No. 697,767. Patented Apr. 15, 1902.

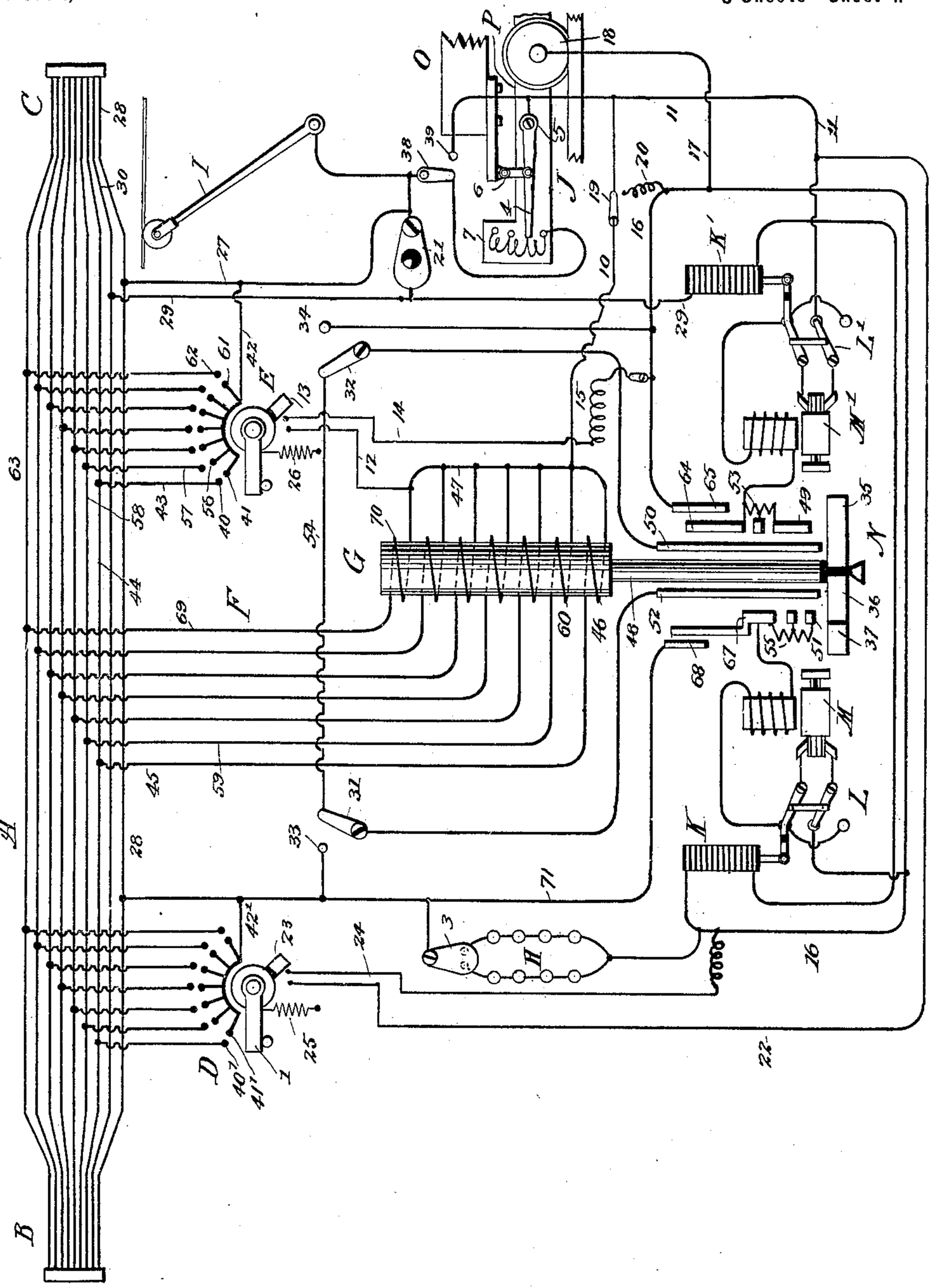
G. T. & L. WOODS.

SYSTEM OF ELECTRICAL CONTROL.

(Application filed May 18, 1901.)

(No Model.) 3 Sheets—Sheet 1.

Fig. 1.



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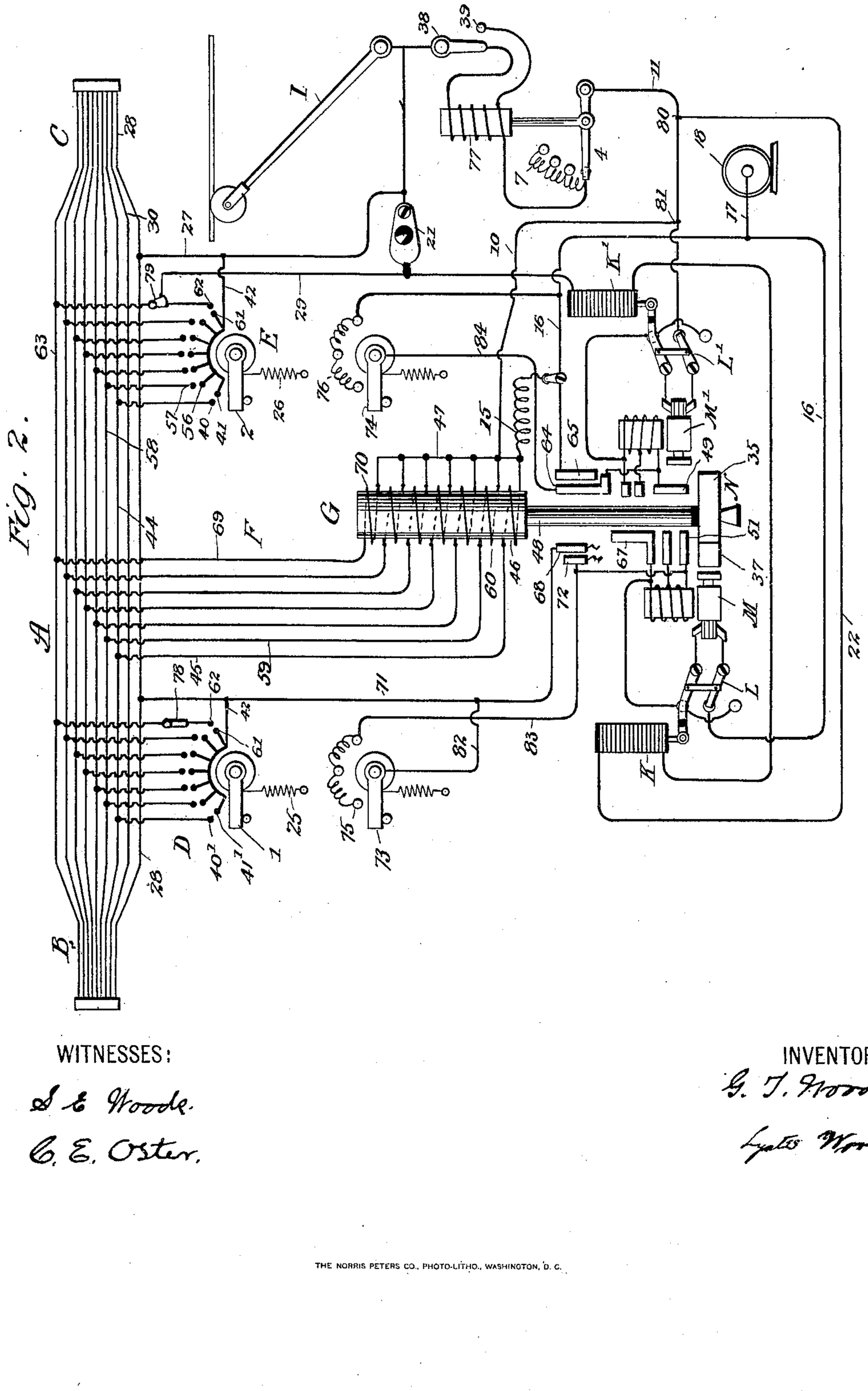
(No Model.) 3 Sheets—Sheet 2.



