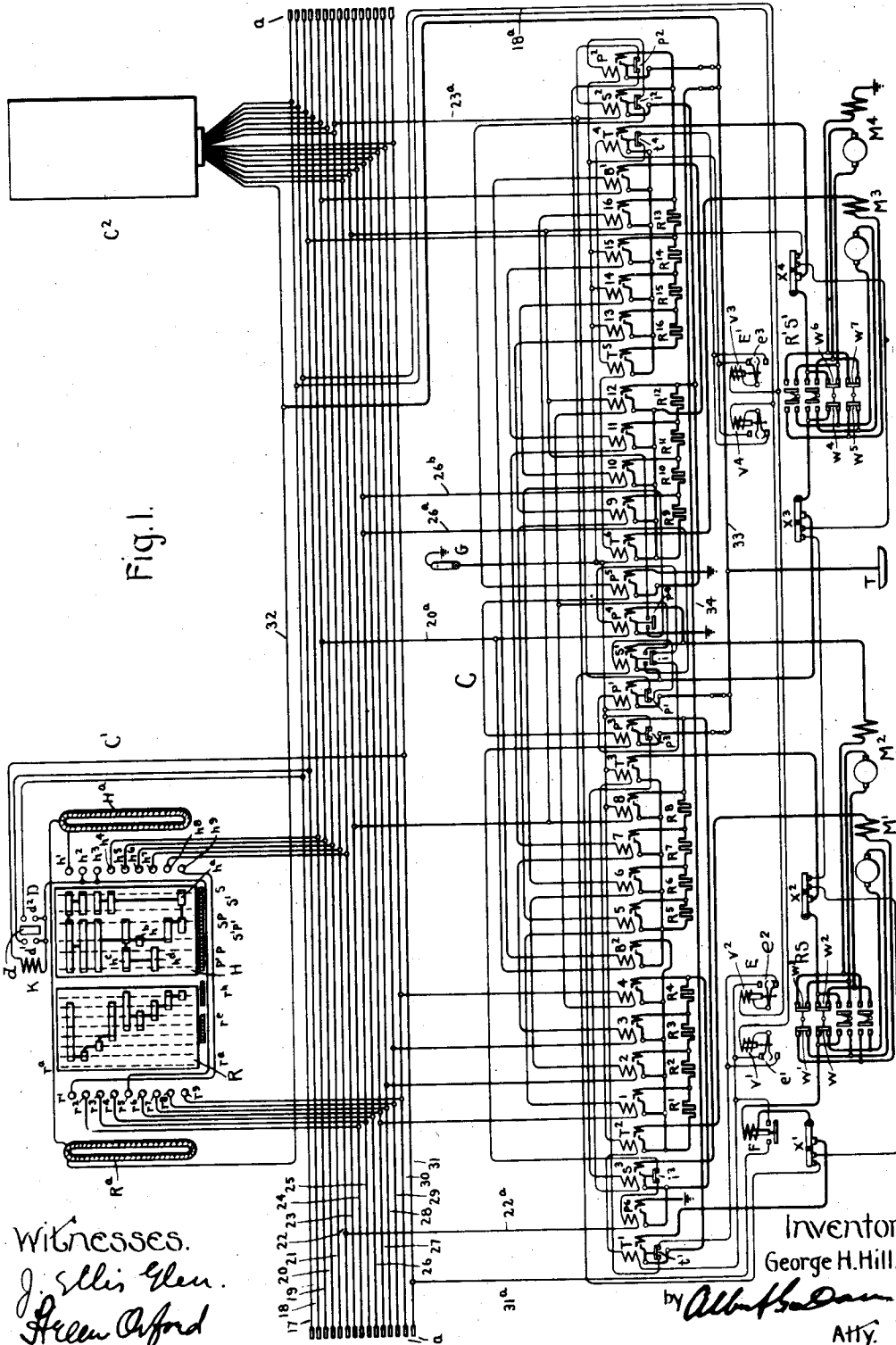


No. 872,938.

PATENTED DEC. 3, 1907.

G. H. HILL.
SYSTEM OF CONTROL.
APPLICATION FILED OCT. 31, 1904.

3 SHEETS—SHEET 1.

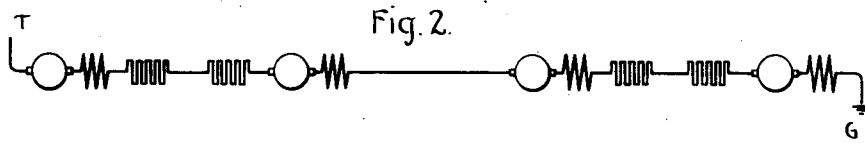
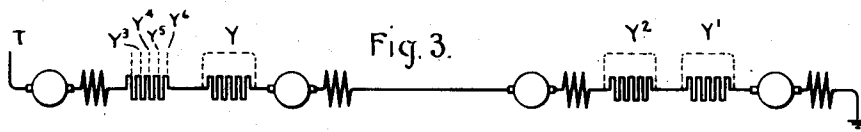
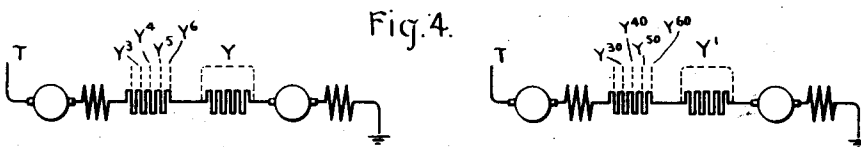
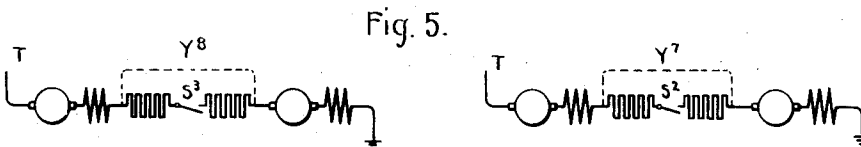
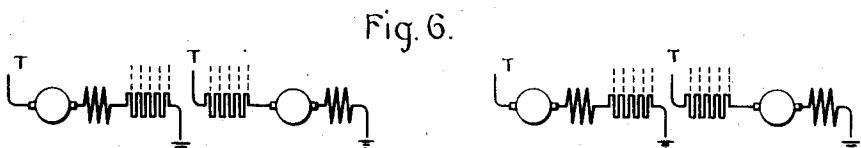


