F. H. SHEPARD.

SYSTEM OF CONTROL.

APPLICATION FILED APR. 29, 1915.

1,267,916. Patented May 28, 1918.

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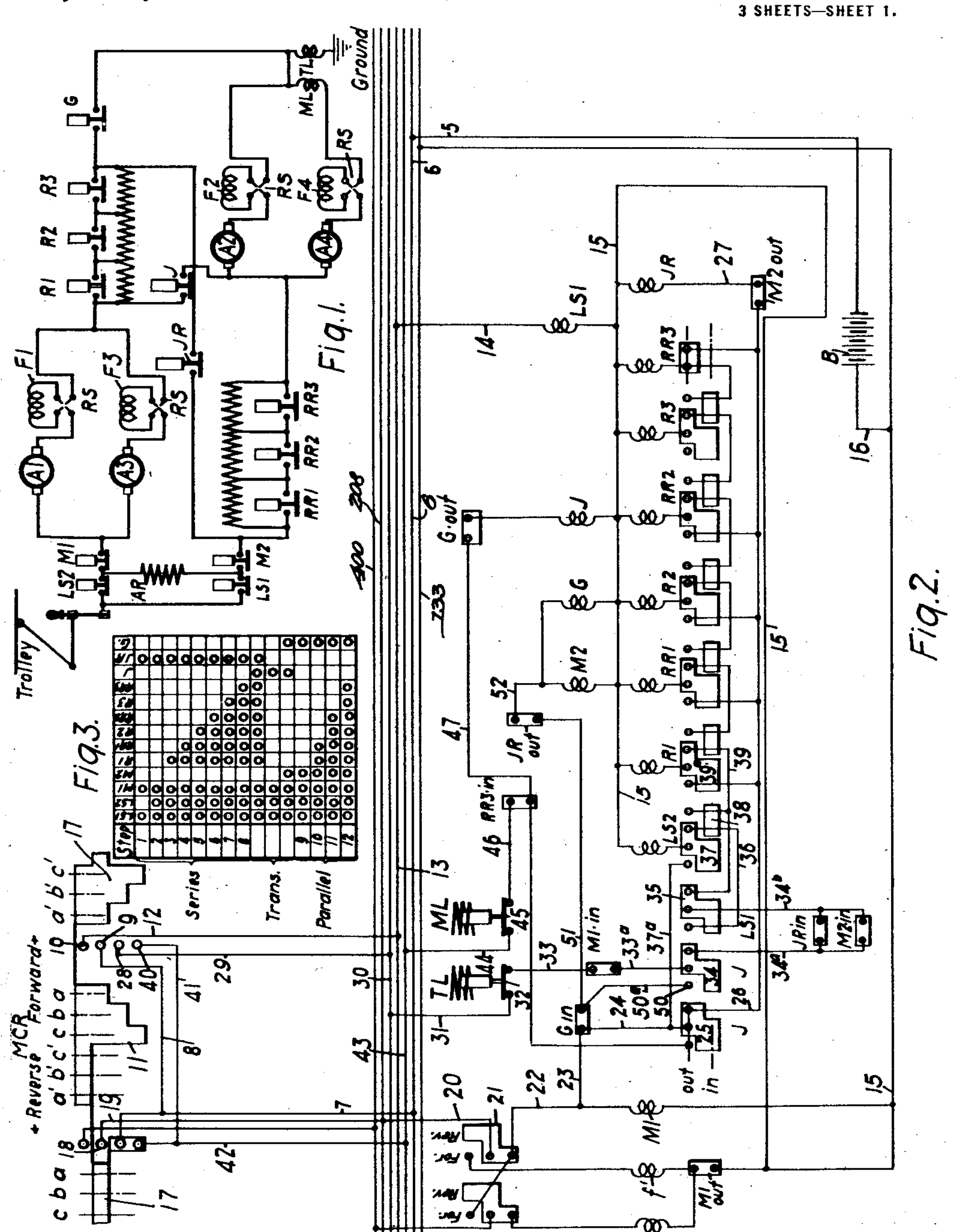

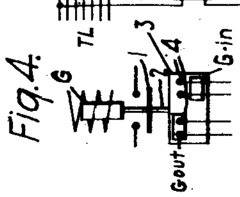

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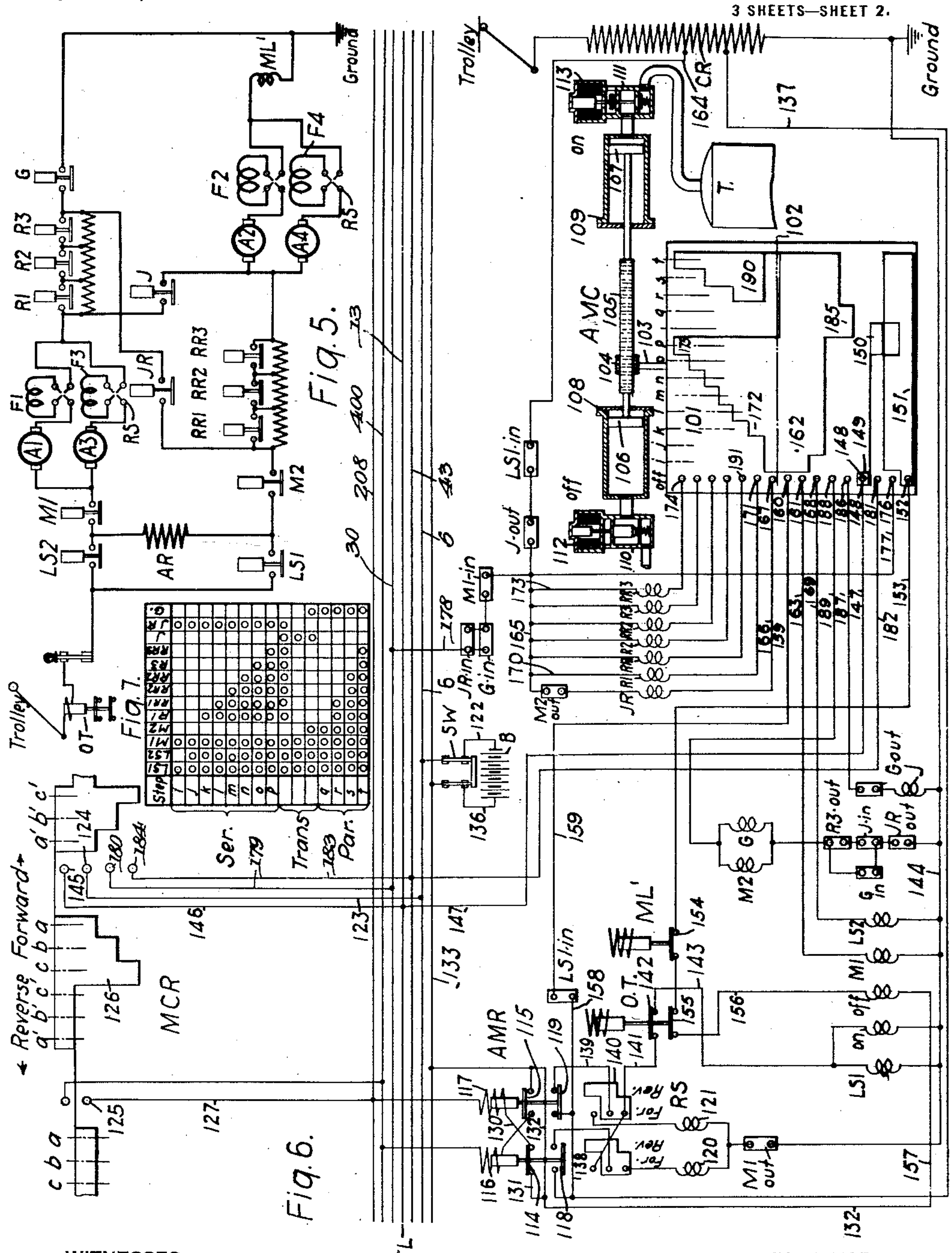

