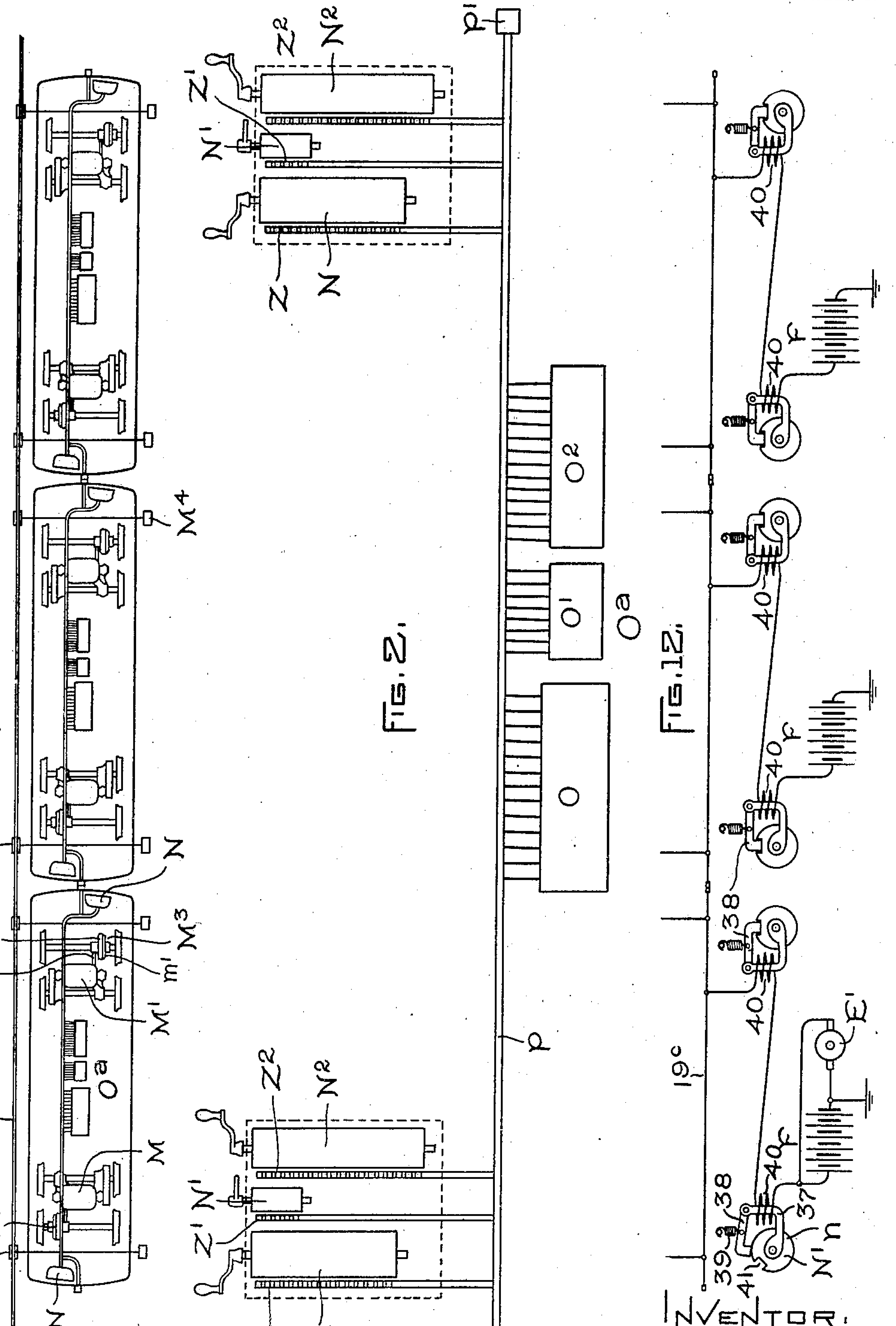
No. 736,816. PATENTED AUG. 18, 1903.

F. E. CASE.

SYSTEM OF TRAIN CONTROL.

APPLICATION FILED FEB. 28, 1898.

NO MODEL. 4 SHEETS—SHEET 1.



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APPLICATION FILED FEB. 23, 1898.

NO MODEL. 4 SHEETS—SHEET 2.

FIG. 3.

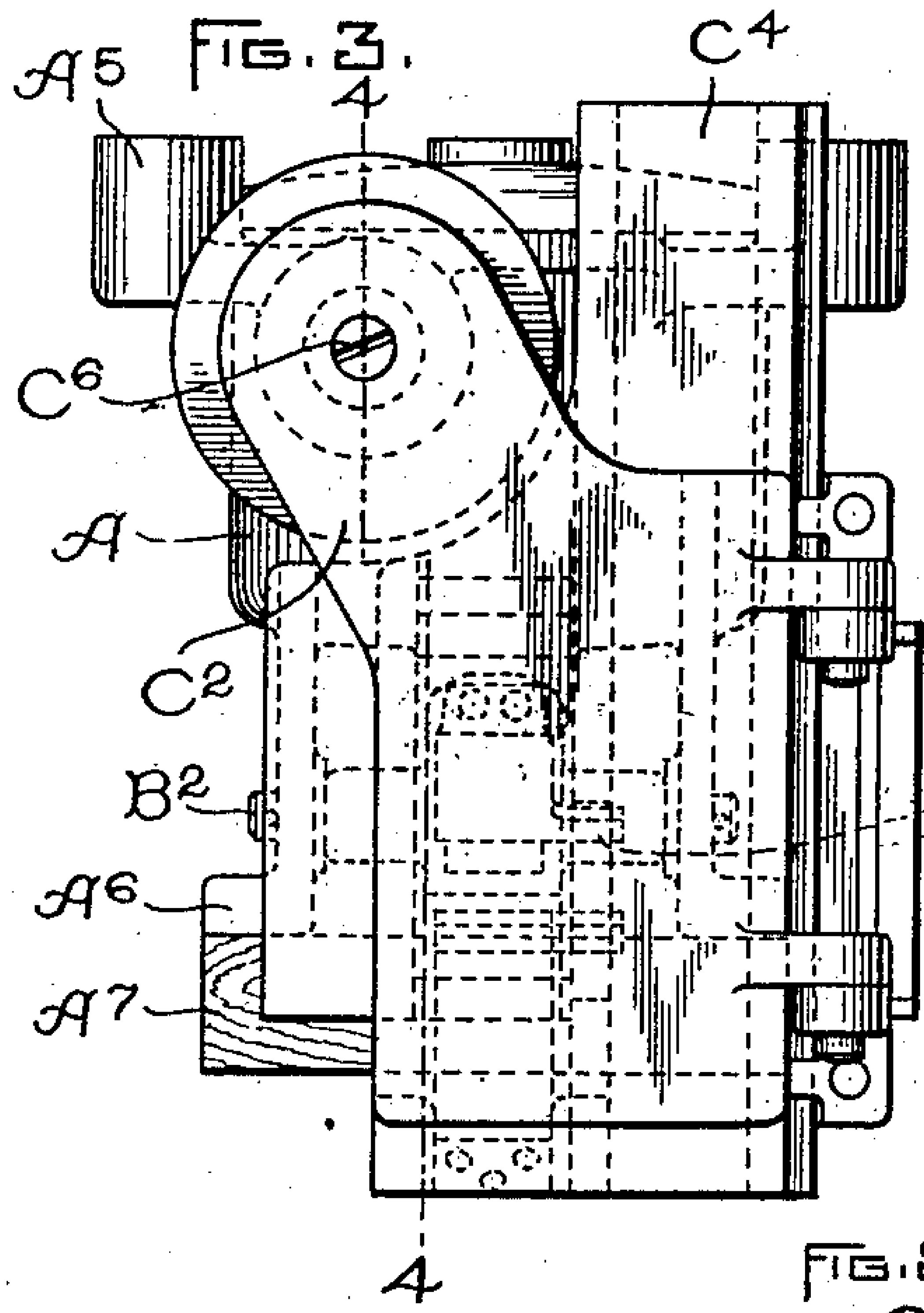


FIG. 4.