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(No Model.) 3 Sheets—Sheet 3.

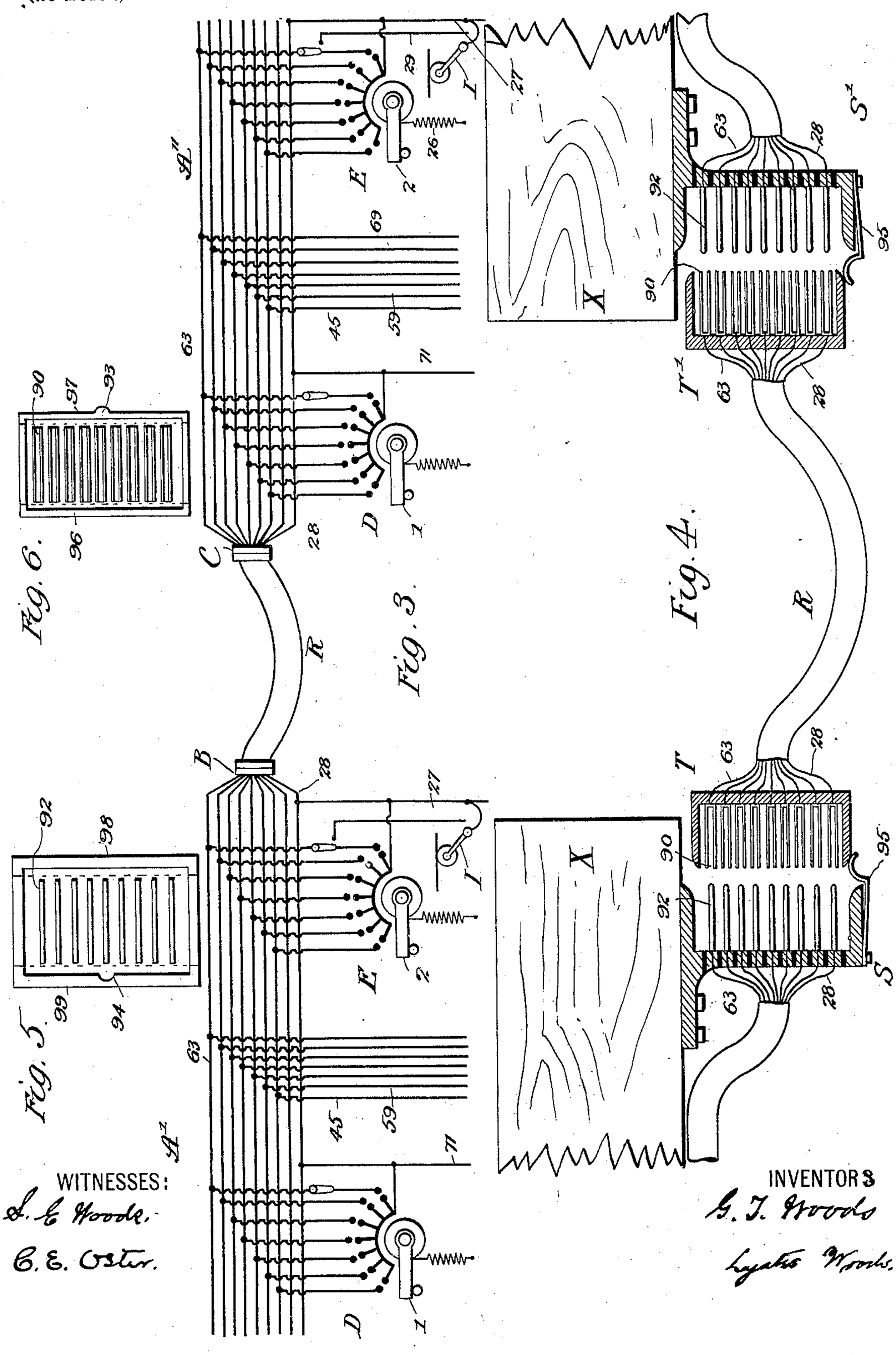

Fig. 3.

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UNITED STATES PATENT OFFICE.

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SYSTEM OF ELECTRICAL CONTROL.

SPECIFICATION forming part of Letters Patent No. 697,767, dated April 15, 1902.

Application filed May 18, 1901. Serial No. 60,903. (No model.)

To all whom it may concern:

Be it known that we, GRANVILLE T. WOODS and LYATES WOODS, citizens of the United States, and residents of New York, in the county of New York and State of New York, have invented certain new and useful Improvements in Systems of Electrical Control, of which the following is a specification.

The object of our invention is to provide simple and effective means whereby any one or more motors or translating devices may be controlled through any suitably-arranged power-actuated (energized) controlling apparatus and from any suitable point where a manually-operable switch is located for such purpose. The power employed to actuate said controller may be of any suitable kind.