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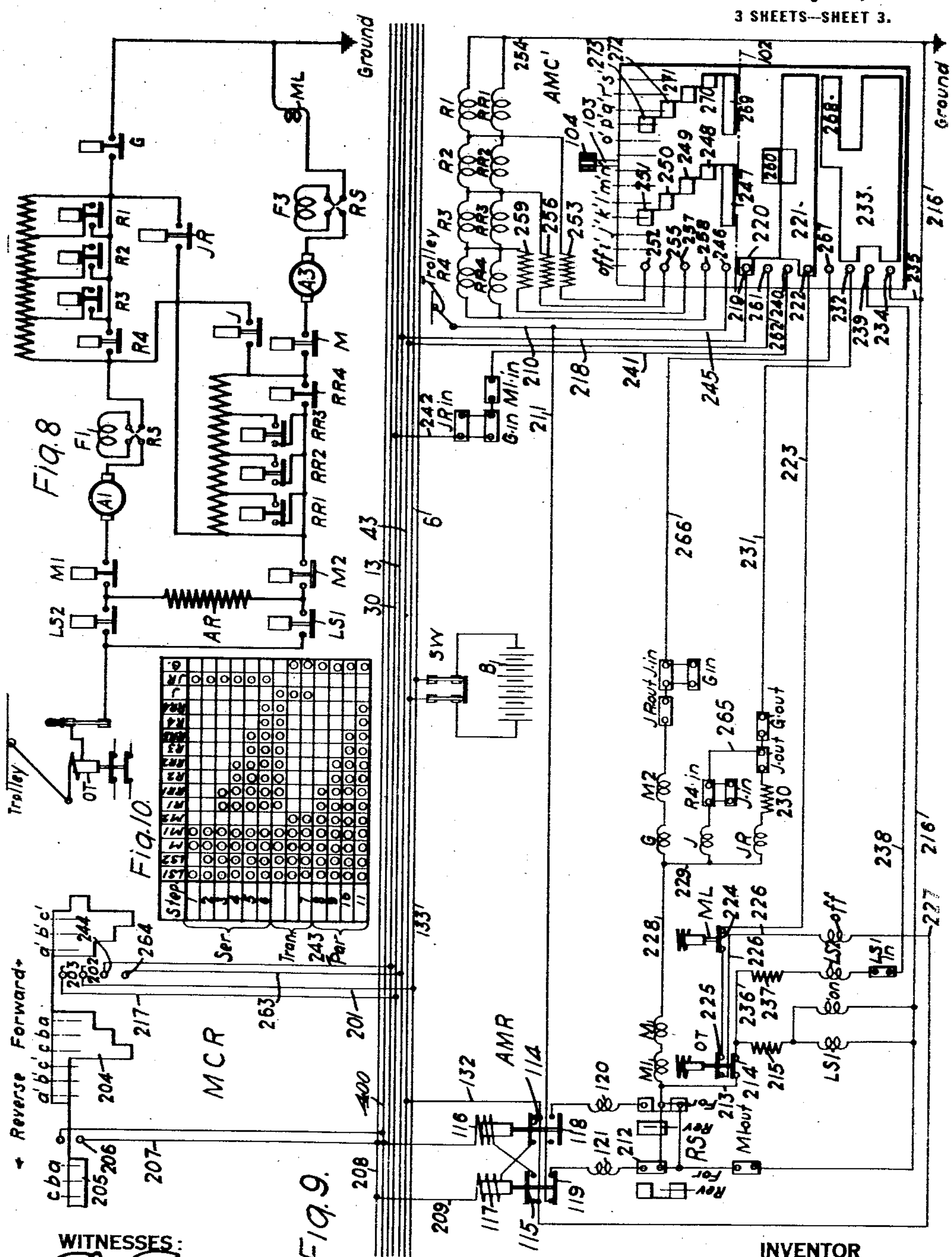

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SYSTEM OF CONTROL.

1,267,916. Specification of Letters Patent. Patented May 28, 1918.

Application filed April 29, 1915. Serial No. 24,716.

To all whom it may concern:

Be it known that I, FRANCIS H. SHEPARD, a citizen of the United States, and a resident of New Rochelle, in the county of Westchester and State of New York, have invented a new and useful Improvement in Systems of Control, of which the following is a specification.

My invention relates to systems of control and it has special reference to the concurrent operation of dissimilar control systems for electric railway motors and the like.

One object of my invention is to provide universally adaptable means whereby one type of control in one or more cars of multiple-unit train may be taken as standard, that is, no changes or additions being made in the system, and one or more other types of control may readily and inexpensively be adapted to concurrently operate in multiple with the standard system.

Another object of my invention is to provide a relatively simple and inexpensive control system of the above-indicated character that shall be adapted to be associated with dissimilar control systems, as in the various cars of a multiple-unit train, and which shall permit of concurrent operation of the system without entailing any considerable changes in the general arrangement of circuits and while maintaining all of the individual good features of each control system.

In the prior art, various means for permitting concurrent operation of dissimilar control systems of the unit switch or contactor type, in particular, have been devised, but they have embodied apparatus, such as master controllers or certain train-line conductors, which have been used only in connection with the operation of one system and have been inoperative or have required substitutes in connection with the operation of the other system, thus forming a relatively expensive and complicated system of concurrent operation which was not fully universally operative.

According to my present invention, therefore, I provide a relatively simple, reliable and identical means that is adapted to be associated with each of unlike supply circuits and associated dissimilar vehicle-control systems in a multiple-unit train and to effect concurrent operation of the control systems with the assumed standard system and with each other while being fully employed in connection with all of the systems, as hereinafter more fully set forth.