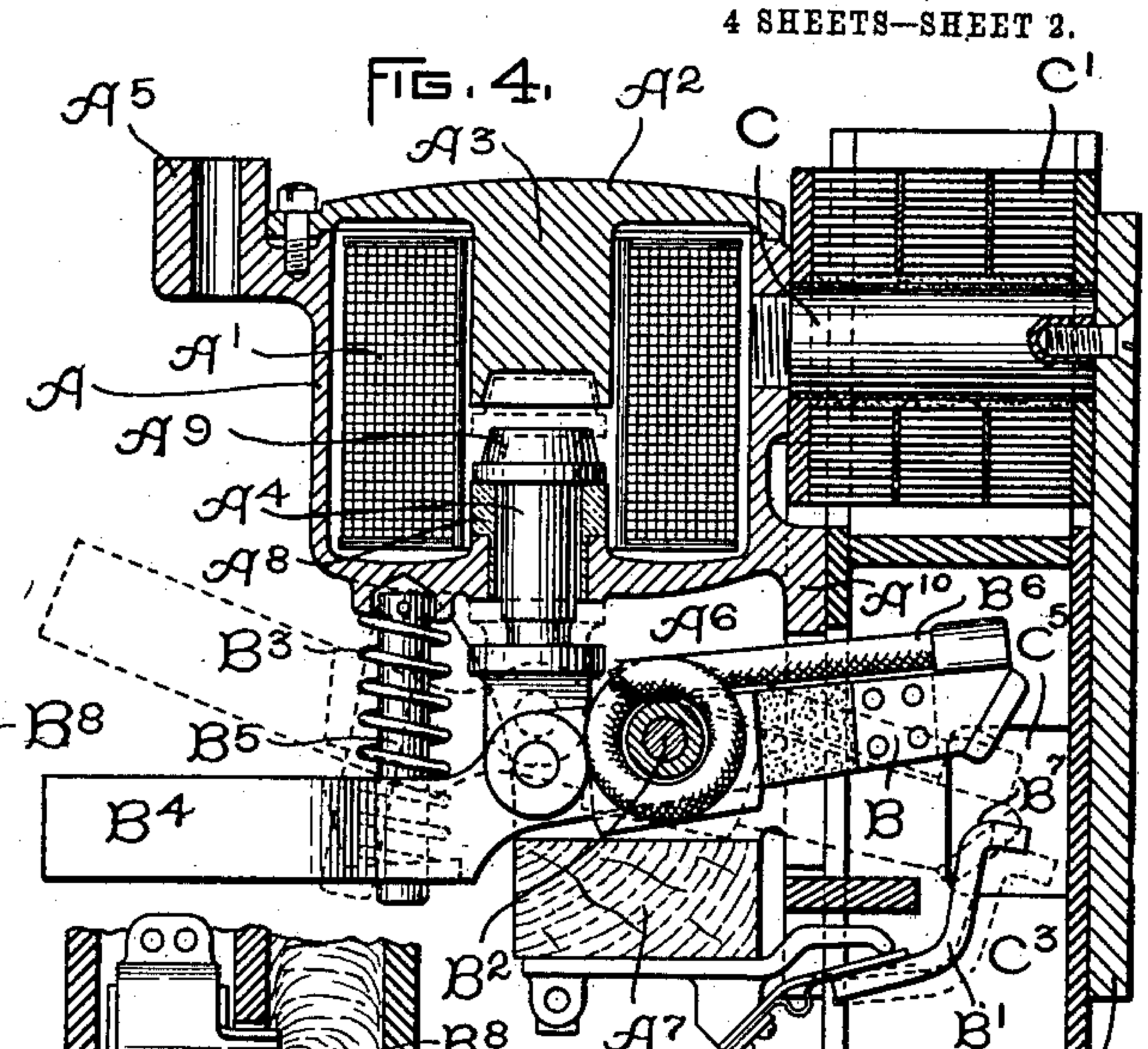


FIG. 5.