Witnesses.
J. Ellis Glen.
Green Oxford

Inventor.
George H. Hill.
by *Albert H. Hill*
Atty.

G. H. HILL.
SYSTEM OF CONTROL.
APPLICATION FILED OCT. 31, 1904.

3 SHEETS—SHEET 2.



Witnesses.
J. Ellis Glen.
Allen Orford

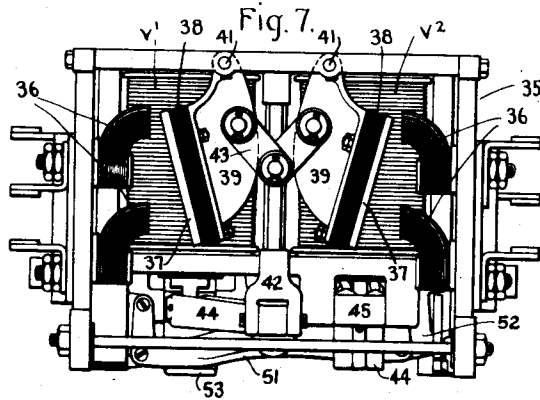
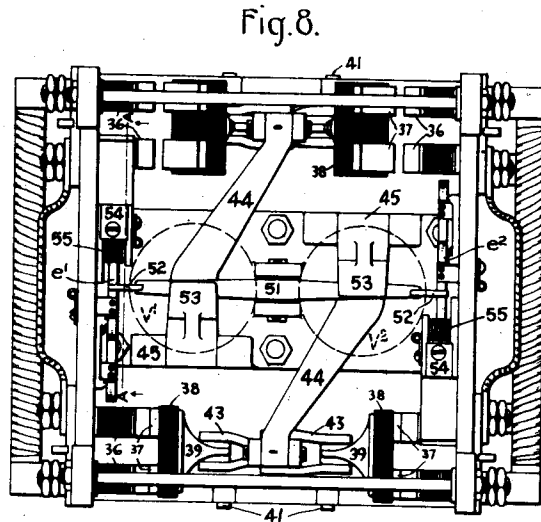
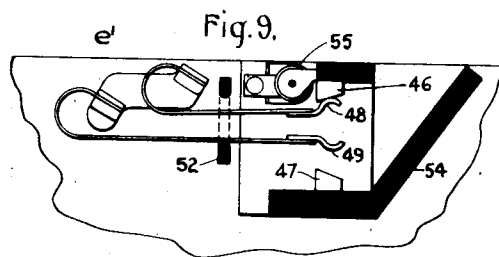
Inventor.
George H. Hill.
by Albert H. Davis
Atty.

No. 872,938.

PATENTED DEC. 3, 1907.

G. H. HILL.
SYSTEM OF CONTROL.
APPLICATION FILED OCT. 31, 1904.

3 SHEETS—SHEET 3.



Witnesses:

Irving E. Stearns.
Helen Oxford

Inventor,

George H. Hill.

By Albert S. Davis
Att'y.

UNITED STATES PATENT OFFICE.

GEORGE H. HILL, OF SCHENECTADY, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

SYSTEM OF CONTROL.

No. 872,938.

Specification of Letters Patent.

Patented Dec. 3, 1907.

Application filed October 31, 1904. Serial No. 230,834.

To all whom it may concern:

Be it known that I, GEORGE H. HILL, a citizen of the United States, residing at Schenectady, county of Schenectady, State of New York, have invented certain new and useful Improvements in Systems of Control, of which the following is a specification.

The present invention relates to systems of motor control and particularly to control systems for units embodying a plurality of motors arranged to be grouped in various relations.

For electric railway traffic and especially for heavy traffic where the locomotive used in hauling heavy passenger or freight trains is replaced by an electric locomotive, it has been found to be advisable to divide the motive apparatus into a number of elements which normally coöperate to propel the motor car or locomotive and which are controlled simultaneously and from a single point. It is desirable that the control of the motors be such that they may start very slowly and with a smooth and uniform acceleration, whereby the train is started without disagreeable shocks and jerks; and therefore there should be a large number of control steps in order that proper currents may be impressed at the extremely low as well as at the high speeds. It is furthermore desirable that the entire number of resistance elements shall be available during each stage in the changes of the relative motor connections while accelerating, in order that no idle resistance need be carried and in order to permit the use of a minimum number of resistance contacts and to otherwise simplify the apparatus.