In the accompanying drawing, Figure 1 is a diagrammatic view of the main circuits of a complete and well-known system of unit-switch control that is adapted to be installed upon one car of a multiple-unit train, and which, for the purpose of this application may be assumed to be a standard or a preferred system; Fig. 2 is a diagrammatic view of the auxiliary control circuits for governing the operation of the motor-controlling switches shown in Fig. 1 in accordance with the sequence chart, of well-known form, that is illustrated in Fig. 3; Fig. 4 is a detail diagrammatic view of one of the switches that is employed in the system of Fig. 1, showing the relation of the electrical interlocks of Fig. 2 to the switches by which they are respectively operated; Fig. 5 and Fig. 8 are diagrammatic views of the main circuits of other systems of control that may be employed in other cars of the multiple-unit train; Fig. 6 and Fig. 9 are diagrammatic views of the auxiliary control circuits for the type of control systems that are illustrated in Fig. 5 and Fig. 8, respectively; and Fig. 7 and Fig. 10 are sequence charts for indicating the operation of the switch-actuating coils that are respectively shown in Fig. 5 and Fig. 8.

A general discussion of the invention will first be given and then a detailed description of the various control systems will be made. The common control means hereinbefore mentioned and that is adapted to be associated with each of two or more unlike supply circuits and associated dissimilar vehicle-control systems to effect concurrent operation thereof with the assumed standard system and with each other, may conveniently comprise identical primary master controllers that are suitably located on each car, a set of train-line conductors which extend through the train and are all employed in each car, and a relatively small number of switch or controller-actuating coils which are energized from one of the supply circuits. These master controllers and train-line conductors are adapted to govern the operation of automatically-actuated auxiliary master controllers having a plurality of contact segments that are arranged to operate the actuating coils of the various motor-controlling switches of the associated control system from the other supply circuit, in accordance with the customary sequence of the particular system employed. The auxiliary master controllers also partially control the circuits of the above-mentioned common means by other segments disposed upon them. By merely changing the development of the first-mentioned contact segments of the auxiliary master controllers, any type of control system may be readily incorporated with the primary master controllers and train-line conductors to effect automatic concurrent operation of all of the systems from any one of the primary master controllers, the auxiliary master controller of each system, however, being governed by the motor current in that particular system. Thus, no necessity arises for synchronous operation of the auxiliary master controllers and the interconnecting train-line conductors are thereby maintained relatively small in number.

I provide also, as a part of the common means above referred to, auxiliary coils which are operated, through any master reverser, from one supply circuit and are suitably interlocked through a switch that corresponds to the other auxiliary coil to effect the operation of the reversing coils of the main-circuit reversing switch from the other supply circuit.

In these ways, I provide auxiliary control means which readily permits of universal concurrent operation of any number of different types of control systems.

Referring to Fig. 1 of the drawings, the main circuits here shown comprise a supply circuit including conductors respectively marked "Trolley" and "Ground;" a plurality of pairs of parallel-connected electric motors respectively having armatures A1 and A3, and A2 and A4, and corresponding field magnet windings F1 and F3, and F2 and F4; a common reversing switch RS, preferably of a familiar electrically-controlled drum type, for reversing the electrical relations of the corresponding armatures and field windings; an accelerating main-circuit resistor the sections of which are respectively adapted to be short-circuited by switches R1, R2 and R3, a second main-circuit resistor, the sections of which are respectively adapted to be short-circuited by switches RR1, RR2 and RR3; an auxiliary main-circuit resistor AR; a plurality of motor-controlling switches LS1, LS2, M1, M2, JR, J and G; and a plurality of limit switches TL and ML of familiar form the actuating coils of which are respectively adapted to be energized by the entire motor current and by the current traversing the armature A4.

For simplicity and convenience in illustration, the electrical interlocks that are associated with, and actuated by, the various switches are not completely illustrated in connection with the switches of Fig. 1, but the well-known general arrangement of switch and interlock members is shown in Fig. 4, and it is believed that such illustration will be sufficient for the purposes of the present specification. In Fig. 4, the switch G is shown as provided with an auxiliary-circuit movable contact member 1 to which is suitably secured an insulating member or rod 2, and a terminal block or board 3 is suitably attached to the lower end of the member 2, being provided with a plurality of control fingers 4 and interlock members G-in and G-out that are respectively adapted to bridge certain pairs of the control fingers 4 when the switch occupies the corresponding position.

Referring now to Fig. 2, the auxiliary control system illustrated comprises, in addition to the actuating coils and the various interlocking contact members for the switches that are shown in Fig. 1, a suitable source of energy, such as a battery B, for energizing the actuating coils; a combined primary master controller and master reverser MCR that is adapted to assume a plurality of operative positions *a*, *b* and *c*, when actuated in a forward direction, and a plurality of operative positions *a'*, *b'* and *c'*, when moved in the reverse direction; a plurality of train-line conductors TL; and the auxiliary contact members of the limit switches TL and ML.

Assuming the master controller MCR to be moved to its initial forward operating position *a*, the operation of the system illustrated may be set forth as follows: a circuit is first established from one terminal of the battery B, through conductor 5, train-line conductor 6, conductors 7 and 8, control fingers 9 and 10 that are bridged by contact segment 11 of the master controller MCR, conductor 12, train-line conductor 13, conductor 14, the actuating coil of the switch LS1, and conductors 15 and 16 to the negative terminal of the battery B.

Another circuit is established from a contact segment 17 of the master controller that is connected to the contact segment 11, through control finger 18, conductors 19 and 20, interlock 21 that is associated with the main reversing-switch RS, conductors 22, 23 and 24, interlock 25 of the switch J, in its open position, conductor 26, interlock M2—out, conductor 27, and the actuating coil of the switch JR to the conductor 15. The actuating coil of the switch M1 is also energized from the conductor 22, circuit being completed through the negative conductor 15 to the battery B. The pairs of parallel-connected motors are thus disposed in initial series relation, with all of the accelerating resistors included in circuit.

When the master controller MCR is moved to its second operative position *b*, a circuit is first established from contact segment 11 through control finger 28, conductor 29, train line conductor 30, conductor 31, coöperating stationary and movable contact members 32 of the limit switch TL, provided the motor current has decreased to a value sufficient to allow the limit switch to assume its lower position, conductor 33, interlock M1—in, conductor 33ª, interlock 34 of the switch J in its open position, conductor 34ª, interlock JR—in, conductor 34ᵇ, interlock 35 of the switch LS1 in its closed position, conductor 36, interlock 37 of the switch LS2 in its open position and the actuating coil of the switch LS2 to the negative conductor 15. After the switch LS2 is closed, a holding-circuit therefor is established from conductor 24 through conductor 27ª and the interlock 37 of the switch in its closed position.

The closure of the switch LS2 effects energization of an interlock 38 thereof from the conductor 36, whereupon the actuating coil of the switch R1 is energized from the interlock 38, through conductor 39 and interlock 39ª of the switch R1 in its open position. The switches RR1 to RR3, inclusive, are progressively closed and held closed, in a manner similar to that just set forth, in accordance with the position of the limit switch TL, as will be familiar to those skilled in the art. When the switch RR3 is closed, the pairs of parallel-connected motors are disposed in full-series relation, with all of the accelerating resistors excluded from circuit.