Our system is such that when a single car is equipped with two or more motors and should one of said motors become disabled then the car may be made to proceed with the remaining motor, provided the motor has the proper amount of reserve power. In case a motor should fail while acting as a part of an equipment that motor may be cut out and the control of the remaining motors will continue to be the same as if all the motors were in circuit. When a number of cars are equipped with our system, they may be coupled together at will to form a train. The coupling at one end of the car being a duplicate of that at the other end, no trouble will be experienced when coupling or uncoupling the cars, and as each car is disconnected from the train it may be driven by its motors onto a siding or elsewhere. It may be necessary to couple up a train which will include one or more cars which are not equipped with our system. In such case it will be necessary to use couplings long enough to span across the unequipped cars. Thus the equipped cars may all come under one common control. In every case where one car of a train is unequipped with our system such car should not be the end of the train, because the last car should always be under full control.

In practice it will be noted that some cars will be more lightly loaded than the others, and therefore it should require less current to "slip the wheels" of the "light" cars than to do so with the other wheels. There are times in which a collector shoe or trolley of one car will make a bad contact, thus in some systems partly or wholly depriving the motor or motors (of the car carrying that trolley) of operative power.

In our invention we believe that we have devised a system which is free from the faults and failings of other systems designed for the purpose for which the present invention is intended.

We shall use certain terms throughout this specification and the claims to indicate the various parts of the apparatus illustrated in the drawings.

The following explains various terms used hereinafter.

"Driving-motor" refers to the car-propelling motor.

"Motive switch" indicates a switch whose motive apparatus is a part of the switch itself. One form of such may be made as follows: A set of solenoid-coils, a single armature or core controlled thereby, and a contact-piece carried by said core and preferably in circuit with said coils. Such device is a self-containing switch which is adapted to be operated step by step by current sent through its motive coils in sequence.

"Commuting-switch" refers to the switch which the motorman will have to use in controlling a train. By the use of this switch he controls the movements of the motive switch, which in turn governs the speed of the driving motor or motors.

"Rheostatic switch" indicates the switch which is adapted to be used in one arrangement when it becomes necessary to operate one motor of a car equipment when another motor of the same car becomes disabled.

"Reversing-switch" is the term used to indicate the switch which is connected in the armature-circuit of the driving-motor to reverse the direction of rotation of the same.

"Reversing-magnets" refers to the magnets or solenoids which when energized control the movement (in one direction) of the reversing switch or switches.

"Automatic switch" refers to the switch which automatically throws a resistance into the driving-motor circuit whenever the current becomes abnormal.

To more fully understand and appreciate our improvements, we refer to the accom-

panying drawings, in which similar reference characters indicate corresponding parts.

Figure 1 is a diagrammatic view of one of our arrangements for equipping one car. Fig. 2 is another diagrammatic view of an arrangement for the equipment of one car. Fig. 3 is still another diagrammatic view. This view illustrates two sections of wiring (supposed to be on different cars) joined together by means of an appropriate coupling. Fig. 4 illustrates a diagrammatic sectional view of the coupling connectors or heads of the car-wires and a coupling-link. Fig. 5 is a face view of a car-wire coupling-head. Fig. 6 illustrates a face view of a coupling-link connector or head.

Referring now to Fig. 1, A is a set of circuit-wires having four sets of terminal contacts or connectors B C D E and a set of branch wires F, which connect each with one appropriate coil of the of the motive switch G. The terminals or contacts B C when not in use are normally open; but they are adapted to be coupled up to other cars to form a train. The terminals or contacts D E are arranged at the respective ends of the car and remain in open circuit until one switch-arm is brought into use, at which time switch-arm 1 will be moved over the terminals or contacts at D or switch-arm 2 will be moved over the terminals or contacts at E. When either of such arms are moved, it is for the purpose of actuating the motive switch G. At H a set of lamps is shown connected up in series multiple with a switch 3, which is adapted to cut out either series of the set. At I is shown the ordinary trolley-arm and trolley-wheel. At J a mechanism is illustrated which is intended to automatically proportion the current used in the motor to the load to be moved—that is to say, when the car is lightly loaded there will be more resistance cut into the circuit, and of course as the load increases the resistance decreases. The finger 4 is pivoted to the truck-frame at 5 and hung from the car-body O by means of link 6. As the car becomes loaded the free end of finger 4 moves over resistance 7 to cut out the same. K K′ are reversing magnets or solenoids which are connected in series and act through their cores to control the upward or "one-way" movement of the reversing-switches L L′, respectively, the downward movement of the said switches being accomplished by gravity. M M′ are the car-driving motors. The motive switch G, as shown in Fig. 1, has the terminals of its coils electrically connected together and then connected, by means of conductor 10, to the conductor 11, which leads power-current into the driving-motor. The counter electromotive force of the latter motor causes a minimum current to be maintained in the finally-energized coil of motive switch G, so that such coil will not be overheated when maintained in the circuit. A normally open circuit-wire 12 leads from this collection of terminals to the contact 13 on commuting switch-arm 2, so that when said arm is moved to close the contacts at E the contact 13 will temporarily ground conductor 12 through wire 14, resistance 15, wires 16 17, and car-wheel 18 for starting purposes. A similar arrangement is shown in connection with commuting switch-arm 1. In that case conductor 22 leads from wire 11 and terminates in the path of contact 23, which is carried by arm 1. When said arm is moved to start the car or cars, said contact 23 connects conductor 22 to ground through wires 24 16 17 and wheel 18. It will be noted that switch-arms 1 and 2 are normally open and that position is maintained by them because of springs 25 26, respectively. Such springs automatically cause the said arms to open the circuit as soon as the motorman releases the arm. At 19 is shown a switch which may be used to connect wire 10 to ground through resistance 20, wire 17, and wheel 18 whenever desirable. At 21 is illustrated a single-point switch which is adapted to open and close the circuit between the trolley I and the reversing-magnets K K′. It will be seen that the trolley I has a permanent electrical connection through wire 27 with wire 28 of group A, while the reversing-magnets K K′ are in constant electrical connection with wire 29, and through that connection these magnets electrically communicate with wire 30 of group A. Switches 31 and 32 are shown in their normal positions—that is to say, when the motor system is normal these switches are maintained in the positions shown; but if one of the driving-motors should burn out or otherwise become disabled then the appropriate switch 31 or 32 would be shifted so as to connect the normal driving-motor to ground through the appropriate contact 33 or 34. The contact-bar N (the lower part of motive switch G) is divided into three parts 35, 36, and 37. Part 35 controls the contacts of driving-motor M′, while parts 36 37 control the contacts of driving-motor M. At 38 is shown a switch which may be used to electrically connect the trolley I to point 39 in case resistance 7 burns out. It will be noted that this resistance 7 is supported by an extension of one of the truck-timbers.