Among the objects of the present invention are to so arrange the control system for a plurality of motors that a smooth and uniform acceleration is obtained by means of a large number of control steps requiring but a minimum number of resistance contacts, and to so govern the resistances and motor connections that the motor current has at all times the most effective value.

Where a number of motors are employed, provision should be made for cutting out one or more motors in case of injury thereto or defects therein; and this cutting out of defective motors should be accomplished without diminishing the effective motive power by a greater amount than that furnished by the defective motor or motors, and without

necessitating an unsymmetrical arrangement of the connections of the remaining motors during acceleration.

A further feature of the present invention contemplates an arrangement of cut-out switches for the several motors and such an interdependence between the control system and the cut-out switches that only symmetrical groupings of the motors can be made in case one or more motors are cut out.

In systems of this character a reversing switch of some kind is required for giving the proper motor connections for either direction of rotation of the motors. The type of reversing switch which has heretofore been employed, comprises fixed contacts and a cylindrical section carrying the movable contacts. These contacts are adapted to have a sliding engagement with each other and are so arranged that when the contacts for permitting one direction of rotation of the motors are in engagement the contacts governing the other direction of rotation are out of engagement with each other. In this construction the greatest effort which must be exerted in operating the switch is right at the beginning of movement when the static friction between one set of contacts must be overcome. Electromagnets are used to operate the reversing switches, and it is evident that these must be made very powerful if the switch is to be thrown quickly, since the strength of electromagnets is relatively small when the magnet is first energized and the magnetic gap is long, but builds up when the moving plunger decreases the air gap. Consequently, if the electromagnets are designed so as to have only sufficient ultimate strength to operate the switch, the operation of the switch must necessarily be slow; if, on the other hand, the electromagnet is designed to throw the switch quickly, the ultimate strength thereof is greatly in excess of the force required and the switch may be thrown with such force that it rebounds and breaks or partially breaks contact. Furthermore, in order to adapt such a reversing switch to carry heavy currents of the character employed in heavy traffic, it becomes so bulky as to be unwieldy.

One of the objects of the present invention is to so construct and arrange a reversing switch that it shall embody great capacity in a compact structure and require but a minimum force to start it.

Further objects of the present invention will appear in connection with the following description of one embodiment thereof.

The present invention is illustrated in the
5 accompanying drawings in which

Figure 1 illustrates diagrammatically the motor and control equipment of a locomotive or other vehicle; Figs. 2—6, inclusive, show diagrammatically several motor and
10 resistance couplings; Figs. 7 and 8 are respectively a side elevation and a plan view of my improved reversing switch, and Fig. 9 is a detail of said switch illustrating one of the interlocks, the view being taken along line
15 A A, Fig. 8.

Similar reference characters will be used throughout the specification and drawings to denote like parts.

In the accompanying drawings I have
20 illustrated a four-motor, car or locomotive equipment, although the number of motors may be varied. The system as a whole is illustrated diagrammatically, as is usual in cases of this kind, since the various struc-
25 tural details, except that of the reversing switch, are old and well known. For detailed descriptions of the general system, the contacts and the interlocks, reference may be had to patents 617,546 to Elihu Thomson, granted January 10, 1899; 736,816 to Frank
30 E. Case, granted August 18, 1903; and 733,252, to W. O. Mundy, granted July 7, 1903; the present invention relating simply to improvements in the system as a whole to
35 effect a new and useful result.

Reference being had to Fig. 1, M^1 , M^2 , M^3 and M^4 represent four motors of any suitable type; C represents a motor controller of the separately actuated contact type including
40 line contacts T^1 — T^6 , inclusive, series contacts S^1 — S^3 , parallel contacts P^1 — P^6 , bridging contacts B^1 and B^2 , and contact 1—16, inclusive, governing resistance sections R^1 — R^{16} , respectively; F is a throttle or overload relay which
45 closes a circuit through a controller checking device K, as set forth in a patent to Frank E. Case, No. 801,214, October 10, 1905, for systems of motor control; C' and C'' are master controllers, the one developed and the
50 other shown in outline. The master controllers are connected in multiple to wires 17—31, which are in turn connected with the governing circuits of the motor controller C. The wires 17—31 extend throughout the length of
55 the locomotive or car and are provided at their respective ends with couplers a whereby the equipments of two cars or locomotives may be connected together in the usual manner and controlled from either controller
60 upon either car or locomotive. R S and $R' S'$ are reversing switches for the motors M^1 , M^2 and M^3 , M^4 , respectively. E and E' are interlocks operatively associated with the reversing switches R S and $R' S'$, respectively.
65 X^1 , X^2 , X^3 and X^4 are cut-out switches for

cutting out the motors M^1 , M^2 , M^3 and M^4 , respectively. T is the trolley shoe or other current collecting device and several of these may of course be employed. D indicates a master reversing switch. The master controllers consist preferably of two cylinders H and R, controlling, respectively, the motor connection and the resistances. These cylinders are geared together so that R revolves three times while H passes from "off" to
70 "full parallel" position, the movement being either a complete revolution or only a portion thereof. Cylinder H is provided with contacts, as shown, which cooperate with the stationary contacts h^1 — h^9 , while the contacts
80 carried by cylinder R cooperate with the stationary contacts r^1 — r^9 . The cylinder H is preferably constructed with contacts to connect the motors all in series, in series-parallel and in parallel, and with a bridging contact
85 whereby the motor circuits are not interrupted during the change from series-parallel to parallel.