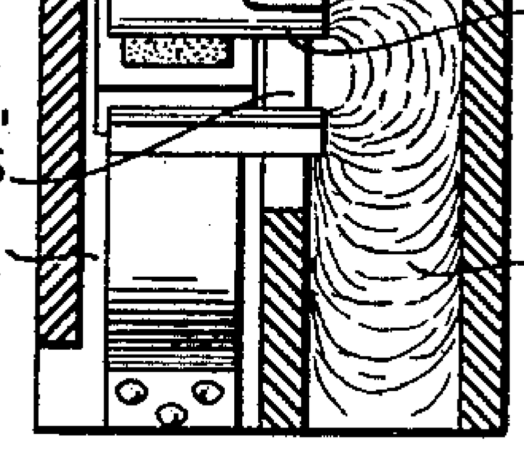


FIG. 5a FIG. 5b

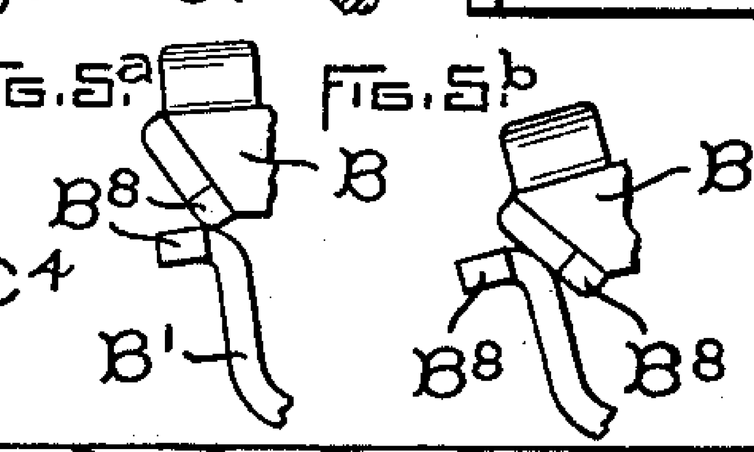
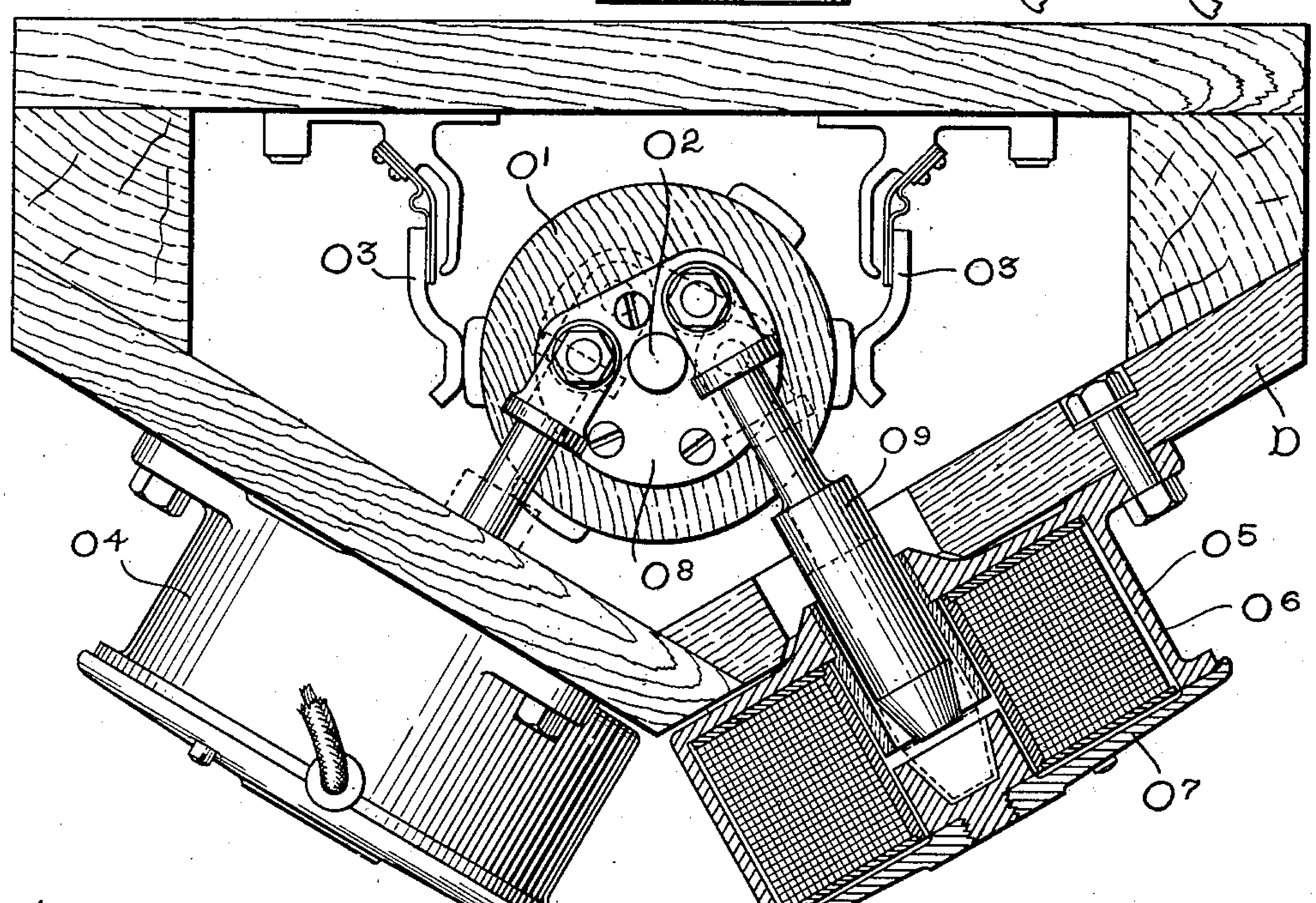


FIG. 6.



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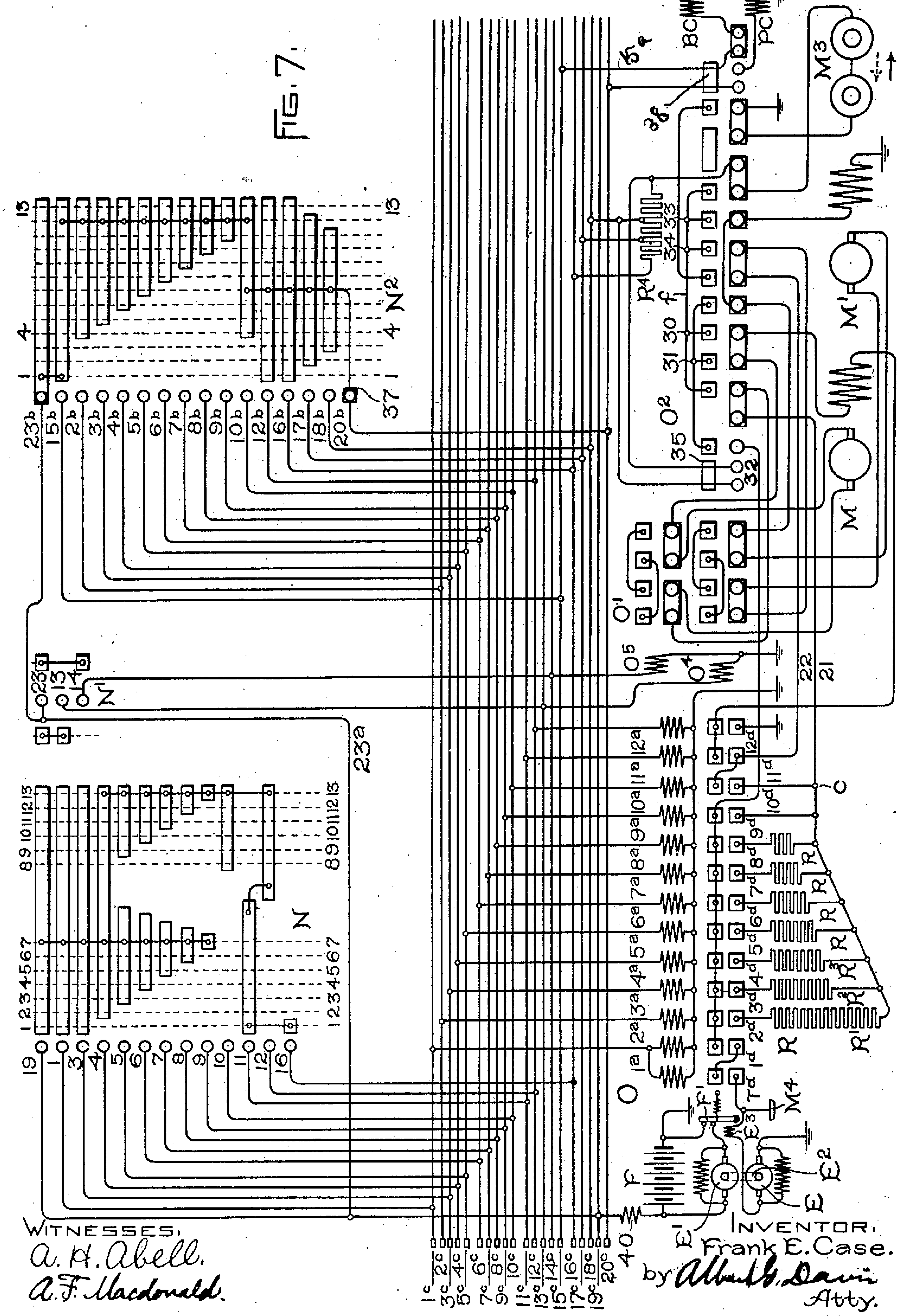
NO MODEL. 4 SHEETS—SHEET 3.