The *modus operandi* is as follows: Suppose the switches at D E are open and current is passing down trolley-arm I. From there it will flow over single-point switch 21, wire 29, solenoids or magnets K K′, (in series,) wires 16 17, and wheel 18 to ground or return. To start the car, (toward the right,) switch-arm 2 is moved upward, contact 13 closes circuit-wires 12 and 14. Meanwhile said arm 2 electrically bridges contacts 40 and 41. This causes an increased amount of current to flow along trolley I and to wire 27, thence across conductor 42 to contacts 41 and 40, wires 43 44 45, coil 46, wires 47 and 12, contact 13, and wires 14 15 16 17, and wheel 18 to ground. The current passing through the motive

switch-coil 46 causes the switch-core 48 to be moved one step, thus causing the part 35 of the switch-bar N to make connection with the contacts 49 50 and part 36 to connect contacts 51 52. Then more current will move down trolley I and pass over switch 38, resistance 7, finger 4, wire 11, switch L′, the armature of driving-motor M′, thence through the field of motor M′, resistance 53 to contact 49, across 35 50, switch 32, conductor 54, switch 31 to contacts 52 36 51, resistance 55, field of driving-motor M, switch L, the armature of motor M, thence over conductors 16 17, and wheel 18 to return. In the meantime the connection made by the motive switch G has also completed a new outlet for the current which actuates said motive switch. This outlet is along conductor 10, switch 19, wire 11, and thence over the circuits described, which pass through the driving-motors and over the switch-bar N.

It will be noted that the driving-motors are in series with each other and with the dead resistances 51 55. If switch-arm 2 is progressively moved so as to connect or bridge the next two appropriate serial contacts 56 57, the current will be shifted from contacts 40 41 and will flow over 56 57 58 59, coil 60. From thence it will follow conductor 10 to join the power-current on wire 11. The latter movement of the switch-arm 2 caused contact 13 to disconnect wires 12 14, which connection was made to complete a circuit for the initial current supplied to the motive switch G. As the commuting switch-arm 2 is progressively moved the pairs of commuting-switch contacts are brought into the circuit in sequence until the final contacts 61 62 are reached, at which time wires 63 69 and top coil 70 are in circuit and the switch-core 48 is drawn to its highest point of travel. As the switch-bar N moved along step by step following the indications of the commuting switch-arm it first cut out the resistance 55. Then resistance 53 was cut out. Then contact part 35 connected 64 65, thus connecting motor M′ to ground through conductor 16 17, and wheel 18. Then part 36 cut out motor M by passing from the circuit at offset 67. The continued upward movement of bar N caused contact part 37 to electrically connect offset contact-piece 67 and contact-piece 68. This latter connection supplies current to motor M over the following circuit: from trolley I over conductors 27, 28, 71, 68, and 67. Thus it will be noted the driving-motors are thereby placed in parallel. Switch-arm 2 when moved backward cuts out motive switch G. As the switches and circuit connections at D and E are exactly alike and the manipulations correspond it will be unnecessary to repeat the described operation of E. At D wire 22 corresponds to wire 12 (at E) and communicates with motive switch G through conductors 10 11, and wire 24 at D corresponds to wire 14 at E. To reverse the direction of rotation of the driving-motor armatures, or, in other words, cause the car to move toward the left, it will be necessary to open switch 21. Then the reversing-switches L L′ will be assisted in changing the armature-circuits by the weight of the solenoid-cores. When several cars are equipped with our system, as shown in this figure, and coupled together, it will be found that each wire branching from group A on one car will be in multiple with the corresponding branch wire on all the other cars. Therefore when trains are made up all of the switches corresponding to switch 21 (except the one on the front of the pilot-car) must be opened and thus maintained, so that all of the reversing-switches may be controlled from the front of the pilot-car.

In Fig. 2 the group of wires A is shown substantially as that in Fig. 1, except wire 30, which is normally idle, and conductor 63, which has switches 78 and 79 inserted in its terminals at commuting-switches D and E, respectively, instead of the reversing devices or magnets K K′ being permanently electrically connected to wire 30, as shown in Fig. 1. The switch 79 is adapted to connect said magnets through wire 29 to the speed-controlling wire 63 and contact 62 at the same time on the pilot-car of a train. When only one car is to be operated, switches 78 and 79 may be left open, and when the reversing-magnets are to be energized single-point switch 21 may be closed for that purpose; but if a train of cars are equipped then all the train-switches corresponding to the switches 21 illustrated in the drawings must be maintained at open circuit. This statement excepts such switch on the pilot-car. This switch may be used, as previously described, to control the reversing devices or magnets K K′. Thus it will be noted the speed-controlling wire may be used for controlling the direction of rotation of the motors. When the direction in which the cars are moving is such that the reversing-magnets K K′ are maintained energized, it would not interfere with the apparatus if all of the switches (shown here as 78) were closed and commuting-switch arm 1 moved to connect points 61 and 62. In the present figure the conductor leading from magnet K is connected at point 80 to the driving-motor circuit. In the present instance the path for the current leaving conductor 47 of switch G is as follows: The initial or starting current passes directly from conductor 47 through resistance 15, wires 16 17, and wheel 18. The second path from said wire 47 is along conductor 10 to point 81, where it connects with the driving-motor circuit. 73 represents a switch-arm which is adapted to be used for controlling motor M in case motor M′ fails to work. 75 is the resistance which said arm 73 inserts or cuts out of the circuit when so desired. When the arm closes, the circuit-current flows from the trolley along arm I and wires 27 28 71 82, arm 73, resistance 75, conductor 83 to motor M. 74 is a similar arm, and 76 is the resistance which said arm must

control. When this circuit is closed, current flows along the trolley-arm I over switch 38, solenoid 77, finger 4, wire 11, through switch L′, motor M′, contact 64, wire 84, arm 74, resistance 76, conductors 16 and 17 to wheel 18. The solenoid 77 has its core attached to finger 4, and whenever an abnormal current or a current above a predetermined limit begins to flow through the motor-circuit then the said core is drawn up and finger 4 cuts resistance 7 into the motor-circuit. As the counter electromotive force in the motor increases the finger moves downward and cuts out a proportionate amount of said resistance. Such resistance may be infinite, if so desired. It will be seen that the latter arrangement absolutely prevents the burning out of the motor and also prevents the slipping of motor-driven wheels.