The various features of novelty will be more clearly understood by tracing a complete cycle of operations in as brief a manner
90 as possible. Assume that it is desired to move the car or train forward, i. e., to the right; the movable member d of the master-reversing switch D is moved into engagement with fixed contacts d' , and the master controller is moved to its first position. The contacts along line s of cylinder H engage with contacts h^1 — h^9 ; but there are
95 no contacts along line r^a of the resistance-controlling cylinder R and therefore, in the first position of the master-controller, the resistance is not effected. A circuit may now be traced from trolley T to wire 32, blow-out coil R^a , blow-out coil H^a , contact
100 h^1 , contact of cylinder H, contact h^2 , contacts d^1 , train wire 18, wire 18^a, coil v^3 of reversing switch $R' S'$, lower contact of interlock e^3 , interlock t^4 of line contact T^4 , to ground; thereby throwing reversing switch
110 $R' S'$ to the position shown, and moving interlock e^3 so that its movable member engages with its upper fixed contact. The circuit is now interrupted at the lower contact of interlock e^3 and passes through the
115 upper contact of this interlock, actuating coil of contact T^4 , actuating coil of contact T^5 , actuating coil of contact T^6 , to ground; thereby closing line contacts T^4 , T^5 and T^6 ; a branch circuit extends from wire 18^a to
120 actuating coil v^4 of the reversing switch R S, lower contact of interlock e^1 , interlock t^4 of line contact T^1 , to ground; thereby throwing reversing switch R S and interlock e^1 to the position indicated. The circuit now, instead of passing through the lower contact of interlock E passes through the upper contact of this interlock, actuating coil of contact T^1 , actuating coil of contact T^2 , actuating
125 coil of contact T^3 , to ground; thereby

closing the line contacts T^1 , T^2 and T^3 . It is seen that the line contacts cannot be closed until the reversing contacts have been properly operated; nor can the reversing contacts be operated unless the corresponding line contacts are open. The operation of the reversing switch and its interlocks will be more fully described hereinafter. In this same position of the master-controller a further circuit passes from contact h^2 to contact h^3 , contacts of cylinder H, to contact h^4 , train wire 19, through the interlocks x^4 , x^3 , x^2 and x^1 of cut-out switches X^4 — X^1 , through the actuating coil of contacts S^1 , interlock p^1 of parallel switch P^1 , actuating coil of contact S^2 , interlock p^2 of contact P^2 , actuating coil of contact S^3 , interlock p^3 of contact P^3 to ground; thereby closing the series contacts. The motor circuit is now as follows: trolley T, wire 33, wire 34, contact T^1 , cut-out switch X^1 , throttle relay F, contact w of switch R S, armature of motor M^1 , contact w^1 , field of motor M^1 , contact T^2 , resistance R^1 — R^4 , contact S^3 , resistance R^8 — R^5 , contact T^3 , cut-out switch X^2 , contact w^2 of reversing switch R S, armature of motor M^2 , contact w^3 , field of motor M^2 , contact S^1 , cut-out switch X^3 , contact w^4 of reversing switch R^1 S^1 , armature of motor M^3 , contact w^5 , field of motor M^3 , contact T^6 , resistance R^9 — R^{12} , contact S^2 , resistance R^{13} — R^{16} , contact T^5 , contact T^4 , cut-out switch X^4 , contact w^6 , armature of motor M^4 , contact w^7 , field of motor M^4 , to ground. The motors are therefore connected in series with each other and with the resistances, as indicated in Fig. 2.

If the master controller is now turned from the first series to full series position, cylinder H is rotated so as to bring its contacts along line s^1 into engagement with the fixed contacts h^1 — h^9 and during this time cylinder R will make a complete revolution. The circuits passing out of the cylinder H remain unchanged, but on the first position of cylinder R an additional circuit is established from contact h^3 , through the fixed contacts of cylinder H, including contact h^a , to contact h^9 , contact r^1 , contacts of cylinder R, contact r^2 , train wire 24, actuating coil of contact 8, to ground. The motor circuit, instead of passing from contact S^3 through resistance R^8 — R^5 and to contact T^3 , now passes from contact S^3 through contact 8 and directly to contact T^3 , thereby cutting out the entire block of resistance R^8 — R^5 , as indicated at Y in Fig. 3.

In the next position of cylinder R, contact is broken at r^2 and established at r^3 , current passing to train wire 25, actuating coil of contact 16, actuating coil of contact 8 to ground. Contact 16 is therefore closed and contact 8 maintained closed: the motor circuit, instead of passing from contact S^2 , through resistance R^{13} — R^{16} and then to contact T^5 , now

passing directly from contact S^2 , through contact 16, to contact T^4 , eliminating resistance sections R^{13} — R^{16} , as indicated at Y^1 in Fig. 3.

In the next position of cylinder R contact is broken at r^3 and made at r^4 , current passing from the latter contact to train wire 26, wire 26^a, upper contacts of interlock i of series contact S^1 , actuating coil of contact 12, actuating coil of contact 16, actuating coil of contact 8, to ground; contacts 8 and 16 are therefore maintained closed and by reason of the closing of contact 12, the motor circuit, instead of passing from contact T^6 through resistance R^9 — R^{12} , to contact S^2 , now passes from contact T^6 through contact 12 and directly to contact S^2 , thereby eliminating resistances R^9 — R^{12} from the motor circuit, as indicated at Y^2 in Fig. 3. There now remain in the motor circuit only resistance sections R^1 — R^4 , and these are cut out individually.