To effect the transition of the motors from series to parallel relation, the master controller MCR is first moved to its final operative position *c*, whereupon the contact segment 11 engages control finger 40, whence circuit is completed through conductors 41 and 42, train line conductor 43, conductor 44, coöperating stationary and movable contact members 45 of the limit switch ML, conductor 46, interlock RR3—in, conductor 47, interlock G—out and the actuating coil of the switch J to the negative conductor 15. The circuits of the actuating coils of the resistor short-circuiting switches R1 to RR3, inclusive, and of the switch JR are thereupon interrupted at the interlock 25, and these switches are opened.

Upon the closure of the switch J, the interlock 34 thereof engages a control finger 50, whence circuit is established through conductors 50ª and 51, interlock JR—out, conductor 52 and the actuating coils of the switches M2 and G to the negative conductor 15. The closure of the switch G effects the opening of the switch J by reason of the exclusion from the control circuit of the actuating coil of the switch J of the interlock G—out. The parallel-connected pairs of motors are disposed in initial parallel relation at this time, with the various accelerating resistors included in the circuits of the respective pairs of motors.

As soon as the switch M2 is closed, a circuit is established from conductor 34ª through interlock M2—in, conductor 34ᵇ, interlock 35 of the switch LS1, conductor 36, interlock 38 of the switch LS2, conductor 39, and thence, in automatic progression, through the actuating coils of the various resistor short-circuiting switches R1 to RR3, inclusive, in a manner similar to that already set forth. When the switch RR3 has been closed, the parallel-connected pairs of motors are disposed in full parallel relation, corresponding to the final running condition of the motors.

The system just described is old and well-known in the art and may be considered as a standard system of control with which it is desired to concurrently operate in a multiple-unit train, for example, a number of other dissimilar control systems, such as those illustrated in the following figures.

Referring now to Fig. 5, it will be observed that the only difference from the system of Fig. 1 resides in the addition of a familiar type of overload trip OT and in the employment of a limit switch ML′ that receives the combined currents of the motors having the armatures A2 and A4, this limit switch ML′ being used in place of the limit switches ML and TL of Fig. 1.

The auxiliary control system illustrated in Fig. 6 comprises, in addition to the actuating coils and interlocks that are associated with the various switches illustrated in Fig. 5, the combined master reverser and primary master controller MCR; the train-line conductors TL; the battery B for supplying energy to a portion of the actuating coils; a control resistor CR that is connected across the supply circuit and is adapted to transmit a relatively low voltage to another portion of the actuating coils; an auxiliary master reverser AMR having coils that are adapted to be energized from the battery circuit to close certain control circuits from the control resistor CR; the coöperating stationary and movable contact members of the limit switch ML′ and of the over-load trip OT; and an auxiliary master controller AMC that is adapted to occupy a plurality of positions *i* to *t*, inclusive, in accordance with the operation of the master controller MCR for energizing certain of the actuating coils of the switches in a predetermined sequence, as indicated in the chart of Fig. 7.

The auxiliary controller AMC comprises preferably a drum 101, of usual form, that is provided with a plurality of contact segments, those above the dot-and-dash line 102 corresponding, in general, to the special type of control system which is to be concurrently operated with other types upon the remaining cars, and those below the line 102 being similar on each car that employs an auxiliary master controller and corresponding to the master controller MC and the train line conductors TL, which are embodied in the common means hereinbefore referred to for adapting the various systems for concurrent operation. The drum 101 is provided with an operating shaft 103 to one end of which is secured a pinion 104 which meshes with a rack 105, to the opposite ends of which pistons 106 and 107 are secured and are respectively adapted to operate within suitable cylinders 108 and 109, to which fluid pressure from a tank or reservoir T may be respectively admitted by valves 110 and 111 having actuating coils 112 and 113, respectively.

The actuating coil 112 for the valve 110 will hereinafter be referred to as the "off" magnet and is normally in an open position, as shown in the drawing, to admit fluid pressure to the cylinder 108 and maintain the drum 101 in its "off" position. The actuating coil 113 for the valve 111, which will hereinafter be termed the "on" magnet, is normally adapted to assume a closed position, as shown in the drawing, to connect the corresponding end of the cylinder 109 to the atmosphere.

The operation of the auxiliary master controller AMC, without reference to the electrical connections it makes, may be briefly described as follows: if both the "off" and the "on" magnets are energized, fluid pressure is exhausted from the cylinder 108 through the valve 110 and is admitted to the cylinder 109 through the valve 111, thereby effecting a movement of the auxiliary master controller to one of its operative positions, the movement being arrested by the deënergization of the "off" magnet through the limit switch L, as hereinafter described, and thereby imparting a step-by-step motion to the controller as the motor current successively decreases to a predetermined value after each successive increase thereof by reason of the exclusion of resistance from the main circuit, as will be understood. To return the auxiliary master controller to its "off" position, it is merely necessary to deenergize both the "off" and the "on" magnets when fluid pressure will be exhausted from the cylinder 109 and admitted to the cylinder 108 to return the drum to its "off" position, as shown in the drawing.

The auxiliary master reverser AMR comprises a pair of switches corresponding to reverse and forward operation and respectively having coöperating stationary and movable auxiliary contact members 114 and 115, and adapted to be respectively operated by actuating coils 116 and 117 to respectively close switches 118 and 119, in the circuits of the "reverse" and the "forward" coils 120 and 121, respectively, of the main reversing switch RS.

Assuming that the auxiliary master reverser AMR occupies the position shown in the drawing, and that the reversing switch RS occupies its "reverse" position, the operation thereof may be set forth as follows: if the master controller MCR is momentarily moved to its first operative position, a circuit is established from one terminal of the battery B through conductor 122, one blade of a switch SW, train-line conductor 6, conductor 123, control fingers 124 and 125, which are connected by a contact segment 126 of the master controller, conductors 127 and the actuating coil 117 of the auxiliary master reverser, conductor 130, contact member 114 of the other switch 118 of the auxiliary master reverser, conductors 131 and 132, train-line conductor 133, a second blade of the switch SW, and conductor 136 to the negative battery terminal. The switch 119 is thus closed to energize the "forward" coil 121 of the reversing switch RS.

It may advantageously be pointed out at this time that the common means hereinbefore referred to as adapted to be associated with the various types of control systems, except the assumed standard system, to effect concurrent operation thereof, comprises essentially the master controller MCR, the auxiliary master reverser AMR, the train-line conductors TL, the "off" and "on" magnets of the auxiliary master controller AMC and the contact segments thereof that are disposed below the dot-and-dash line 102 in the drawing. The remainder of the system shown comprises a complete and well-known type of control system which will be more fully described hereinafter in connection with the operation of the master controller MCR and its allied apparatus. It will be appreciated that, where the auxiliary resistor AR is employed as an additional step of accelerating resistance, it is of advantage in providing a smoother and more effective initial acceleration of the propelling motors.