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NO MODEL. 4 SHEETS—SHEET 4.

FIG. 8.

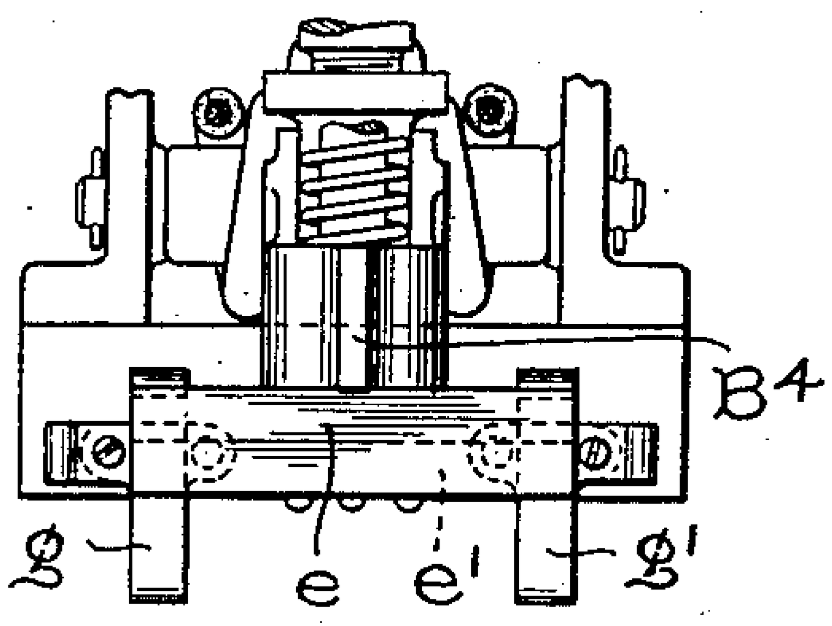


FIG. 9.

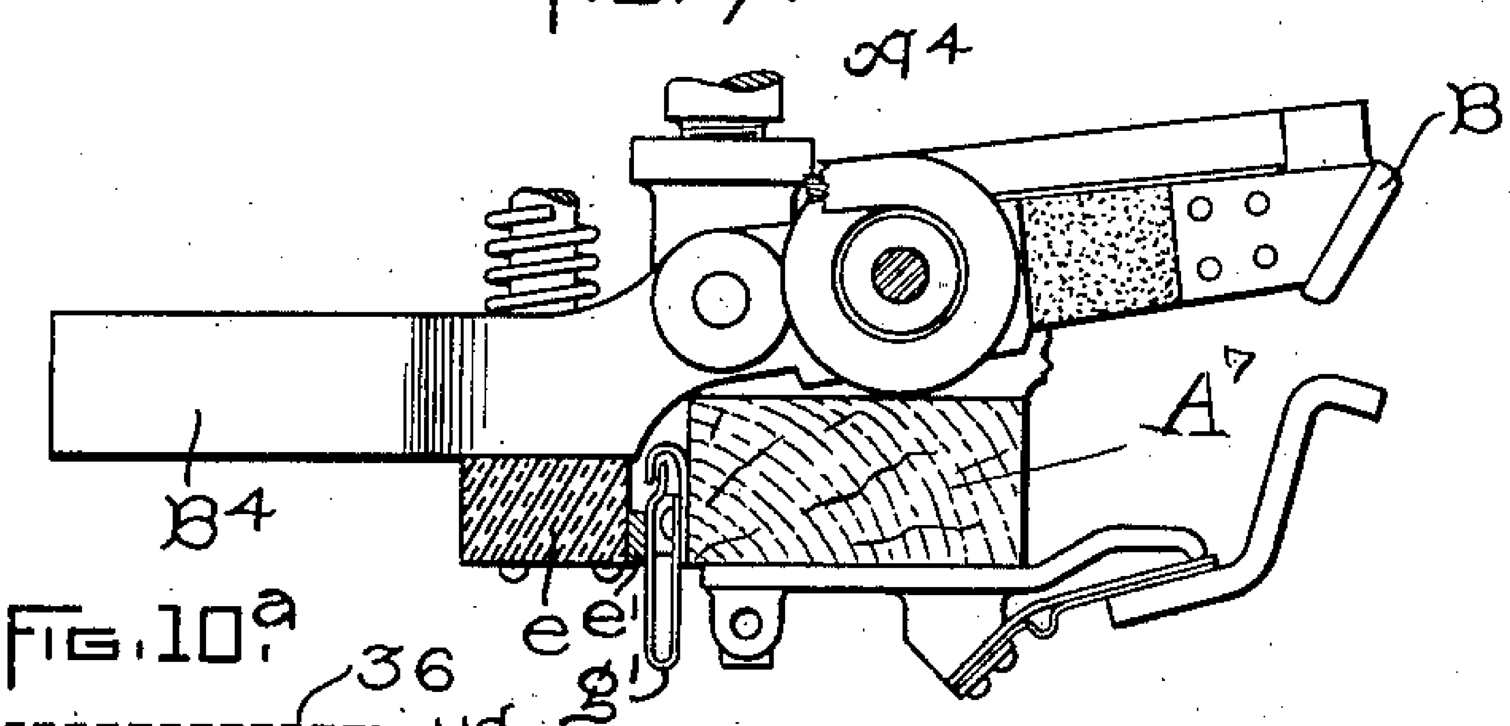


FIG. 10a.