In the next position of cylinder R, (position r^5) contacts 8, 12 and 16 are maintained closed and new circuits are established. Contact is made at r^5 and current passes from contact h^2 to contact r^5 , contacts of cylinder R, contact r^6 , to train wire 27, actuating coil of contact 1, actuating coils of contacts 5, 9 and 13, to ground. Resistance section R^1 is thus cut out of the motor circuit as indicated at Y^3 in Fig. 3. The closing of contacts 5, 9 and 13 produces no effect since the resistances which they control are already cut out.

In the next position of the cylinder, R, contact is made at r^7 and current passes from this contact to train wire 28, through the actuating coil of contact 2, actuating coils of contacts 6, 10 and 14, to ground; cutting out resistance section R^2 , as indicated at Y^4 in Fig. 3, and closing contacts 6, 10 and 14.

In the next position of cylinder R, contact is broken at r^6 and made at r^8 , current passing from the latter contact to train wire 29, through the actuating coil of contact 3, actuating coils of contacts 7, 11 and 15, to ground; thereby cutting out resistance section R^3 , as indicated at Y^5 in Fig. 3.

In the final position of cylinder R, (namely r^9) contact is made at r^9 and current passes from this contact to train wire 30, actuating coil of contact 4, actuating coils of contacts 12, 16 and 8, to ground; thereby cutting out the last resistance section R^4 and leaving the motors connected in series with no extraneous resistance in circuit therewith. It will be noted that contact h^a upon cylinder H is shortened so that contact at h^9 is broken when cylinder R is in its last position, but contacts 12, 16 and 8 which were previously maintained closed by current passing through contact h^9 are now maintained by current passing from contacts h^2 r^5 and r^9 .

A movement of the master controller which carries cylinder H past position s^1 breaks all circuits and permits all contacts to open.

As soon as the cylinder H reaches the position sp and cylinder R position r^a , the reversing switches and interlocks and live contacts T^1 — T^6 will be operated as before; but the second circuit, instead of passing through contact h^4 , now includes contact h^5 and current flows as follows: from contact h^5 to train line 20 wire 20^a actuating coil of P^4 , interlock i of series contact S^1 , actuating coil of P^1 , to ground. Current also passes from contact h^5 to train wire 23, wire 23^a, actuating coil of contacts S^2 , interlock p^2 of parallel contact P^2 , actuating coil of contact S^3 , interlock p^3 of parallel contact P^3 , to ground. The contacts now closed are line contacts T^1 — T^6 , parallel contacts P^1 and P^4 , and series contacts S^2 and S^3 . The following motor circuits may now be traced: from trolley T to wire 33, wire 34, contact T^1 , cut-out switch X^1 , throttle relay F, contact w of switch R S, armature of motor M— M^1 , contact T^2 , resistance R^1 — R^4 , contact S^3 , resistance R^4 — R^5 , contact T^3 , cut-out switch X^2 , contact w^2 of reversing switch R S, armature of motor M^2 , contact w^3 field of motor M^2 , contact P^4 , to ground. At wire 33 the current divides, a portion passing through the circuit just traced and the other portion flowing as follows: to contact P^1 , cut-out switch X^3 , contact w^4 of reversing switch $R^1 S^1$, armature of motor M^3 , contact w^5 , field of motor M^3 , contact T^6 , resistance R^9 — R^{12} , contacts S^2 , resistance R^{13} — R^{16} , contact T^5 , contact T^4 , cut-out switch X^4 , contact w^6 , armature of motor M^4 , contact w^7 , field of motor M^4 , to ground. The motors are therefore connected into two groups, each group comprising two motors in series and in series with half of the resistance, and these two groups are connected in parallel between the trolley and ground. Upon the continued movement of the master controller so as to bring the cylinder H to position $s^1 p^1$, the final series-parallel position, contacts 8 and 16 are closed as before and resistance sections R^5 — R^8 and R^{13} — R^{16} are cut out of their respective motor circuits as indicated at Y and Y^1 , Fig. 4. Contact 12 was the third resistance contact to be closed as the controller was moved from first series to full series position, the circuit therefor passing through the upper contacts of interlock i associated with series contact S^1 . Contact S^1 is open, however, during the series-parallel arrangement of the motors and therefore contact 12 is not now closed. Contacts 8 and 16 are maintained closed by means of a branch circuit passing from train wire 26 to a branch wire 26^b through interlock p^4 , actuating coils of contacts 16 and 8, to ground. When cylinder R reaches the position r^b and passes on to its extreme position, r^h , contacts 1, 5, 9 and 13; 2, 6, 10 and 14; 3, 7, 11 and 15; and 4, 12, 16 and 8 are closed as be-

fore; and resistance sections R^1 and R^9 ; R^2 and R^{10} ; R^3 and R^{11} and R^4 and R^{12} are cut out in pairs as indicated at Y^3 , Y^{30} , Y^4 , Y^{40} , Y^5 , Y^{50} , and Y^6 , Y^{60} in Fig. 4. At this point all the resistance has been eliminated from the motor circuits, and, in order to further accelerate the speed of the motors, it is necessary to connect all four motors in parallel between the trolley and ground.