Assuming the control resistor CR to be connected to the supply circuit as shown and assuming the master controller MCR to be moved to its initial operative position *a*, the operation of the system illustrated may be set forth as follows.

A circuit is first established from an intermediate point of the control resistor CR, through conductors 137 and 138, auxiliary contact members 119 of the auxiliary master reverser AMR, conductor 139, contact member 140 of the main reversing switch RS, conductor 141, coöperating stationary and movable contact members 142 of the overload trip OT, conductor 143, the parallel-connected actuating coils of the switch LS1 and of the "on" magnet valve, and conductor 144 to the negative conductor "ground."

Another circuit is simultaneously established from the battery-energized contact segment 126 of the master controller through control finger 145, conductors 146 and 147, control finger 148, contact segments 149, 150 and 151 and control finger 152 of the auxiliary master controller AMC, conductor 153, coöperating stationary and movable contact members 154 of the limit switch ML′, in its lower position, auxiliary contact members 155 of the overload trip OT, conductor 156, the "off" magnet coil, and conductors 157 and 132 to the negative terminal of the battery B.

Upon the closure of the LS1 switch, a circuit is established from conductor 138 through conductor 158, interlock LS1—in, conductor 159, control fingers 160 and 161, which are bridged by contact segment 162 of the auxiliary master controller AMC, conductor 163 and the actuating coil of the switch M1 to the ground conductor 144.

Both the "on" and "off" valve magnets being energized, the auxiliary master controller AMC will be moved forward step-by-step, in accordance with the position of the limit switch ML′, in the manner already set forth.

Another control circuit is then established from a second intermediate point of the control resistor CR, through conductor 164, interlocks LS1—in and J—out, conductor 165, interlock M2—out, the actuating coil of the switch JR, conductor 166, control finger 167, and contact segment 162, providing the auxiliary master controller occupies its initial operative position *i*.

When the auxiliary master controller has been actuated to its second position *j*, a circuit is established from contact segment 162 through control finger 168, conductor 169 and the actuating coil of the switch LS2 to the ground conductor 144, thereby effecting the short-circuit of the accelerating resistor AR.

As soon as the auxiliary master controller occupies its position *k*, a circuit is completed from conductor 165 through conductor 170, the actuating coil of the switch R1, control finger 171 and contact segment 172 of the auxiliary master controller, and thence to the ground conductor 144, in the manner already described.

The step-by-step movement of the auxiliary master controller from the position *k* to the position *p*, inclusive, progressively effects the energization of the actuating coils of the switches R1 to RR3, inclusive, from the conductor 165, the actuating coil of the last switch RR3 being energized through conductor 173 that is connected to conductor 165, control finger 174 and contact segment 175 of the auxiliary master controller.

It should be noted that, if the master controller MCR is not moved beyond its initial operative position *a*, the movement of the auxiliary master controller AMC will be arrested as soon as the controller AMC occupies its initial operative position *i* by reason of the disengagement of the control finger 148 and the contact segment 149. However, if the master controller MCR has been moved to its second position *b*, the energizing circuit for the "off" magnet coil is transferred through the contact segment 151 of the auxiliary master controller, control finger 176, conductor 177, interlocks M1—in and JR—in, conductor 178, train line conductor 30, conductor 179, control finger 180 and the contact segment 126 of the master controller MCR.

The engagement of the contact segment 151 and the control finger 176 of the auxiliary master controller is broken when the controller reaches its position *p*, which corresponds to full-series relation of the parallel-connected pairs of motors, and the auxiliary master controller will remain in the position *p* unless the master controller MCR is moved to its final operative position *c*, whereupon the energizing circuit of the "off" magnet coil is transferred through contact segment 150 and control finger 181 of the master controller, conductors 182 and 183, control finger 184 and contact segment 126 of the master controller MCR. The energizing circuit referred to is re-transferred to the control finger 176 and the associated circuit when the auxiliary master controller AMC is actuated to its position *g* which corresponds to initial parallel relation of the pairs of motors.

Assuming that the master controller MCR occupies its position *c*, the transition of the pairs of motors from series to parallel relation is effected by reason of the engagement of the contact segment 185 of the auxiliary master controller with control finger 186, whence circuit is completed through conductor 187, interlock G—out, the actuating coil of the switch J and the ground conductor 144.

The closure of the switch J effects the opening of the switch JR and of the resistor short-circuiting switches R1 to RR3, inclusive, by reason of the exclusion from their common control circuit of the interlock J—out.

Another circuit is then established from the contact segment 185 through control finger 188, conductor 189, the parallel-connected actuating coils of the switches M2 and G, and interlocks R3—out, J—in and JR—out to the ground conductor 144.

The closure of the switch G effects the opening of the switch J by reason of the exclusion from the control circuit of the switch J of the interlock G—out.

The maintenance of the energization of the actuating coils M2 and G is effected by reason of an interlock G—in bridging the two interlocks R3—out and J—in as soon as the switch J is closed.

When the auxiliary master controller AMC has moved to its position *r*, a contact segment 190 engages control fingers 171 and 191, whereby the actuating coils of the switches R1 and RR1 are energized; and the remaining resistor short-circuiting switches are then automatically and progressively closed in pairs, according to the position of the limit switch ML′, in a manner similar to that already set forth.

When the auxiliary master controller AMC occupies its final operative position *t*, all the accelerating resistors are short-circuited and the parallel-connected pairs of motors are disposed in their final running positions; namely, full parallel relation.

Reference may now be had to Fig. 8, wherein the main circuits of the system shown comprise the supply-circuit conductors, "trolley" and "ground," a plurality of motors having armatures A1 and A3 and field windings F1 and F3, respectively, the accelerating resistor AR as in the systems already described, a second accelerating resistor, the four sections of which are respectively adapted to be short-circuited by switches R1 to R4, inclusive; a third accelerating resistor, the four sections of which are respectively adapted to be short-circuited by switches RR1 to RR4, inclusive; a plurality of motor-controlling switches LS1, LS2, M1, M2, JR, J, M and G; the limit switch ML that is adapted to be energized in accordance with the current traversing the armature A3; and the overload trip OT.

Referring now to Fig. 9, the system illustrated comprises, in addition to the actuating coils for the various motor-controlling switches shown in Fig. 8 and suitable coöperating resistors for certain of said coils, as hereinafter described, another combined master controller and master reverser MCR and an auxiliary master reverser AMR, which are the exact counterparts of those employed in the system of Fig. 6; the battery B that is adapted to energize certain of the switch-actuating coils; an auxiliary master controller AMC′, and the inter-connecting train-line conductors TL.

The auxiliary master controller AMC′ comprises the same operating mechanism as that shown in connection with the controller AMC of Fig. 6; a plurality of contact members located below the line 102 that are substantially identical or equivalent to the contact members disposed below that line in Fig. 6; and a plurality of other contact members located above the line 102 and that are associated with the actuating coils of the resistor short-circuiting switches, in a manner to be described. The controllers AMC and AMC′ are thus dissimilar in that their contact members are in part different and are, of course, designed with special reference to the corresponding system.