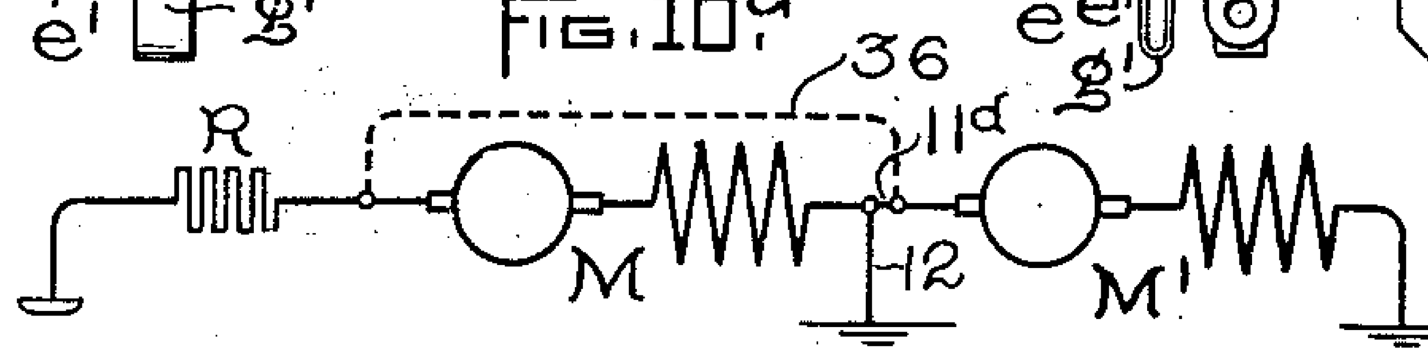
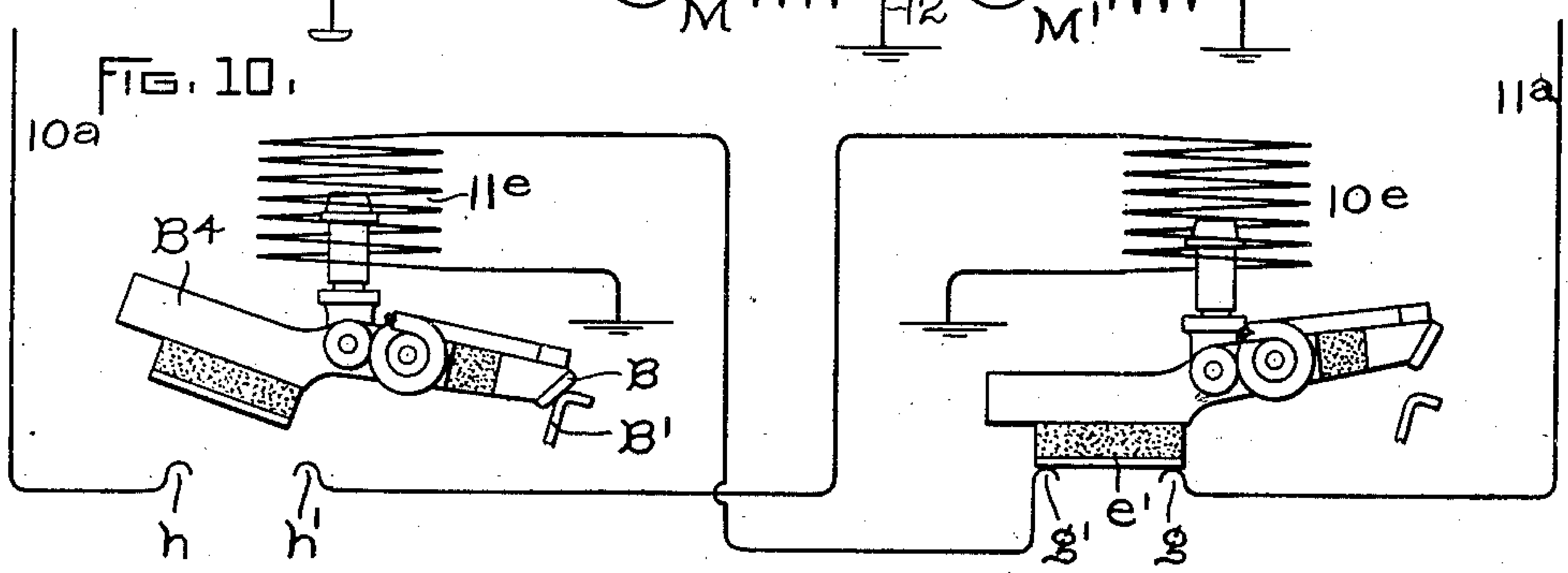


FIG. 10.



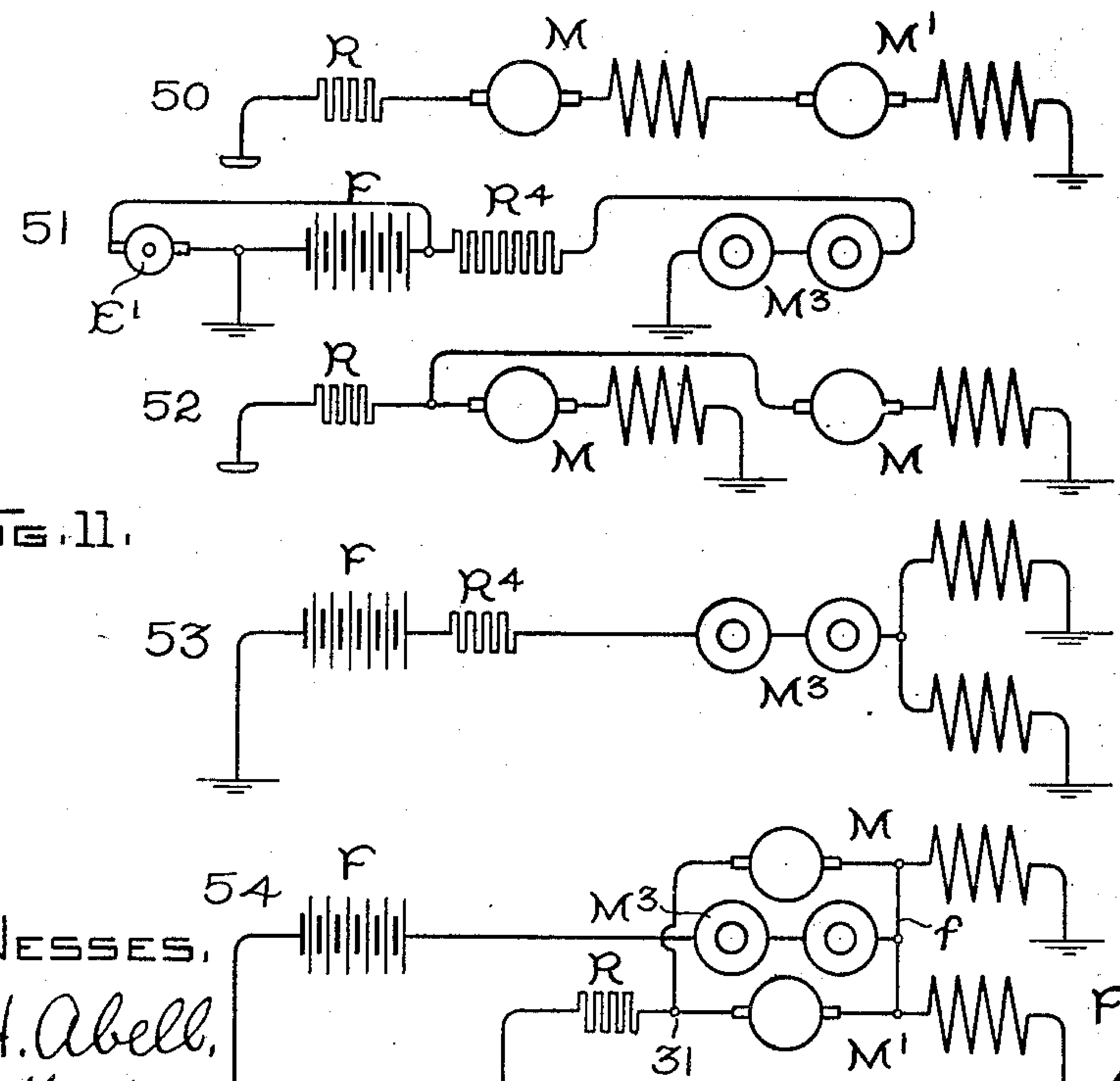


FIG. 11.