It is noted that when the master controller reaches full series-parallel position, namely when cylinder H engages with the fixed contacts h^1 — h^9 along line $s^1 p^1$, a contact h^b carried by said cylinder engages with fixed contact h^6 . This establishes bridge connections about the resistances and about the series switches in the motor circuits in order that the motor circuits may not be interrupted in changing from series-parallel to parallel. No bridging arrangement is shown for preventing the opening of the motor circuits during the transition from series to series-parallel, although such an arrangement might be employed. The motor speed is low at that time, however, and the breaking of the circuit is not of much consequence. When contact h^b engages with contact h^6 , current passes to train wire 21, actuating coils of contact B^1 and B^2 , actuating coil of P^4 , interlock i of series contact S^1 , actuating coil of contact P^1 , to ground. If now the master controller is moved to its first parallel position, cylinder R will immediately break the circuits of the resistance contact coils, permitting the resistance contacts to open. At the same time contact will be broken at h^8 and contacts S^3 and S^2 will open. The closing of contacts B and B^1 has formed shunts about these resistance and series contacts as indicated at Y^7 and Y^8 in Fig. 5, so that the opening of the resistance and series contacts does not interrupt the motor circuits. The contacts on controller cylinders H are so arranged that contacts h^c and h^d engage with contacts h^5 and h^7 before contact h^b breaks connection with contact h^6 . As soon as contacts h^5 and h^7 come into play two circuits are formed; one from contact h^5 , to train wire 20, wire 20^a, actuating coil of contact P^4 , lower contacts of interlock i of series switch S^1 , actuating coil of contact P^1 , to ground; the other from contact h^7 , to train wire 22, wire 22^a, actuating coil of contact P^5 , interlock i^3 of series contact S^3 , actuating coil of contact P^3 , actuating coil of contact P^5 , interlock i^2 of series contact S^2 , actuating coil of contact P^2 , to ground. Thus all the parallel contacts are closed and immediately thereafter the circuit of the bridging contact is opened at contact h^5 , leaving the motors connected in multiple and each in series with a block of resistance as indicated in full lines in Fig. 6. There is no contact on cylinder H for engaging with contacts h^8 and h^9 during the parallel position of the master controller and

therefore contacts r^1 — r^4 of the resistance controller are not energized during this period. No resistance is cut out until the contacts along line r^e upon cylinder R engage with the fixed contacts and then contacts 1, 5, 9 and 13; 2, 6, 10 and 14; 3, 7, 11 and 15; and 4, 12, 16 and 8 are actuated in the manner previously described and the resistances are cut out section by section from the four motor circuits, until the motors are connected in parallel with no resistance in circuit.

If at any time the motor current rises above a predetermined safe maximum, throttle F is closed, completing the circuit of checking coil K and causing the controller to be locked until the current again falls within safe limits.

By this arrangement a great number of speed controlling steps are obtained by the use of a minimum number of contacts and train wires, every resistance section comes into play during each arrangement of motor connections. Any number of motors and corresponding resistances may be employed and controlled in this manner, the resistance being cut out by groups until but one group remains in series with any motor or series of motors, and the several sections of the remaining group being then cut out section by section.

In case of failure of any motor, the corresponding cut-out switch may be opened, removing that motor from circuit and permitting the operation of the remaining motors independently thereof. If one of the cut-out switches X^1 — X^4 is opened, the circuit of the series contacts S^1 — S^3 is broken at the corresponding interlock x^1 — x^4 , so that these contactors are not actuated during the series positions of the master controller and no motor connections are completed until the master controller is moved into its series-parallel positions. Then, assuming cut-out switch X^1 to have been opened, motors M^3 and M^4 alone are supplied with current and in the same manner as if all the motors were active: no current is as yet supplied to motor M^2 , since it would have to be connected in parallel with the series group of motors M^3 and M^4 producing an unsymmetrical arrangement. When, however, the master controller reaches its first parallel position, motor M^2 is cut in and motors M^2 , M^3 and M^4 are connected in parallel. In this way any motor may be cut out if desired because of a defect or for any other reason, and the remaining motors will be brought into play without unbalancing the system. Similarly two or three motors may be cut out and the car operated with the remaining motors or motor.

It is evident that if the master reversing switch D is moved so that its movable contact d engages with the fixed contacts d^2 ,

electromagnets v^2 and v^4 will be actuated, giving reverse motor connections; the remainder of the control system operating as before.