Assuming that the master reverser AMR occupies its "forward" position and that the master controller MCR has been moved directly to its final running position *c*, the automatic operation of the system may be described as follows: a circuit is first established from one terminal of the battery B, through train-line conductor 6, conductor 201, control fingers 202 and 203, which are bridged by a contact segment 204 of the master controller MCR, contact segment 205, control finger 206, conductor 207, train-line conductor 208, conductor 209, actuating coil 117 and coöperating contact members 114 of the auxiliary master reverser AMR, and conductors 132 and 133 to the negative side of the battery B. Another circuit is then established from the trolley (Fig. 9) through conductors 210 and 211, switch 119 of the auxiliary reverser AMR, the forward coil 121 thereof, contact member 212 of the main reversing switch RS, conductor 213, auxiliary contact members 214 of the overload trip OT, control resistor 215, the actuating coil of the switch LS1 and the "on" valve magnet, and conductor 216 to the negative conductor.

The "off" valve magnet is energized through control finger 203 of the master controller MCR, conductor 217, train-line conductor 13, conductor 218, control finger 219, contact segment 220 and 221 and control finger 222 of the auxiliary master controller AMC, conductor 223, coöperating stationary and movable contact members 224 of the limit switch L, providing the latter occupies its low-current position, auxiliary contact members 225 of the overload trip OT, conductor 226, the "off" coil, conductor 227 and conductor 132 to the negative battery terminal. The controller AMC′ is thus given a forward step-by-step movement, as hereinbefore explained, in accordance with the position of the limit switch ML. When the controller AMC′ occupies its operative position *i*, another circuit is established from the conductor 213, through the actuating coils of the switch M1 and M, conductors 228 and 229, the actuating coil of the switch JR, a resistor 230, interlocks

J—out and G—out, conductor 231, control finger 232, contact segment 233 and control finger 234 of the auxiliary master controller AMC′, and conductor 235 to the negative conductor, thereby effecting the initial connection of the motors to their supply circuit.

A circuit is next established, when the controller AMC′ has reached its second operative position *j*, from contact members 214 of the overload trip OT, through conductor 236, control resistor 237, the actuating coil of the switch LS2, interlock LS1—in, conductor 238, control finger 239 that engages contact segment 233 of the controller AMC′, and thence to ground, thereby effecting the exclusion of the resistor AR from circuit. Movement of the controller AMC′ from its off position effects the disengagement of control finger 219 and contact segment 220, which would deënergize the "off" valve magnet to arrest the controller movement if the master controller MCR were not actuated beyond position *a*. In the assumed case, however, with the master controller MCR occupying its position *c*, the circuit of the "off" magnet is not interrupted, inasmuch as, before the disengagement of control finger 219 and contact segment 220, a new circuit is established from contact segment 221 of the auxiliary master controller AMC′, through control finger 240, conductor 241, interlocks M1—in and JR—in, conductor 242, train-line conductor 30, conductor 243, and control finger 244 which engages the energized contact segment 204 of the master controller MCR.

A circuit is next established directly from the trolley through conductors 210 and 245, control finger 246 of the auxiliary master controller AMC′, contact segment 247 thereof, provided the auxiliary master controller has been moved in the step-by-step manner hereinbefore described to its position *k′*, contact segments 248, 249, 250 and 251, control finger 252, a resistor 253, the parallel-connected actuating coils of the switches R1 and RR1, and conductor 254 to ground. The switches R1 and RR1 are thus substantially simultaneously closed to short-circuit a predetermined portion of the main accelerating resistors.

As soon as the limit switch ML has dropped to its lower position again to reënergize the "off" magnet, the auxiliary master controller AMC′ is actuated to its position *l′*, wherein the contact segment 250 engages a control finger 255, from which point a circuit is completed through a resistor 256, the parallel-connected actuating coils of the switches R2 and RR2 and of the switches R1 and RR1, and conductor 254 to ground. Similarly, as soon as the auxiliary master controller occupies its operating positions *m′* and *n′*, respectively, the contact segments 249 and 248 engage control fingers 257 and 258, from which points circuits are respectively established through resistor 259, the parallel-connected actuating coils of the switches R3 and RR3 and of the previously closed resistor-short-circuiting switches to ground, and, through the parallel-connected actuating coils of switches R4 and RR4 and the sets of actuating coils of the previously closed resistor-short-circuiting switches, again to ground.

When the controller AMC′ occupies its position *n′*, the deënergization of the "off" valve magnet by reason of the disengagement of control finger 240 and contact segment 221, arrests the movement of the controller, unless the master controller MCR occupies its final position *c*, when the circuit is transferred through contact segment 221 to segment 260, control finger 261, conductor 262, train-line conductor 43, conductor 263, and control finger 264 which engages the energized contact segment 204 of the master controller MCR.

It will be noted that the system herein illustrated is adapted to maintain a predetermined resistance in the circuits of the actuating coils of the various switches, this resistance being provided by either a suitable resistor, as 253, which is connected in circuit with the actuating coils of the switches R1 and RR1, or resistors such as 256 and 259 of gradually decreasing resistance, the total circuit resistance remaining approximately the same, or by disposing all four sets of the parallel-connected actuating coils of the various resistor-short-circuiting switches in series relation, as is the case when the auxiliary master controller AMC occupies its position *n′*. The system outlined is familiar to those skilled in the art, and no further description of the method for maintaining a substantially constant resistance in the circuits of the actuating coils, as they are successively energized, is deemed necessary.

When the limit switch ML has again assumed its low-current position, after the closure of the switches R4 and RR4, which completes the straight series connection of the propelling motors, the auxiliary master controller AMC′ is moved to its transition position intermediate its operative positions *n′* and *o′*, whereupon a circuit is first established from conductor 229, through the actuating coil of the switch J, interlock R4—in, conductor 265, interlock G—out and to the negative conductor ground through contact segments on the auxiliary master controller, as already described. The switch JR is opened as soon as the switch J is closed, by reason of the exclusion from its control circuit of the interlock J—out.

The various resistor short-circuiting switches R1 to RR4, inclusive, are also opened upon the disengagement of contact segments 247 and 248 of the auxiliary master controller from the control fingers 246 and 258, respectively. The switch J remains closed by reason of an interlock J—in bridging the interlock R4—in in the control circuit of the actuating coil of the switch. Another circuit is then established from conductor 229, through the actuating coils of the switches G and M2, interlocks JR—out and J—in, conductor 266, control finger 267, contact segment 268 of the auxiliary master controller, and thence, through contact member 233, to the negative conductor. As soon as the switch G is closed, the energizing circuit of its actuating coil is transferred through interlock G—in, which is connected in parallel relation with the above-mentioned interlock J—in, thereby maintaining the closure of the switches M2 and G when the switch J is opened by reason of the exclusion from its control circuit of the interlock G—out.