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No. 736,816. Patented August 18, 1903.

UNITED STATES PATENT OFFICE.

FRANK E. CASE, OF SCHENECTADY, NEW YORK, ASSIGNOR TO THE GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK.

SYSTEM OF TRAIN CONTROL.

SPECIFICATION forming part of Letters Patent No. 736,816, dated August 18, 1903.

Application filed February 28, 1898. Serial No. 671,994. (No model.)

To all whom it may concern:

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

In order to obtain the greatest tractive and accelerating effort on a train propelled by electric motors, it is necessary to divide the motive force into a number of units and to apply the several units to the axles of the different cars.

To successfully operate a train having a number of motor-cars, it is necessary that the controlling be done from a single point on the train; otherwise the motors of one car may be called upon at times to do an amount of work which differs materially from the amount being done by the motors of another car.

To reduce the complications of a train system to a minimum and to enable the train to be conveniently made up of different lengths as may be required, it is desirable to make each motor-car a complete unit in itself—that is to say, to provide it with a contact device, motor or motors, and a suitable controlling mechanism, which is arranged to work in conjunction with other controlling devices on the train. The system should be so arranged that any number of similar cars may be coupled together in any desired order or position and that all the motors of the train may be controlled from any one of the cars. Further, it is highly desirable that the contact devices on each car should take current sufficient for the needs of that particular car only and that the heavy currents which actuate the motors should not pass from car to car.

It is the principal object of my invention to provide a system of train control fulfilling the requirements above set forth, such that from any selected point on the train all of the machines may be made to act simultaneously and equally to accelerate the train or to maintain it in motion in either direction or to retard it evenly and strongly and that all of these actions in all cars of the train may be under the control of a single motorman.

In carrying out my invention I prefer to divide the motors of the train into sets, each set preferably comprising the motor equipment of a single car, and to govern each set of motors by a separate set of motor-controlling devices, and, further, to provide at a number of selected points on the train master-controllers so arranged that each desired master-controller will actuate all of the motor-controllers.

It is obvious that with the arrangement above outlined at any particular time the train as a whole will be operated from a single selected point. It is one object of my invention to provide means sufficient to prevent any successful attempt from any other point to interfere with such operation. To this end I may provide an interlocking arrangement, preferably electrically controlled, such that any movement of either of the master-controllers from its off position will automatically lock all other master-controllers of the train. These devices are preferably so arranged that as long as all of the master-controllers are at the off position any one of them may be operated, while the operation of that one will lock all of the others.

It is another feature of my invention to provide each master-controller with three switches—the power-switch, the reversing-switch, and the braking-swith, respectively, and to divide the motor-controllers into corresponding switches or divisions.

It is a further feature of my invention to accomplish a part of the motor control, as the usual series-parallel and resistance steps, by a number of separate contacts or switch-blades, while the other steps are provided by the action of controller-cylinders or their equivalents. All of these devices should be controlled or actuated by electromagnetic means.

My invention also comprises various details of construction and arrangement, to be hereinafter more particularly described and claimed.

In the accompanying drawings, which show an embodiment of my invention, Figure 1 represents diagrammatically a three-car train viewed from below. Fig. 2 is a diagram illustrating the controllers and cables on a single car. Fig. 3 is an end elevation of a contact-operating magnet. Fig. 4 is a section of a magnetically-operated contact, taken on the line 4 4 of Fig. 3. Fig. 5 is a detail section of the stationary and moving contacts, together with the arc-disrupting chute. Figs. 5^a and 5^b are details of the contacts. Fig. 6 is an end view of a switch-operating mechanism. Fig. 7 is a diagram of the motor and controller circuits. Figs. 8 and 9 are detail views of a slight modification of the magnetically-actuated contacts. Fig. 10 is a diagram of the circuit connections of the modified contacts. Fig. 10^a shows the applications of said contacts to the motor-circuits. Fig. 11 illustrates diagrammatically the motor and brake combinations, and Fig. 12 illustrates the locking device for the controllers.

Referring to Fig. 1, I have shown each car provided with two motors M M′, mounted, respectively, on two of the four axles; but the number may be varied to suit the traffic conditions. Mounted on those axles which are not provided with motors are electromagnetic brakes M^3, of any desired construction, the ones shown comprising a disk m', which revolves with the axle, and a magnet m, which is prevented from rotating by bar m^2, as well understood in the art. By this arrangement the retarding effect is applied to all the car-axles, and consequently a good distribution of the braking effect is obtained. If all the axles on the vehicle are provided with electric motors, then the brake-magnets may be mounted in the usual manner and the braking effect of both brake-magnet and generator obtained from each axle. One or more contact devices M^4, making contact with the stationary conductor M^5, should be provided for each car. Situated on the front and rear platforms of the cars are shown "master-controllers" N, so called because they regulate the operation of the motor-controllers O^a, which are located under the car or seats, as may be desired.

Referring to Fig. 2, the relation of the master and motor controllers is clearly shown. Each motor-controller consists of three switches O O′ O^2, which will be more fully described in detail later; but for the present it is sufficient to say that switch O is arranged to couple the motors in series and parallel and to control the resistance of the circuit. Switch O′ is the ordinary reversing-switch arranged to establish the proper relation of the motor-circuits for forward and backward movement of the car, and switch O^2 assists while in one position to establish the proper relation of the motor-circuits when the motors are employed in propelling the vehicle and in the other position to convert the motors into braking-generators employed to retard the progress of the car and to apply the brake-magnets.

The master-controller consists of three cylindrical switches N, N′, and N^2, each provided with a separate actuating-handle, and while no interlock mechanism is shown between the switches it is to be understood that such a mechanism is employed and may be of any of the well-known constructions. Mounted for engagement with the cylinders N N′ N^2 are vertical rows of stationary brushes Z Z′ Z^2, which are connected, respectively, as will be shown hereinafter, to the various wires of a cable P, which extends through the car. Since the master-controllers of the different cars are similar in construction and connected to the cable in multiple-arc relation, similar movements produce similar relations of the circuits. The switch or power cylinder N, through suitable electromagnetic means to be hereinafter described, controls the action of the series-parallel motor-switch O. Reversing-cylinder N′ controls the action of the motor-reversing switch O′, and brake-cylinder N^2 controls the action of the power brake-switch O^2. The ends of cable P are provided with terminals P′, which engage similar terminals on adjacent motor-cars. For simplicity of illustration no trail-cars are shown on the train; but it is to be understood that they may be employed and placed between the motor-cars or at the front or rear end of the train, as desired. Obviously it is possible to place a master-controller upon one or more of the trail-cars and to omit them from one or more of the motor-cars, if preferred. When trail-cars are placed in front of or between motor-cars, it will be necessary to provide them with a cable P in order to complete the train connections.