In Figs. 7, 8 and 9 I have illustrated my improved reversing switch, shown diagrammatically in Fig. 1. Within a suitable frame 35 are arranged the magnets v^1 and v^2 , and on opposite sides thereof are arranged the contacts for connecting the motors for forward and reverse rotation, respectively. Each set of contacts comprises eight fixed contacts 36 and four movable contacts 37. The contacts 37 are arranged in pairs as shown, being supported on blocks of insulation 38 carried by arms 39. The arms 39 are pivoted to the frame 35 at 41, 41, so that the contacts of each set are symmetrically arranged. When otherwise free, the arms 39 are acted upon by gravity to carry the movable contacts 37 away from the fixed contacts 36. A toggle 42 connects each pair of arms, the toggles being in turn connected by means of links 43, 43 to levers 44, 44 controlled by magnets v^1 and v^2 . The levers 44, 44 are pivotally mounted upon the frame 35 at 45, 45 and are operatively related to the cores of the electromagnets whereby, upon the energization of one magnet or the other, one of the toggles is actuated to cause the engagement of the corresponding fixed and movable contacts 36 and 37. Pivotally supported between the electromagnets v^1 and v^2 is a lever 51 which extends transversely of the levers 44, 44 and engages under hooks or shoulders 53, 53 upon these levers. Consequently, when either electromagnet is energized, drawing with it the corresponding lever 44, the lever 51 is actuated to positively throw the other lever 44 upward and so insure the opening of one set of contacts when the other set is closed. This construction furnishes in a simple and compact form a very efficient reversing switch and one in which contact is effectively made and broken. Arranged at right angles to the planes in which the arms 39 swing are the contacts constituting the interlocks e^1 and e^2 . Each of these interlocks comprises fixed contacts 46 and 47 and a movable contact consisting of two spring arms 48 and 49. These auxiliary contacts are located adjacent the ends of the lever 51 and are connected thereto by means of yokes of insulating material 52 which surround the spring arms 48 and 49. As the lever 51 is actuated, the spring arm 48 is moved into engagement with its cooperating contact 46 while engagement at contact 47 is broken; at the same time the spring arms 48 and 49 at the opposite end of the lever are moved in the reverse direction, making connection at contact 47 and breaking it at 46. This operation is diagrammatically indicated in Fig. 1, in which the spring arms of interlock e^1 are shown raised

while the spring arms of interlock e^2 are lowered. In Fig. 1 the auxiliary contacts are illustrated as connected directly to corresponding electromagnets in order to simplify the diagram. If the master reversing switch D is thrown in the opposite direction, causing the throwing of switch R S to give motor connections for reverse rotation, the movable members of interlocks e^1 and e^2 will reverse direction, the movable member e^2 rising and the movable member of interlock e^1 descending. The auxiliary contacts 46—49 are arranged in chutes 54 composed of insulating material. Blow-out coils 55, arranged adjacent the contacts, force the arcs which are formed upon breaking contact at 46 or 47 outwardly through the chutes.

It is apparent that by employing independent sets of contacts and closing them by means of toggles, the closure may be effected quickly and with electromagnets only powerful enough to give the requisite pressure upon the closed contacts. Furthermore the main contacts may be made massive, so as to safely carry heavy currents, without materially increasing the size of the switch as a whole.

While I have described my present invention as embodied in the best form known to me, the invention is not limited to such particular form since in its broader aspects, it may be embodied in various other forms.

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

1. In a system of motor control, in combination, a plurality of motors, a plurality of groups of resistance sections, and means for grouping said motors in different relations to each other with all resistance in circuit therewith and for cutting out by groups all except one group of resistance sections in series with any motor or group of motors and for cutting out the last group, section by section.

2. In a system of motor control, in combination, a plurality of motors, a plurality of groups of resistance sections, and means for grouping the motors in different relations to each other and to said groups of resistance sections and for cutting out by groups all except one of the groups of resistance sections in circuit with any motor or group of motors and then cutting out the last group, section by section.

3. In a system of motor control, in combination, a plurality of motors, a plurality of groups of resistance sections, and a motor-controller arranged to group said motors in various relations to each other with all resistance in circuit and to successively cut out by groups all except one of the groups of resistance sections in circuit with any motor or group of motors and to cut out the last group, section by section.

4. In a system of motor control, in combination,

a plurality of motors, an equal number of groups of resistance sections, and a motor-controller arranged to group the motors in various relations to each other and to distribute the groups of resistance sections symmetrically during the various motor groupings, to cut out by groups all except the last of the groups of resistance sections in circuit with any motor or group of motors and to cut out said last group of resistance sections step by step.

5. In a system of motor control, in combination, a plurality of motors adapted to be grouped in various relations to each other, groups of resistance sections one greater numerically than the number of motor groupings, and a motor-controller arranged to produce the various motor groupings with all resistance in circuit with the motors, to cut out all except the last group of resistance sections in series with any motor or group of motors, and to cut out said last group, section by section.

6. In a system of motor control, in combination, a plurality of motors, a plurality of groups of resistance sections, means for grouping said motors in series, series-parallel, and parallel with the resistance symmetrically distributed, and for cutting out by groups all except the last group of resistance sections in series with any motor or group of motors and then cutting out said last group, section by section.

7. In a system of motor control, in combination, a plurality of motors, a plurality of groups of resistance sections, a motor controller arranged to connect said motors in series, in series-parallel and in parallel with all resistance in circuit in each motor grouping, and to cut out all except one group of resistance sections in series with any motor or group of motors by groups and the one group, section by section.

8. In a system of motor control, in combination, a plurality of motors adapted to be connected in series, in series-parallel and in parallel, four groups of resistance sections, a motor-controller arranged to form the several motor connections with all resistance in circuit and to cut out all except one group of resistance sections in series with any motor or group of motors group by group and said one group section by section, and means for operating the motor-controller.

9. In a system of motor control, a plurality of motors, a series-parallel motor-controller, a cut-out switch for one of said motors, and means controlled by said cut-out switch for preventing the closing of the contacts adapted to connect the several motors in series.

10. In a system of motor control, a plurality of motors, a motor-controller arranged to connect said motors in series, in series-parallel and in parallel, cut-out switches for mo-

tors, and means controlled by said cut-out switches whereby the opening of one prevents the completion of the circuit of another of said motors except when all the remaining

5. active motors are in parallel.