In the operation of the driving-motor as shown in Fig. 2 (the present figure) the commuting-switches are handled in exactly the same way as that described in Fig. 1, and the motive switch G acts just the same in both cases. Such current as would flow through the coils of switch G for the operation of magnets K K′ would be small, and therefore have practically no effect upon the switch-core 48. In shifting the commuting-switch arm the switch-core 48 moves upward, thus cutting out by successive steps the field of the motor M while the motors are in series with each other, and then it cuts out step by step the field of motor M′. Then the entire field of motor M′ is cut into the circuit. Then the latter motor is grounded by part 35 connecting 64 and 65 and circuit 16 17 and wheel 18. Then part 37 connects 68 and 72, so that motor M receives current along the trolley I, conductors 28 71, and across part 37, at which time said driving-motors will be in parallel or multiple. The action of the motive switch will be reversed when the commuting-switch moves back to its normal position. Each movement of the commuting-switch is copied by the said motive switch, because of the peculiar construction of the latter device and because of the fact that the two such devices are in direct electrical communication with each other. From the description of Fig. 2 it will be understood that a single wire is made to carry current for the actuation of a motor-speed-controlling device and a motor-reversing device. Therefore no special circuit is needed or used (in this figure) for the motor-reversing magnets. In this figure wire 30 is shown as a normally idle emergency-conductor which is adapted to be substituted for one of the other conducting-wires in case of the failure of one of such wires. When the equipped cars are connected up to form a train, it will be observed that wire 28 then extends through the train, and being normally connected to the power-circuit by each current-collector or trolley-arm, and in direct communication with all of the motors when the train is in full motion, then in case any current-collector or trolley-arm I fails to make proper contact, the power-current will flow from the other current-collectors, along wire 28, to the motors which should have been supplied through the defective current collector or collectors. It should be noted that the bar N is mechanically a part of motive switch G and electrically a part of the circuits thereof. The commuting-switch arms 1 and 2 are detachable and are also normally "dead"—that is to say, they have no permanent electrical connection with any of the circuits. Therefore each move of one of said arms must bridge two contacts to complete a circuit. We prefer to arrange all of the motor-controlling contacts upon a fixed flat surface and then move a single contact-bridge N so as to make the appropriate circuit connections. It will be observed that the motive switch is untrammeled with dash-pots or such other devices as would prevent the movable part of such switch from promptly responding to the action of said commuting-switch independently of the speed of the commuting-switch movement. The quick action of the motive switch prevents the formation of arcs when the various sections of resistance are cut out of the motor-circuit.

Fig. 3 shows two diagrammatic sections of wire groups joined together by a flexible coupler. These parts A′ A″ each represent sectionally the group of wires A in Fig. 2 and the terminals B C D E.

Fig. 3 is intended and illustrated only for the purpose of showing the coupling R connecting the terminals B C between two cars. Therefore it is not necessary to repeat the previously-illustrated details of the switch connections.

Fig. 4 is in part a sectional view of the coupler R and the terminal coupler-heads S S′ of the groups of wires A′ A″ or two such groups, as A, Fig. 2. It will be seen that as the same relative position is occupied by the corresponding wires on the respective cars the terminal connectors or heads of the flexible coupler R must be arranged so that mistakes cannot be made when coupling cars together. To this end the coupling-heads should be composed of some strong insulating material, into which reasonably stiff wire-terminating fingers 90 92 should be inserted in this insulating material and the wires arranged to connect the fingers in head T in exactly the same relative position as those are in head T′—that is to say, the top finger at T must be connected to the top finger at T′ and the other connections must follow in the same manner. The connecting-fingers of the coupler or terminal heads are what is commonly termed "male" and "female"—that is, one is so made that it will slip within the other. By preference these coupling-heads are made oblong, as shown in Figs. 5 and 6. At 93, Fig. 6, is shown a safety-lug which fits into a groove 94 of Fig. 5 when the coupling-head, Fig. 6, is inserted into the terminal-head, Fig. 5, which is affixed to car-frame X. Mistakes in

coupling are thus avoided. The wire terminal-heads which are affixed to the car-body may face in any suitable direction.

It should be understood that where we speak of "motive switch" we mean any switch which is self-containing so far as its motive mechanism is concerned and adapted to be used in substantially the same manner as the apparatus herein described.

Having now described our invention, we claim the following:

1. The combination of a plurality of motors, a series-parallel controller therefor, and an automatically-acting current-modifying device having its movable portion in circuit with said motors, and adapted to be actuated by an abnormally great flow of current and thereby interrupt the tendency of such current to affect the normal condition or action of said motors.

2. In a system of electrical control the combination of a motor or other translating device, a motive switch having a step-by-step motion and adapted to control the normal action of said motor or other translating device, means for placing said motive switch in communication with the source of power-supply, and an automatically-acting electromechanical device having its movable portion in circuit with said motor or other translating device and adapted to move and thereby interrupt the tendency of a current to affect the normal action or condition of said motor or other translating device.

3. In a system of electrical control the combination of a motor or other translating device, a motive switch having a plurality of current-conveying coils, each of which is energized independently of the other coils, a commuting-switch for electrically connecting said coils in sequence to the appropriate current-supply circuit thereby enabling said motive switch to control said motor or other translating device, and a spring or other device which constantly tends to cause the movable part of said commuting-switch to cut all of said coils out of the circuit and thereby permitting the motive switch to assume its normal position.

4. In a system of electrical control the combination of a motor, a motive switch for controlling the speed of said motor, the energizing-coils of said motive switch having one set of their terminals permanently connected together to lead current from said coils while the other set of their terminals are in a normally open circuit and a manually-operable switch which is adapted to connect the latter terminals in sequence to the open-circuit terminals of the current-supply circuit, said manually-operable switch being provided with means which constantly tends to cause said latter switch to cut out of circuit all of the coils of said motive switch.

5. In an electric system the combination of a driving-motor, a reciprocating motive switch for controlling the speed of said motor, one set of the terminals of the motive-switch-energizing coils being permanently connected together and leading to the armature of said motor while the other set of terminals of said coils are in a normally open circuit, and means for connecting the latter terminals in sequence to the current-supply circuit.

6. In an electric system the combination of a driving-motor, a motive switch for controlling the speed of said motor, a commuting-switch for controlling the action of said motive switch, a speed-controlling circuit connection between said commuting-switch and said motive switch, a driving-motor-reversing device having one terminal electrically communicating with the armature of said driving-motor and the other terminal of said device being adapted to be electrically connected to said speed-controlling circuits, and a single-point switch for controlling said motor-reversing device.