As the master-controllers do not vary the motor-currents, but only the small currents necessary for switching purposes, they need not be as large and heavy as the motor-controllers.

The motor-controller O comprises a plurality of separate electromagnetically-actuated contacts or switches of the form shown in Figs. 3, 4, and 5. Each contact is provided with a cup-shaped casting or supporting-frame A, arranged to form a part of the magnetic circuit, and within said casting is mounted an energizing-coil or solenoid-winding A′. Secured to the top of casting A is a cover A^2, provided with a downwardly-extending core A^3, slightly hollowed out at its lower end to receive the upper end of core A^4. On the side of casting A are lugs A^5, by means of which the contacts or the switches as a whole are secured to a suitable support. Extending downwardly from the casting are lugs A^6, which support pivots B^2 of the switch-blade B, at the same time forming a part of the magnetic circuit of the blow-out. Connecting the lower ends of the lugs A^6 is a piece of wood or other insulating material A^7, forming a support for the stationary contact B′. The core A^4 is pivotally secured at its lower end to switch-arm B and under normal conditions—that is, when no current is flowing in coil A′—is held in the position shown by a compression-spring B^3 and by the weighted arm B^4. The spring B^3 surrounds a pivoted pin B^5, which acts as a guide for the switch-arm and at the same time retains the spring in place. The movable core A^4 is surrounded by a non-magnetic bushing A^8 and surmounted by a sheet-metal cap A^9 to prevent it from sticking to the casting and stationary core A^3. The outer and inner ends of the switch-blade are insulated from each other, as indicated in the drawings, and connection is established between the outer end of the switch-blade and the motor-circuit by a flexible cable B^6, which is wrapped around the pin B^2 to further increase the flexibility of the connection. The stationary terminal B' consists of a spring-supported piece of metal provided at its outer end with a rounded portion B^7, with which the switch-blade makes contact. The switch-blade and fixed brush are provided with arcing points or projections B^8, as shown in Figs. 3 and 5. The arrangement of the terminal mounted on the switch-blade and the terminal constituting the fixed brush is a particularly desirable one, for it permits a wiping connection between the parts as they are moved to the position shown by the dotted lines, Fig. 4, yet when the parts are free to return to their normal position there is no friction between them tending to retain them in the closed position. On the contrary, there is a decided effort exerted by the brush, tending to force the switch-blade back to its full-line position. The direction of the wiping movement is transverse to the movement of approach of the switch terminals or contacts. When the circuit is first closed between the switch-arm B and brush B', the projections B^8 are in contact; but as the switch-blade moves to its final closed position, as shown in dotted lines, Fig. 4, the projections B^8 move away from each other. This particular feature is more fully represented in Figs. 5^a and 5^b. In the first figure switch-blade B is just making contact with the fixed brush B' and the projections B^8 are in contact. These projections being the first to close the circuit are the last to break it. Consequently all of the arcing takes place at this point, and the remainder of the parts are left bright and clean. Fig. 5^b represents the final closed position of the switch-blade, the projections B^8 being separated by a definite space. No matter how much arcing takes place at the projections B^8 the contact between the parts will always be good, for it is made at some distance from the point at which the arc forms.

Screw-threaded to casting A is the blow-out-magnet core C, and surrounding the core is a winding C', consisting of a number of turns of flat metal ribbon which is connected to cable B^6 in any suitable manner. The downwardly-extending lugs A^6 are connected by a web A^{10}, having a central opening through which extends the switch-blade. This web, in connection with lugs A^6, forms one pole-piece for the blow-out magnet, and plate C^2 forms the other. Plate C^2 is hinged on the right-hand side to enable it to be swung outward when it is desired to inspect the contacts and is retained in position by a screw C^6, which enters the core C. Situated between the metal parts of the blow-out magnet and the switch-blade are insulating-walls which form an open-bottom chamber C^3. Extending parallel to this chamber in a vertical direction is a rectangular open-ended chute C^4, made of insulating material. The chamber and chute are connected by a rectangular opening C^5, through which project the arcing extensions B^8 of the switch-blade and fixed contact-brush. By winding coil C' in the proper direction the arc may be made to travel toward the extensions B^8 and into the open-ended chute C^4, since an arc when in a magnetic field tends to travel at right angles to the direction of the lines of force. This action causes the arc to be stretched, as shown in dotted lines in Fig. 5, and as the arc is blown farther away from the contacts by the action of the magnet it strikes against the side wall of chute C^4, and as the progress of the arc in this direction is limited by the wall of the chute, the arc still being within the influence of the magnetic field, it is expanded in flattened loops until disrupted, the sides of the loops extending parallel to the side walls of the chute. By this arrangement it will be seen that the arc is first blown to the right for a certain distance and then by reason of the restrictions afforded by the walls of the chute the arc is blown in two directions from a central point and parallel to the direction of movement of the moving switch-blade or contact B.

In Fig. 6 I have shown the means employed for actuating the motor-reversing switch O'. The reversing and power brake switches of the motor-controllers being similar in construction, except for the number and relation of the contacts, a description of one of them will be sufficient. The reversing-switch cylinder O' is provided with a central shaft O^2, mounted in suitable bearings. (Not shown.) On the outer periphery of the cylinder is a plurality of contacts arranged to make and break the circuit of fixed brushes O^3. The cylinder is actuated by means of iron-clad electromagnets O^4 and O^5. These consist of cup-shaped castings O^6, provided with detachable covers O^7, having inwardly-projecting and hollowed-out cores. Mounted upon the top of the switch-cylinder is a metal plate O^8, to which are attached the movable magnet-cores O^9. By setting the magnets O^4 and O^5 at an angle to each other I am enabled to economize space, and also to limit the movement of the cores by securing them to the switch-cylinder at points near the center of movement. The parts are shown as being mounted on a wooden support D, but any other form of support may be employed.

With the parts in the position shown the power-circuit is established, the motors being connected in the proper manner to propel the car in the forward direction. The dotted-line position represents the reverse of the above.

For operating the separate contacts and also the motor-controller and reversing-switch I prefer to employ a source of power in addition to that supplied to the motors, so that in the event of failure of the motor-supply from any cause I am still able to control the action of any one of the contacts or switches. For braking the vehicle or train suitable switch mechanism is provided for converting the motors into generators and connecting them in local circuit, resistance being employed to regulate the flow of current. In addition to these generator-brakes the separate source of energy employed for actuating the switches and contacts is utilized for braking purposes. This is accomplished by providing the cars with suitable brake-shoes *m m'*, Fig. 1, provided with energizing-coils, (indicated in diagram at M^3, Fig. 7,) and passing a current from the said source through the coils, suitable regulating means being employed. In operating the brakes I prefer to close the circuit of the brake-magnets before setting the generator-brakes in action; but this is not essential. By this arrangement I obtain the advantage of a double set of brakes, each independent of the other, the power of the braking-generators decreasing relative to the decrease in speed of the moving train or vehicle, while the braking effect of the brake-magnets may be constant or increasing as the current in the braking-generators decreases. The arrangement possesses a further advantage in that the brake-magnets will hold the car when stopped on a grade without the use of hand or air brakes, since the source of supply for the brake-magnets is independent of the braking-generators.