11. In a system of motor control, a plurality of motor groups, a motor-controller arranged to connect said motors and motor groups in different relation to each other, and
10 a cut-out switch for each of said motors, the arrangement of parts being such that the opening of one of said cut-out switches prevents the completion of a circuit through the remainder of the group of motors with which
15 the cut-out switch is associated except to connect it symmetrically with the other motors or group of motors.

12. In a system of motor control, a plurality of motors, a motor-controller of the separately-actuated contact type, a cut-out switch for one of said motors, and means controlled by said cut-out switch for rendering a portion of said motor-controller inoperative.

13. In a system of motor control, a plurality of motors, a motor-controller of the separately-actuated contact type, control circuits, cut-out switches for said motors, and means controlled by said cut-out switches for interrupting a portion of the control circuits
30 when one of the cut-out switches is open.

14. In a system of motor control, a plurality of motors, a motor-controller, cut-out switches for said motors, auxiliary contacts operated by said cut-out switches, and an actuating circuit for said motor-controller passing through said auxiliary contacts.

15. In an electromagnetically-actuated switch, two sets of contacts disposed on opposite sides of the switch-actuating member,
40 circuit-closing members adapted to abut against the contacts of the two sets, a toggle lever mechanism for actuating said circuit-closing members, and an electromagnet for operating said mechanism.

16. In a reversing-switch, two sets of main contacts, independent closing means for each set of contacts, a lever cooperating with said closing means to positively open one set of contacts when the other set is closed, and
50 auxiliary contacts controlled by said lever.

17. In a reversing-switch, two sets of main contacts, a lever operatively associated with each set of contacts for closing it, an electromagnet operatively associated with each lever, a third lever cooperating with said contact closing levers for positively opening one set of contacts when the other set is closed, and auxiliary contacts actuated by said third lever.

18. In a reversing-switch, in combination with two sets of contacts each of which sets comprises fixed contacts and movable contacts disposed between the fixed contacts and connected together by a toggle, an electromagnet operatively associated with each
65

of said toggles for actuating the toggle to close the contacts, and means for causing one of said toggles to open one set of contacts when the other set closes.

19. In a reversing-switch, in combination with two sets of contacts each of which sets comprises fixed contacts and movable contacts disposed between the fixed contacts, of a toggle operatively associated with each of said sets of contacts, independent actuating
75 means for actuating said toggles to close the contacts, and an operative connection between said actuating means for positively opening one set of contacts when the other set is closed.

20. In a reversing-switch, in combination with two sets of contacts each of which comprises fixed contacts and movable contacts disposed between said fixed contacts, of a toggle connected to the movable contacts of
85 each set, two electromagnets, connection between said toggles and said electromagnets whereby the toggles are operated to close said contacts, a lever associated with the closing means of the contacts for causing
90 one set of contacts to open when the other set is closed, and auxiliary contacts actuated by said lever.

21. The combination with a plurality of electric motors and an auxiliary control system which is governed by a master controller to regulate the connections thereof and the amount of resistance inserted in circuit therewith, of means for so modifying said auxiliary control system that one or
100 more of said motors may be excluded from said circuit and the remaining motor or motors be properly controlled by normal operation of the said master controller.

22. The combination with a plurality of electric motors, resistances therefor and an auxiliary control system which is governed by a master controller to regulate the connections thereof and the amount of resistance inserted in circuit therewith, of means
110 for modifying said system to open-circuit one or more motors without interfering with the operation of the remaining motor or motors by said master controller in the normal manner.

23. The combination with a vehicle equipment comprising a control system governed by a master controller, a plurality of electric motors and resistances therefor, of means for modifying said system to open-circuit one or
120 more motors without interfering with the operation of the remaining motor or motors by said master controller in the normal manner.

24. The combination with two electric motors and an auxiliary control system which is governed by a master controller to successively connect both motors in series with a predetermined resistance, gradually decrease said resistance, connect said motors
130

in parallel, with a predetermined resistance in series with each motor, and gradually and simultaneously decrease said resistance, of means for so modifying said control system
5 that the normal operation of said master controller may successively connect one of said motors in circuit with a predetermined resistance and gradually decrease said resistance.

10 25. The combination with a plurality of electrical translating devices, a plurality of independently actuated switches for adjusting the circuits thereof and means for causing closure of the switches in a predetermined order, of means whereby the order
15 of closure of the switches may be changed in order to remove one or more of the translating devices from the circuit without interfering with the adjustment of the circuits of the remaining devices.
20

26. The combination with a plurality of electrical translating devices, a plurality of switches for adjusting the circuits thereof and electrically actuated means for control-

ling operation of the switches, of means for 25 interrupting the circuits of certain of the switch controlling means whereby one or more of the motors may be removed from the circuit without interfering with the adjustment of the circuits of the remaining devices. 30

27. The combination with a plurality of electrical translating devices and a plurality of electrically controlled switches for adjusting the circuits thereof, of means for arranging and controlling circuits for the switches 35 to cause them to operate in a predetermined order, and means for rearranging the switch controlling circuits to cause them to operate in other predetermined orders and thereby exclude one or more of the translating de- 40 vices from the circuit.

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

GEORGE H. HILL.

Witnesses:

BENJAMIN B. HULL,
HELEN ORFORD.