brake position, whereby the previously-traced circuit through the brake-application coil is completed to produce the desired service-brake operation. By oscillating the controller 30 between the service-brake and the lap position, the familiar air-braking retardation of the vehicle is secured.

Whenever the foot-operated controller 30 occupies any one of the positions "Lap", "Service-brake" or "Emergency-brake", any one of which may be occupied when the vehicle comes to rest, the vehicle doors may be opened by depressing the push-button 14. Under such conditions, a circuit is completed from the contact segment 41 of the foot-operated controller through control finger 86, conductor 87, train-line conductor 88, conductors 90 and 91, which are bridged by movable contact member 90 of the push-button 14, whence circuit is continued through train-line conductor 92, conductor 93, actuating coil of the door-opening valve, and thence, through the negative conductor

46, to the battery B. Thus, the vehicle doors are opened whenever the push-button 14 is depressed and the foot-operated controller 30 concurrently occupies a suitable position.

To effect reverse operation of the vehicle to make the return trip, for example, the foot-operated controller 30 is locked in its "lap" position in the manner set forth in our above-identified copending application, whereby the brake applications are prevented, and the pedal 27 may then be removed to be placed upon the corresponding controller at the other end of the vehicle.

However, if it is desired to reverse the operation of the car from the operating end, at that time, the selective switch 29 is actuated to its position s', for example, after the vehicle has come to rest. Under such conditions, a circuit is established, as soon as the foot-operated controller has been returned to its "power on" position, from the positively energized control finger 61 through contact segment 99 and control finger 100, whence circuit is continued through conductor 101, train-line conductor 102, conductor 103, contact segment 104 of the main-circuit reversing switch 7, conductor 105, and the actuating coil Rev. of the reversing switch to negative conductor 46. In this way, the reverser which, as previously stated, is preferably of the familiar electrically-controlled pneumatically-actuated type, is thrown to its reverse position before movement of the vehicle may be obtained.

As soon as the reversing switch 7 occupies its reverse position, the circuit of the conductor 103 is transferred through contact segment 104 to conductor 66, whereby the line switch LS may be closed and the operation of the vehicle may be effected, as already set forth.

A further advantage of the system illustrated resides in the fact that, under emergency conditions, such as failure of the air-brake system or opening of the line switch under operating conditions, for any reason, dynamic braking of the motors to effectively retard the vehicle motion may be readily effected.

Such braking action is possible because the main controller 1 may be actuated to its parallel positions independently of the condition of the line switch LS, since both the on and the off coils for the operating mechanism 4 are energized directly through the foot-operated controller 30 and the main controller 1 without any interlocking with the line switch.

Consequently, under the above-noted emergency conditions, the selective switch 29 may be thrown to the position corresponding to reverse operation of the motors, while the foot-operated controller is maintained in, or actuated to its "power on" position. Under such conditions, the main controller 1 is rapidly actuated to its final parallel position k, since the limit switch 6 remains in its lower or circuit-closing position. As soon as the first parallel position h is reached, a local circuit is closed through the two motor armatures and field windings, the latter being reversed by reason of the above-mentioned operation of the selective switch 29 to effect the familiar dynamic-braking action.

It should be noted, however, that the line switch LS may not be closed and, therefore, the supply circuit may not be connected to the motors under the braking conditions noted, since it is necessary to return the main controller 1 to its initial position c before the actuating coil of the line switch LS can be energized, by reason of the inclusion of the interlock Drum-c in the circuit of that coil. In this way, an emergency-braking action is made available without requiring any additional or special circuits therefor, and such action may be safely employed by reason of the fact that it is impossible, under such conditions, to reconnect the motors to the supply circuit.

We do not wish to be restricted to the specific structural details, circuit connections or arrangement of parts herein set forth, as various modifications thereof may be made without departing from the spirit and scope of our invention. We desire, therefore, that only such limitations shall be imposed as are indicated in the appended claims.

We claim as our invention:

1. In a system of control, the combination with a dynamo-electric machine and brake-controlling means therefor, of a multi-position foot-operated controller for electrically governing said machine and said brake-controlling means.

2. In a system of control, the combination with a plurality of governing circuits and brake-controlling means, of a foot-operated controller for electrically governing said circuits and said brake-controlling means in a predetermined step-by-step manner.

3. In a system of control, the combination with a dynamo-electric machine and electrically-governed brake-controlling means therefor, of a foot-operated electrical controller having certain positions respectively corresponding to certain operating conditions of said machine and of said brake-controlling means and having other positions corresponding to modified machine conditions and brake applications.

4. In a system of control, the combination with a dynamo-electric machine and electrically-governed brake-controlling means therefor, of a foot-operated electrical controller having its extreme positions respectively corresponding to certain operating conditions of said machine and of said brake-

controlling means and having intermediate positions corresponding to modified machine conditions and brake applications.

5. In a system of control, the combination with a dynamo-electric machine and brake-controlling means therefor, of a foot-operated controller having a normal position for effecting "emergency" braking operation of said brake-controlling means, an adjacent position for effecting "service" braking operation of said means, and other successive positions for effecting "release" operation of said means and operating connections of said machine.