7. In combination, a motor, a controller therefor comprising fixed contacts and a movable contact, a series of separately-actuated devices adapted to move said movable contact step by step, in one direction, through a series of operative positions, and a commuting-switch controlling only the circuit connections which are adapted to successively operate said actuating devices to change the speed or work of said motor.

8. In an electrically-controlled system, the combination of a motor or other electrical translating device, a self-containing motive switch having a plurality of independent current-conveying coils, each of which when energized influences a movable electromagnetic body which is common to all of said coils, said coils being in a branch circuit in series with the motor, a contact carried by but insulated from said magnetic body and adapted to change the resistance of the motor-circuit, and means whereby said coils are connected in sequence to the supply-circuit.

9. In a system of electrical control the combination of a motor, circuits therefor, a motor-speed controller, a device adapted to control the direction of rotation of said motor-armature, a single group, or set of wires whereby both of said devices are connected to said motor and an automatically-acting current-modifying device in circuit with said motor and adapted to move and interrupt the tendency of a current to affect the normal action or condition of said motor.

10. In an electrical system the combination of a motor, circuits therefor, a motive-switch device, a direction-controlling device, both of said devices being connected to said motor-circuits, a commuting-switch, means for causing the latter switch to resume its normal position when the manual control of the said latter switch ceases, and means in circuit with said motor and adapted to move automatically and interrupt the tendency of a current to affect the normal condition or action of said motor.

11. In an electrical system, the combination of a motor equipment, a motive-switch device, having a plurality of coils, all of which influence, in sequence, one and the same electromagnetic body to change its position in reference to the motor-circuits and a commuting-switch adapted to connect said coils in sequence to the current-supply circuit, the said electromagnetic body being free to act promptly in response to any movement of said commuting-switch.

12. In an electrical system, the combination of two sets of contacts, one set being connected to the current-supply circuit while the contacts of the other set are each connected with one wire leading to a coil of the motive switch, means for connecting one of the contacts of the latter set with the appropriate one of the former set and an automatically-acting device in circuit with a motor and adapted to move upon the flow of an abnormal current and prevent such current from changing the normal condition or action of said motor.

13. In an electrical system, the combination of a driving-motor, circuits therefor, a plurality of simultaneously-actuated contacts for effecting changes in the motor-circuits a motive switch for controlling said contacts, and a commuting-switch mechanism connected therewith and to the motor-circuits whereby when the movable part of said commuting-switch is actuated one coil of the motive switch is brought into the motor-circuit.

14. In a system of electrical control, the combination of a motor, a commuting-switch, a motive switch, and a dead-resistance connection between the motive-switch coils and the ground or return-conductor.

15. In a system of electrical control, the combination of a motor, a commuting-switch, means whereby said commuting-switch always tends to stand at open circuit, a motive switch, a high-resistance temporary connection between the motive-switch coils and the ground or return-conductor, and a low-resistance connection between said motive-switch coils and the said motor.

16. In a system of electrical control, the combination of a translating device, a commuting-switch, a motive switch, an automatically-acting device which is adapted to move under the influence of an abnormal current and interrupt the tendency of such current to interfere with normal action or condition of said translating device, and a dead-resistance temporary connection between the motive-switch coils and the ground or return-conductor.

17. In a system of electrical control the combination of a motor-controlling apparatus having a series of wire coils and adapted to control said motor, the said coils of said apparatus having one set of their terminals permanently connected together and leading to one part of their supply-circuit, while the other set of their terminals are each in a normally open circuit, a manually-operable commuting-switch which is adapted to connect the latter terminals in sequence to the open-circuit terminals of their current-supply circuit, and means located at said commuting-switch whereby if the manual control of the latter switch ceases while the current is on, the circuits will be automatically opened.

18. In a system of electrical control, the combination of a motor, a commuting-switch, a motive switch, a normally open circuit connection between the motive-switch coils and the ground or return-conductor, and means whereby said circuit is closed to initially actuate said motive switch.

19. In an electrical system, a plurality of motor-controlling devices, each having its movable contacts carried by a suitable supporting apparatus, a plurality of separately-energizing coils operatively related to said supporting apparatus of each controller device, each of said coils, when energized, being adapted to cause the movable contacts to move through a portion only of the full length of their paths, a set of wires extending along the train and to which the said coils are connected, and a commuting-switch adapted to supply current simultaneously to the corresponding coils of the several controller devices.

20. The combination of a plurality of cars united to form a train, some of said cars being equipped with driving-motors, motor-speed-controlling apparatus upon each motor-equipped car, the motor portion of said controlling apparatus on each car being energized section by section, means on each motor-equipped car whereby the motors may be reversed, coupling-head devices on each motor-equipped car and connected with the speed-controlling apparatus and the motor-reversing means thereon, and means adapted to be coupled between the coupling-head on one motor-equipped car and a coupling-head on another motor-equipped car, whereby the corresponding sections of all of the motor-speed-controlling apparatus on the train may receive energy simultaneously by the movement of one switch, and all of said motors may be reversed at another time by the movement of another switch.

21. The combination of a plurality of cars connected up to form a train, motors upon and adapted to drive some of said cars, a plurality of wires fixed upon each motor-car, some of said wires, on any given motor-car, having five terminals, the corresponding terminals of the latter wires being grouped together and thus forming sets, two of such sets ending in commuting-switch apparatus, another two of said sets ending in two coupling-head devices located at the respective ends of the car, the remaining set of said terminals ending in sectionally-energized motor-controlling apparatus, and means adapted to be temporarily connected between the appro-

priate coupling-head device on one motor-car and a coupling-head device on another motor-car, whereby the corresponding coils of the motor-controlling apparatus on the several cars will be connected in multiple independently of the order or end relation of said cars, and thereby permitting the simultaneous control of all of the driving-motors by the manipulation of either commuting-switch.

22. The combination of a motor, sectionally-energized controlling apparatus therefor, a commuting-switch to govern said controller apparatus section by section, reversing apparatus for said motor, an independent switch adapted to govern said reversing apparatus, and means located at the commuting-switch whereby the motor-circuits will be caused to be automatically opened upon failure of the motorman to control said commuting-switch during the whole time that operative current is received by said motor.

23. In a system of electrical control, the combination of a pair of motors, a commuting-switch, a speed-controlling device and a direction-controlling device, said speed-controlling device being adapted to couple said motors in series and then in parallel, and both of said devices being electrically connected to the circuits of said motors.