It will be observed that, at this time, the motors are connected in parallel-circuit relation, with the resistors corresponding to switch R1 to R4, inclusive, connected in circuit with the motor having the armature A1 and the resistors corresponding to the switches RR1 to RR4, inclusive, connected in circuit with the motor having the armature A2, this condition corresponding to the position *o'* of the auxiliary master controller AMC'.

As soon as the auxiliary master controller is moved to its position *p'*, the control finger 246 engages a contact segment 269, from which point a circuit is completed through contact segments 270, 271, 272 and 273, the control finger 252 and the parallel-connected actuating coils of the switches R1 and RR1 to ground, as hereinbefore described. The further operation of the auxiliary master controller occurs in accordance with the action of the limit switch ML, and in the positions *q'*, *r'* and *s'* of the auxiliary master controller, the contact segments 272, 271 and 270 successively engage the control fingers 255, 257 and 258, respectively, thereby effecting the energization of the actuating coils of the remainder of the resistor-short-circuiting switches, in a manner hereinbefore pointed out, the motors being then disposed in full parallel relation.

It will be observed that the control means that are common to the system illustrated in Fig. 6 and Fig. 9 are respectively adapted to be energized by a battery, although unlike supply circuits may readily be employed, and the major or distinctive portions of the systems illustrated in these figures are respectively adapted to be energized from a portion of a control resistor CR, and directly from the trolley circuit. The universal adaptability of my control means for effecting concurrent operation of any types of dissimilar control systems is thus amply demonstrated and it is not deemed necessary to show or describe any further types of auxiliary control systems to be used in connection with the common control means that are illustrated in Fig. 6 and Fig. 9.

It will be understood, without further description, that the operation of the auxiliary master reverser AMR in connection with the master controller MCR is identical with that given when describing the system shown in Fig. 6.

It will thus be seen that, by the use of identical master controllers on a plurality of cars of a multiple unit train, which controllers may be respectively energized from one of two unlike supply circuits that are associated with each car, and by the use of a fully operative set of train-line conductors, together with auxiliary master controllers that are automatically actuated in accordance with the current in the particular motors to be controlled and that severally comprise one substantially identical set of contact segments for use in connection with any master controller MCR and a variable set of suitable contact segments that are energized from the other of the said unlike supply circuits for each different system, a control system for permitting universal concurrent operation of dissimilar control systems is thus obtained.

From the above description it is noted that operating any one of the three master controllers MCR disclosed in connection with the three control systems would operate all the systems in a similar manner. Considering the description that has been given as to the operation of each individual control system the above statement may be verified by noting the train-line conductors that are energized when the different master controllers are moved through their various operative positions. With the respective train-line conductors 208, 400, 30, 13, 43, 6 and 133 in Figs. 4, 6 and 9 connected together, the master controllers when moved through positions *a*, *b* and *c* energize similar train-line conductors. In position *a* of the controllers train-line conductors 13 and 208 are connected to the battery train-line conductor 6; in position *b* of the controllers train-line conductors 13, 30 and 208 are connected to the battery train-line conductor 6, and in position *c* of the master controllers the train-line conductors 13, 30, 43 and 208 are connected to the battery train-line conductor 6.

It will be obvious to those skilled in the art that various types of control systems other than those shown may be concurrently operated by the use of my invention and that other modifications in the specific circuit connections or arrangement of parts herein set forth may be made within the spirit and scope of my invention. I desire, therefore, that only such limitations shall be imposed as are indicated in the appended claims.

I claim as my invention:

1. The combination with a motor-control system having a plurality of motor-controlling switching devices adapted to operate in a predetermined sequence, of a plurality of dissimilar motor-control systems embodying switching devices for partially manipulating the circuits of the corresponding motors and each embodying pneumatically operated switching means for effecting the concurrent operation of said dissimilar systems with said first system.

2. The combination with a motor-control system having a plurality of motor-controlling switching devices adapted to operate in a predetermined sequence, of a plurality of dissimilar motor-control systems severally embodying switching devices for partially manipulating the circuits of the corresponding motors and embodying switching means to effect the concurrent operation of said dissimilar systems with said first system and with each other.

3. The combination with a motor-control system having a plurality of motor-controlling switches adapted to operate in a predetermined sequence, of a plurality of dissimilar motor-control systems, a plurality of master controllers for the several systems, and a plurality of train-line conductors, of auxiliary control means adapted to be embodied in each of said dissimilar systems to permit of concurrent operation thereof with said first system from any one of said master controllers and all of said conductors.

4. The combination with a motor-control system having a plurality of motor-controlling switches adapted to operate in a predetermined sequence, of a plurality of dissimilar motor control systems, a plurality of dissimilar controllers therefor, electrically-controlled means for operating said controllers in accordance with the corresponding motor current, and a plurality of identical master controllers severally associated with, and a set of train-line conductors interconnecting, said systems, said motor-controlling switches and said dissimilar controllers being adapted to be governed from any of said master controllers.

5. The combination with a plurality of unlike supply circuits and dissimilar control systems respectively operated therefrom, one of said systems having a plurality of motor-controlling switches adapted to operate in a predetermined sequence, of a plurality of dissimilar step-by-step controllers for the other systems, electrically-controlled means for operating said controllers in accordance with the corresponding motor currents, and a plurality of identical master controllers severally associated with, and a set of train-line conductors interconnecting, said systems and adapted to be energized from one of said supply circuits, said motor-controlling switches and said electrically-controlled means being adapted to be governed by any of said master controllers to effect concurrent operation of the systems.

6. The combination with a plurality of unlike supply circuits and dissimilar control systems respectively operated therefrom, one of said systems having a plurality of motor-controlling switches adapted to operate in a predetermined sequence, of a plurality of dissimilar auxiliary master controllers for the other systems, a plurality of electrically-controlled, pneumatically-operated valves for governing the operation of said controllers in accordance with the corresponding motor current, a plurality of identical primary master controllers for the systems, and a set of train-line conductors operatively interconnecting the systems, said motor-controlling switches and said valves being adapted to be governed by any of said primary master controllers to effect concurrent operation of the system.

7. The combination with a plurality of dissimilar control systems, the first of said systems having a plurality of motor-controlling switches adapted to operate in a predetermined sequence, of a plurality of dissimilar controllers respectively provided with contact segments for suitably governing the operation of the other systems, and means for effecting concurrent operation of said other systems with said first system, said means comprising a master controller, a set of trainline conductors, and a plurality of sets of electrically-controlled means severally embodied in said other systems, severally energized through said master controller and through contact segments on the corresponding first-named controller and severally governed by the corresponding motor current.

8. The combination with a plurality of unlike supply circuits, and a plurality of dissimilar vehicle-control systems respectively operated therefrom, the first of said systems having a plurality of motor-controlling switches adapted to operate in a predetermined sequence, of a plurality of dissimilar step-by-step controllers respectively provided with contact segments for suitably governing the operation of the other systems from the corresponding supply circuit, and means for effecting concurrent operation of said other systems with said first systems, said means comprising a plurality of identical master controllers respectively located in proximity to said systems, a set of train-line conductors operatively associated therewith, and a plurality of sets of elec-

trically-controlled, pneumatically-operated valves for coöperatively actuating said step-by-step controllers, and severally adapted to be energized from one of said supply circuits through any one of said master controllers and through said corresponding step-by-step controller as the corresponding motor current successively assumes a predetermined value during motor acceleration.