6. In a system of control, the combination with a dynamo-electric machine and brake-controlling means therefor, of a multi-position foot-operated controller for electrically governing said machine and said brake-controlling means, and hand-operated multi-position means for effecting rearrangement of the machine circuits.

7. In a system of control, the combination with a dynamo-electric machine and brake-controlling means therefor, of a multi-position foot-operated controller for electrically governing said machine and said brake-controlling means, and a hand-operated controller for effecting reversal of the operation of said machine.

8. In a system of control, the combination with a plurality of dynamo-electric machines and brake-controlling means therefor, of a multi-position foot-operated controller for electrically governing said machine and said brake-controlling means, and a hand-operated controller for effecting adjustment of the connections of the machines for series or parallel relation thereof.

9. In a system of control, the combination with a plurality of dynamo-electro machines and brake-controlling means therefor, of a multi-position foot-operated controller for electrically governing said machine and said brake-controlling means, and a hand-operated controller for effecting reversal and series-parallel operation of said machines.

10. In a system of control, the combination with a plurality of dynamo-electric machines and brake-controlling means therefor, of a multi-position controller for electrically governing said machine and said brake-controlling means, and a second controller for effecting adjustment of the connections of the machine for series or parallel relation thereof.

11. In a system of control, the combination with a dynamo-electric machine and brake-controlling means therefor, of a hand-operated controller for adjusting certain of the machine circuits, and a foot-operated controller for electrically governing said machine and said brake-controlling means and for rendering the circuits of said hand-operated controller active.

12. In a system of control, the combination with a dynamo-electric machine and brake-controlling means therefor, of a hand-operated controller for adjusting certain of the machine circuits, a source of energy, and a foot-operated controller interposed between said source and said hand-operated controller for normally preventing the energization thereof.

13. In a system of vehicle control, the combination with a dynamo-electric machine, of a vehicle-door-controlling circuit, and a multi-position foot-operated controller for governing both said machine and said door-controlling circuit.

14. In a system of vehicle control, the combination with a dynamo-electric machine and brake-controlling means therefor, of a vehicle-door-controlling circuit, and a multi-position foot-operated controller for governing said machine, said brake-controlling means and said door-controlling circuit.

15. In a system of control, the combination with a dynamo-electric machine and brake-controlling means therefor, of a door-closing circuit, and a foot-operated controller having a normal position for effecting "emergency" braking operation of said brake-controlling means, an adjacent position for effecting "service" braking operation of said means, and other successive positions for concurrently effecting "release" operation of said means and rendering said door-closing circuit active, and for effecting operating connections of said machine.

16. In a system of control, the combination with a dynamo-electric machine and brake-controlling means therefor, of a multi-position controller for governing said machine and said brake-controlling means, and means for preventing the operation of said machine unless the "brake-release" operation has been effected.

17. In a system of control, the combination with a dynamo-electric machine and brake-controlling means therefor, of a foot-operated controller having certain positions respectively corresponding to certain operating conditions of said machine and of said brake-controlling means and having other positions corresponding to modified machine conditions and brake applications, and means for ensuring that the "brake-release" operation has been effected before rendering the machine-governing circuits active.

18. In a system of control, the combination with a dynamo-electric machine and brake-controlling means therefor, of a foot-operated controller having a normal position for effecting "emergency" braking operation of said brake-controlling means, an adjacent position for effecting "service" braking operation of said means, and other

successive positions for effecting "release" operation of said means and operating connections of said machine, and means responsive to the "brake-release" operation for effecting the initial closure of the machine circuits.

19. In a system of control, the combination with a plurality of dynamo-electric machines, of control means for connecting said machines in series and in parallel relation, and means comprising a foot-operated member for governing said control means to connect said machines in parallel relation to effect dynamic braking under conditions of de-energization of the machines.

20. In a system of control, the combination with a supply circuit and a dynamo-electric machine, of means for connecting said machine to the supply circuit under operating conditions, and means comprising a foot-operated member for effecting dynamic braking of said machine when said connecting means is open.

21. In a system of control, the combination with a dynamo-electric machine, of control means for normally effecting acceleration of said machine, and means comprising a foot-operated member and a hand-operated member for governing said control means and said machine to effect dynamic braking thereof under predetermined operating conditions.

22. In a system of control, the combination with a plurality of dynamo-electric machines, of a controller for connecting said machines in series and in parallel relation, electrical means for effecting actuation of said controller, means for reversing said machines, and means comprising a foot-operated member for energizing said electrical means to effect connection of the reversed machines in parallel relation and dynamic braking thereof under predetermined operating conditions.

23. In a system of control, the combination with a dynamo-electric machine, of a controller for normally effecting acceleration of said machine, means for effecting actuation of said controller, hand-operated means for reversing said machine, and means comprising a foot-operated member for governing said actuating means to effect dynamic braking of the reversed machine under predetermined operating conditions.

In testimony whereof, we have hereunto subscribed our names this 26th day of May, 1919.

KARL A. SIMMON.
HARRY R. MEYER.