24. In a system of electrical control, the combination of a pair of motors, a motive-switch device having a plurality of coils all of which influence, in sequence, one and the same electromagnetic body to change its position in reference to the said motors, to couple them in series and then in parallel, and a commuting-switch adapted to connect said coils in sequence to the supply-circuit.

25. In a system of electrical control, the combination of a pair of motors, circuits therefor, a plurality of simultaneously-actuated contacts for effecting changes in the electrical connections between said motors, a motive switch for controlling said contacts, and a commuting-switch mechanism connected therewith and with the motor-circuits whereby, when the movable part of said commuting-switch is moved from one pair of its contacts to its next such pair, the resistance in said motor-circuits is thereby caused to change said motive switch being adapted to be connected in series with a motor.

26. In a system of motor control, the combination of a driving-motor, circuits therefor, sectionally-energized speed-controlling apparatus connected to the motor-circuits, a switch for governing said speed-controlling apparatus, motor-reversing mechanism connected to the motor-circuits and adapted to act only when the reversal of said motor is desired, and a switch to govern the action of said reversing mechanism.

27. In a system of motor control, the combination of a plurality of driving-motors, circuits therefor, sectionally-energized speed-controlling apparatus connected to said circuits and adapted to connect said motors in series and then in multiple, a switch for governing said speed-controlling apparatus, motor-reversing mechanism connected to the motor-circuits and adapted to constantly maintain such connection except during the reversal of said motors and a switch adapted to govern said reversing mechanism.

28. In a system of electrical control, the combination of a pair of motors, a motive switch for changing the relation of said motors from series to parallel, a commuting-switch, and a reversing device for each such motor, the coil or coils of one reversing device being in series with the coil or coils of the other such device.

29. The combination of a plurality of electrically-equipped cars, each of such cars having a driving-motor, a plurality of wires upon each car, such wires having five terminals, the corresponding terminals of the several wires upon a car being grouped together to form sets, two of such sets ending in commuting-switch apparatus, another two of said sets ending in two coupling-head devices, at the respective ends of the car, the remaining set of such terminals ending in motor-controlling apparatus, and means whereby the said terminals at the adjacent ends of two cars may be electrically connected together and the corresponding coils of the several controller devices connected in multiple and thereby permitting the simultaneous control of all of the driving-motors by the manipulation of either of said commuting-switch apparatus.

30. The combination of a circuit, and two unlike switches connected therein, one of said switches being adapted to control the other, and both having a constant tendency to automatically open the circuit.

31. The combination of a motor, a motive switch, for controlling said motor, and a single set or group of wires having five sets of terminals, two of the latter sets terminating in coupling-heads, one at each end of the car, two other of the said five sets ending in commuting-switch contacts, and wires of the remaining set of terminals being connected to the coils of the motive switch.

32. A train equipment which includes a motor or motors upon each car of such train, and a motive switch of the character described, carried by each car to control said motor or motors, such motive switches being arranged in multiple relation with each other and the entire plurality of such devices being controllable upon the manual operation of one commuting-switch, said commuting-switch being adapted to be connected in series with a motor.

33. In a system of motor control, the combination of a driving-motor, circuits therefor, speed-controlling apparatus connected to the motor-circuits, a hand-switch for governing said speed-controlling apparatus, means located at said hand-switch and adapted to cause said motor-circuits to be automatically opened if the manual control of said

hand-switch ceases while the motor is receiving operating-current, motor-reversing mechanism connected to the motor-circuits and adapted to constantly maintain such connection except during the reversal of said motor, and a switch for controlling said reversing mechanism.

34. In a system of electrical control, the combination of a plurality of cars, motors on some of said cars, sectionally-energized motor-controlling apparatus upon each of the motor-cars, commuting-switches for governing the motor-controlling apparatus, motor-reversing mechanism upon each motor-car and having a connection with said motors, such connection being constantly maintained except during the reversal of said motors, and means adapted to so couple the motor-governing devices on one car to such devices on another car that the manual operation of any one of said commuting-switches will cause all of said motor-controlling apparatus to act simultaneously independently of the order or end relation of said cars.

35. In a system of electrical control, the combination of a translating device, a commuting-switch, and a motive switch having a plurality of contacts carried by the movable part thereof and in series with the coils of the stationary part of the latter switch.

36. In a system of electrical control, the combination of a translating device, a commuting-switch, and a motive switch having a plurality of contacts carried by the movable part thereof and in series with the coils of the latter switch and also in series with said translating device.

37. In a system of electrical control, the combination of a translating device, a controlling device therefor and an automatic device acting independently of said controlling device and without disturbing the movement thereof, and adapted to proportion the energy received by said translating device to the work being done by the latter device.

38. A train of electrically-equipped cars, each car having a commuting-switch and a reversing-switch at each end thereof, means for coupling said cars together so that the several cars may be operated simultaneously from any one of the several commuting-switches, motive switches, one upon each car, circuit connections between the commuting-switches and the motive switches whereby all of the latter switches may be controlled by any one of the former switches, and motors carried by each car, said motors being governed by such appropriate motive switches as herein described.

39. In an electrically-equipped train system, the combination of motors to drive the train, a self-containing motive-switch device upon each car and adapted to change the connections of the car-motors from series to multiple and vice versa, two commuting-switches upon each car, each such latter switch being adapted to cause the several motive switches to simultaneously adjust the motors under their control, a motor-reversing device on each car and means upon each car whereby the several reversing devices may be controlled from any car on the train.

40. In an electrically-equipped train consisting of "added units" or a series of independently-equipped cars, the combination of a plurality of motors for each car, a motor-controlling switch on each car to control the said motors thereon, a motor-reversing means upon each car, means whereby the several motors upon the train may be adjusted simultaneously from any car of the train, and means adapted to move automatically and acting independently of any of said apparatus to prevent the power-current from causing an abnormal action or condition of said motors.

41. A train of cars each equipped with a motor to drive it, a common controlling device for the motors, means which tend to hold said device out of the circuit, and means acting independently of the said motors and without disturbing any of the controlling apparatus to check any tendency of the power-current to cause the motors to become abnormal.

42. A train with cars each individually equipped with a pair of driving-motors initially coupled together in series, and a current-varying controller therefor, the motors on each car being initially coupled in multiple series with respect to those on the other cars, and means whereby said controllers are always caused to move synchronously and isochronously, thereby the connections of the several pairs of motors are simultaneously changed from series to multiple.

43. In a system of electrical control, the combination of driving-motor, a motive switch having a series of independently-energizable coils, and a commuting-switch adapted to control said motive switch, the contacts carried by said motive switch being insulated from each other and from the parts of said motive switch upon which such contacts are mounted.