9. The combination with a plurality of dissimilar control systems, of means adapted to be connected to each of the systems to form completely operative new systems which are capable of concurrent operation.

10. The combination with a plurality of dissimilar control systems, a master controller, and a plurality of inter-system conductors, of auxiliary means adapted to be embodied in each of the systems to permit concurrent operation thereof from said master controller and all of said conductors.

11. The combination with a plurality of dissimilar control systems, a plurality of identical master controllers therefor, and a plurality of train-line conductors, of auxiliary control means adapted to be embodied in each of the systems to permit concurrent operation thereof from any one of said master controllers and all of said conductors.

12. The combination with a plurality of dissimilar control systems, of a plurality of pneumatically-operated controlling switches therefor adapted to be operated in accordance with the corresponding motor current, and a plurality of identical master controllers severally associated with, and a set of train-line conductors interconnecting, said systems, said controlling switches being adapted to be governed from any of said master controllers.

13. The combination with a plurality of dissimilar control systems, of a plurality of dissimilar controllers therefor, electrically-controlled means for operating said controllers in accordance with the corresponding motor current, and a plurality of identical master controllers severally associated with and a set of train-line conductors interconnecting said systems, said dissimilar controllers being adapted to be governed from any of said master controllers.

14. The combination with a plurality of unlike supply circuits and control systems respectively operated from said unlike supply circuits, of a plurality of dissimilar step-by-step controllers for said systems, electrically controlled means for operating said controllers in accordance with the corresponding motor current, and a plurality of identical master controllers severally associated with, and a set of train-line conductors interconnecting, said systems and adapted to be energized from one of said supply circuits, said electrically-controlled means being adapted to be governed by any of said master controllers to effect concurrent operation of the systems.

15. The combination with a plurality of unlike supply circuits and dissimilar vehicle-control systems respectively operated from said unlike supply circuits, of a plurality of dissimilar auxiliary master controllers for said systems, electrically-controlled, pneumatically-operated valves for governing the operation of said controllers in accordance with the corresponding motor current, a plurality of identical primary master controllers for said systems, and a set of train-line conductors operatively interconnecting the systems, said valves being adapted to be governed by any of said primary master controllers to effect concurrent operation of the systems.

16. The combination with a plurality of dissimilar control systems, of a plurality of controllers therefor severally provided with contact segments for suitably governing the operation of the associated system, and means associated with each system and embodying coöperating contact members on said controllers for effecting concurrent operation of said systems.

17. The combination with a plurality of dissimilar control systems, of a plurality of controllers therefor severally provided with contact segments for suitably governing the operation of the associated system, and means for effecting concurrent operation of said systems, said means comprising a master control switch, a plurality of inter-system conductors, and controller-actuating means partially governed by the movement of said controllers.

18. The combination with a plurality of dissimilar control systems, of a plurality of controllers therefor severally provided with contact segments for suitably governing the operation of the associated system, and means for effecting concurrent operation of said systems, said means comprising a master controller, a set of train-line conductors and a plurality of sets of electrically-controlled means severally energized through said master controller and through contact segments on the corresponding first-named controller and severally governed by the corresponding motor current.

19. The combination with a plurality of dissimilar control systems, of a plurality of controllers therefor severally provided with contact segments for suitably governing the operation of the associated system, and means for effecting concurrent operation of said systems, said means comprising a plurality of identical master controllers, a set of train-line conductors associated therewith, and a plurality of sets of electrically controlled, pneumatically-operated valves for actuating said first controllers, and severally adapted to be energized through any

one of said master controllers and through said corresponding first-named controller when the corresponding motor current assumes a predetermined value to cause a step-by-step actuation of each of said first controllers.

20. The combination with a plurality of unlike supply circuits, and a plurality of dissimilar vehicle-control systems respectively operated from said unlike supply circuits, of a plurality of dissimilar step-by-step controllers severally provided with contact segments for suitably governing the operation of the associated system from the corresponding supply circuit, and means for effecting the concurrent operation of said systems, said means comprising a plurality of identical master controllers respectively located in proximity to said systems, a set of train-line conductors operatively associated therewith, and a plurality of sets of electrically-controlled, pneumatically-operated valves for coöperatively actuating said step-by-step controllers, and severally adapted to be energized from one of said supply circuits through any one of said master controllers and through said corresponding step-by-step controller as the corresponding motor current successively assumes a predetermined value during motor acceleration.

21. In a control system, the combination with a plurality of unlike supply circuits, and an electric motor adapted to be energized from one of said circuits and having an armature and a field-magnet winding, of means for reversing the electrical relations of the armature and field winding, plural electromagnetic means for actuating said reversing means, and means energized from one of said circuits for connecting one of said electromagnetic means to the other circuit under predetermined conditions.

22. In a control system, the combination with a plurality of unlike supply circuits, and an electric motor adapted to be energized from one of said circuits and having an armature and a field-magnet winding, of means for reversing the electrical relations of the armature and field winding, a plurality of actuating coils adapted to effect the operation of said reversing means in the one or the other direction, a master reversing switch, and means energized from one of said circuits through said master switch for connecting one of said actuating coils to the other circuit in accordance with the position of said switch.

23. In a control system, the combination with a plurality of unlike supply circuits, and an electric motor adapted to be energized from one of said circuits and having an armature and a field magnet winding, of a main circuit reverser for reversing the electrical relations of the armature and field winding, a plurality of actuating coils adapted to effect the operation of said reverser in the one or the other direction, a master reverser, and a plurality of switches respectively adapted to connect one of said supply circuits to said actuating coils and to open when the motor is inoperative, said switches having their actuating coils respectively dependent, for energization from the other supply circuit, upon the positions of said master reverser and of the other switch.

24. In a control system, the combination with a plurality of unlike supply circuits, a plurality of dissimilar vehicle-control systems respectively operated from said unlike supply circuits and severally embodying an electric motor having an armature and a field-magnet winding, of a plurality of main circuit reversers for reversing the electrical relations of the corresponding armatures and field windings, a "forward" and a "reverse" actuating coil for effecting the operation of each reverser in the one or the other direction, a master reverser and a master controller disposed in proximity to each control system, and a plurality of sets of switches and auxiliary actuating coils therefor respectively adapted to be energized from one of said supply circuits through any master controller in an operative position, the associated master reverser in its corresponding position, and the associated other switch in its inoperative position, for effecting the energization from the other supply circuit of either said "forward" or said "reverse" coil.

In testimony whereof, I have hereunto subscribed my name this 17th day of April, 1915.

FRANCIS H. SHEPARD.

Witnesses:
Wm. H. Capel,
C. Wesley Pomeroy.