44. In a system of electrical train control, the combination of a plurality of cars each having a driving-motor, motor-controller apparatus upon each such car, and means adapted to electrically connect any given point of each controller apparatus with the corresponding point of each of the other of said controller apparatus.

45. In a system of electrical train control, the combination of a plurality of cars each having a driving-motor, motor-controlling apparatus upon each such car, means adapted to electrically connect the motor-controlling apparatus on one such car to such apparatus on another car so that a given point of one controller apparatus will be in electrical connection with the corresponding point of each of the other controller apparatus.

46. In a system of electrical control, the

combination of a plurality of cars each having a motor to drive it, a motor-speed controller upon each such car, a commuting-switch for each speed-controller and means adapted to so couple the said electrical apparatus on one car to such apparatus on an adjacent car that the manual operation of any one of said commuting-switches will cause all of said speed-controllers to simultaneously and synchronously change the action of said motors.

47. In a system of electrical control, the combination of a plurality of electrical conductors, a plurality of motors connected between said conductors, motor-control apparatus in electrical communication with said conductors, and means adapted to be energized section by section and thereby cause said control apparatus to change the relation of said motors from series to parallel.

48. In a system of electrical control, the combination of a plurality of conductors, a plurality of motors, connected between said conductors, a motor-control apparatus in electrical communication with said conductors, means adapted to be energized section by section and thereby cause said control apparatus to change the relation of said motors from series to parallel, and means adapted to reverse said motors.

49. The combination of a plurality of electrically-equipped cars, a motor-controlling device upon each such car, means adapted to electrically connect the motor-controlling device on the car to such device on an adjacent car, and means adapted to cause all of said controlling devices to start simultaneously and move with a synchronously step-by-step motion.

50. In an electrical system, the combination of plurality of cars, each having two commuting-switches thereon, a commuting-switch or operator's line on each such car and connected between the two said switches thereon, and branches from said switch-lines and adapted to electrically connect the commuting-switches on one car with such devices on the adjacent car independently of any other electrical circuit.

51. An electrically-equipped car having in combination, a motor, controlling apparatus therefor, a plurality of commuting-switches, one each for the respective ends of the car, a group of wires connected between said commuting-switches, a plurality of coupling-heads, one each for the respective ends of the car, each of such heads having all of its connecting fingers or terminals arranged in a vertical series, and appropriate connections between said fingers or terminals and said group of wires.

52. An electrically-equipped car having in combination, a motor, controlling apparatus therefor, a plurality of commuting-switches, one each for the respective ends of the car, a group of wires connected between said commuting-switches, a plurality of coupling-heads, one each for the respective ends of the car, each such heads having all of its connecting fingers or terminals arranged in a vertical series, and appropriate connections between said fingers or terminals and said group of wires, the arrangement being such that a given wire will be connected to fingers or terminals, in the respective coupling-heads, which have the same relative position when the said two series of fingers or terminals are compared.

53. The combination of a plurality of cars, each having a motor to drive it, a motor-controller for each car, and means adapted to electrically connect the corresponding points of all the controllers.

54. The combination of a plurality of cars, each having a motor to drive it, a motor-controller for each car, means adapted to deliver electrical energy simultaneously to the corresponding points of all the controllers and means adapted to reverse said motors.

55. In a motor-controller, the combination of a plurality of coils adapted to be successively energized, and means external to the finally-energized coil and adapted to maintain a minimum current in the latter coil.

56. In motor-control apparatus, the combination of a plurality of individually-actuated coils, and a branch circuit therefrom and in series with the motor.

57. In motor-control apparatus the combination of a plurality of individually-actuated coils having a branch circuit in series with the motor, and contacts moved by said coils.

58. The combination of a motor, a plurality of individually-actuated coils having a branch circuit in series with said motor, and a commuting-switch adapted to actuate said coils.

59. The combination of a motor, and controller apparatus, the coils of the latter apparatus having a branch circuit in series with said motor, and another branch circuit in parallel with said motor.

60. A car, a driving motor or motors thereon, a circuit therefor, a plurality of movable contacts for effecting changes in the motor-circuits, means adapted to operate said movable contacts, and a commuting-switch connected therewith and communicating with a branch circuit which is in series with said motor.

61. A plurality of cars, a plurality of driving-motors on such cars, a set of fixed contacts and a set of movable contacts for effecting changes in the circuits of the motors, means adapted to actuate said movable contacts, and commuting-switches on the several cars and connected with the contact-actuating means and communicating with a branch circuit which is in series with the motor.

62. A plurality of cars, a plurality of driving-motors for such cars, a plurality of contacts for reversing said motors, means adapted to actuate said contacts, means adapted to connect the electrical apparatus on one car to

that on an adjacent car, commuting-switches communicating with said contacts, and means adapted to be energized section by section to connect the motors in series and in multiple.

63. A plurality of cars, a plurality of driving-motors for such cars, a plurality of contacts for reversing the motors, means adapted to actuate said contacts, means adapted to connect the electrical apparatus on one car to that on an adjacent car, commuting-switches communicating with said contacts, and means adapted to be energized section by section to connect the motors in series and in multiple and to vary the resistance in circuit therewith.

64. The combination of a plurality of motors, a plurality of fixed contacts and a movable contact, means controlled thereby for changing the grouping of the motors from series to parallel and vice versa, and electromagnetic apparatus energized section by section to control said means.

65. A plurality of cars, driving-motors upon a number of such cars, movable contacts for changing the circuit connections of the said motors to vary the work performed thereby, means energized section by section to control said contacts, means adapted to connect the electrical apparatus on one car to such apparatus on another car, and one or more commuting-switches for controlling said movable contacts.

66. The combination of one or more commuting-switches each provided with a plurality of contacts, a plurality of motors, and controller apparatus adapted to connect said motors in series and then in multiple, the said controller apparatus being provided with a set of fixed contacts and a plurality of movable contacts and adapted to have one section energized to move said movable contacts one step when the commuting-switch makes connection with one of its contacts.

67. The combination of a plurality of motors, a controller apparatus therefor, and a commuting-switch adapted to govern the controller apparatus section by section, the said controller being so arranged and connected that it will automatically open the motor-circuit upon the failure of the line-current.

Signed at New York, in the county of New York and State of New York, this 25th day of January, A. D. 1898.

GRANVILLE T. WOODS.
LYATES WOODS.

Witnesses:
L. E. WOODS,
C. E. OSTER.