In Fig. 7 the circuits of the controllers and motors are illustrated in detail, also the storage battery and motor-generator used to actuate the contacts and switches. The storage battery F is charged by means of a motor-generator comprising two separate armatures E E', mechanically coupled by shaft E^2. If desired, a single armature having a double winding may obviously be employed. The motor E, which is provided with a shunt field-winding, is supplied with current from contact-shoe m^4. The windings of the motor-generator are so arranged that the voltage of the battery-charging circuit is reduced from that of the line. Under normal conditions—that is, with the full main-line voltage—the motor-generator E' will supply the current employed for actuating the separate contacts, the reversing-switch O', power brake-switch O^2, and the brake-shoes M^3. At the same time a certain amount of current will flow through the storage battery to ground, thus charging the battery. As soon, however, as the potential of the motor-generator is reduced, due to any cause, the battery F will supply the current for actuating the separate contacts, switches, and brake-magnets. It will be seen that by this arrangement a reserve or additional source of supply is always at hand and in a position to perform any useful work as soon as the voltage of the motor-generator decreases.

It is evident that any of the well-known means may be employed on the motor-generator for compensating for variations of main-line voltage; but as this feature forms no part of the present invention reference thereto will be omitted.

In circuit with the lead from the shoe is a coil E^3, which when the normal current is flowing through the motor holds the battery-switch F' closed; but as soon as the current falls below a certain amount, owing to a partial or complete failure of the source of supply, the switch automatically opens. By this arrangement the battery F is prevented from converting the generator E' into a motor and driving the motor E as a generator to supply current to the line. Battery F is charged by the generator E' and is connected to ground at one end and to brush 19 of the master-controller at the other. All the batteries and motor-generators on the train are connected in multiple between cable-wire 19^c and the ground. By this arrangement as soon as the circuit of a master-controller is completed all the batteries and motor-generators E' on the train unite to supply current to actuate the switches and contacts.

In order to facilitate the reading of the diagram of connections in Fig. 7 all wires and brushes which are in electrical connection and the contacts controlled thereby are given the same reference-numeral, but with different exponents. For example, brush 1 of the power-cylinder N is connected to cable-wire 1^c, and cable-wire 1^c is connected to wire 1^a, which in turn furnishes current to the magnet-coil operating the switch-contact 1^d.

The operation of my invention is as follows: Assuming that it is desired to propel the car or train forward, the left-hand set of contacts on reversing-switch N' is moved into engagement with brushes 13 and 23, which causes switch O' to move to the position shown, switch N is moved into engagement with the vertical line of stationary brushes at the position 1 1, and current flows from the storage battery F and motor-generator E' to brush 19, to brush 1, by means of the contacts on cylinder N to cable-wire 1^c, by wire 1^a through two energizing switch-coils, each of which corresponds to coil A' of the switch shown in Fig. 4, to ground. This causes the switch-blades to close the circuit of the first two contacts T^d and 1^d. A second circuit is from brush 19, by cross-connected contact to brush 3, to cable-wire 3^c, thence through wire 3^a and switch-coil to ground. This energizes the switch-magnets and closes the motor-circuit at 3^d. A third circuit is from brush 19, by cross-connected contacts on the cylinder to brush 11, by cable-wire 11^c to wire 11^a, through the switch-coil connected therewith to ground. This causes the motor-circuit to be closed at 11^d, and the motor-circuit is as follows: from contact-shoe M^4 to contacts T^d and 1^d, through section R^2 of the resistance R (the first section R' being employed only for braking purposes) to wire 21, to switch O^2, to reversing-switch O', to armature of motor M, to reversing-switch O', to switch O^2, thence through the field of motor M to contact 11^d, by wire 22 to switch O^2, to reversing-switch O', to armature of motor M', to reversing-switch O', to switch O^2, by cross connection to field of motor M', to ground. With the circuits arranged as above the two motors are connected in series, as indicated at 50, Fig. 11, with full resistance. The different resistance-coils R are preferably graded, (those shown at the left in the drawings being of highest resistance,) as is common in all controllers in which the resistances are thrown in in multiple with each other. I have indicated this roughly in the drawings by the different lengths of the coils. At the time the power-circuit is first closed a circuit is completed from the battery F and motor-generator E' through the brake-shoes M^3 in a direction to deënergize them. This brake-shoe circuit is as follows: from battery F and motor-generator E' to brush 19, by cross-connected contacts on cylinder N to brush 16, to cable-wire 16^c, to auxiliary resistance R^1, to switch O^2, thence through the brake-shoes in the direction indicated by the dotted arrow to switch O^2 and to ground. This circuit is only closed momentarily and acts to deënergize the brake-magnets, so that they will release their hold on the brake-disks. The relation of the brake-magnets, and separate source of supply is shown at 51, Fig. 11. To increase the speed of the motors, switch-cylinder N is moved to the left, and as each contact thereon engages with its corresponding stationary brush an additional switch-coil is energized, which closes the circuit of one of the resistance-contacts. The resistance-circuit is thus gradually decreased by cutting in sections of resistance in multiple until the brushes rest on line 7 7 and the resistance is short-circuited at 9^d. This is the last series running position. After this the resistance is cut back into circuit step by step to a sufficient amount, one motor is shunted, as more fully shown hereinafter, and the motors are connected in multiple. With the brushes resting on line 8 8 the circuit is as follows: from the separate source of supply to brush 19, by cross connection on cylinder N to brush 1, to cable-wire 1^c, by wire 1^a to the switch-coils, and thence to ground. This closes the circuit of the first two contacts T^d and 1^d. A second circuit is from brush 19, by cross-connected contacts to brush 3, to cable-wire 3^c, thence through wire 3^a and switch-coil to ground. This closes contact 3^d. A third path is from brush 19, by cross-connected contacts to brush 4, to cable-wire 4^c, thence through wire 4^a and switch-coil to ground. This closes contact 4^d. A fourth circuit is from brush 19, by cross-connected contacts to brush 10, to cable-wire 10^c, wire 10^a, through its switch-coil to ground. This closes contact 10^d. A fifth circuit is from brush 19, by cross-connected contacts to brush 12, to cable-wire 12^c, wire 12^a, and switch-coil to ground. This closes contact 12^d. With the circuits arranged as above the motor-circuit will be as follows: from contact-shoe M^4 to contacts T^d and 1^d, to contacts 3^d and 4^d, through two sections of resistance in multiple, to switch O^2, to reversing-switch O', to the armature of motor M, to reversing-switch O', to switch O^2, thence, through the field or motor M, to contact 12^d, and to ground. The second circuit is from point *c* on wire 21 by contact 10^d to wire 22, to switch O^2, to the reversing-switch O', to the armature of motor M', reversing-switch O', switch O^2, by cross connection to the field of motor M', and to ground. With the connections as above the motors are connected in multiple with full resistance for that position, as shown at 52, Fig. 11. A further movement of the cylinder N cuts out step after step of resistance R. The reversing-switch O', indicated in diagram as consisting of twelve contacts and eight relatively movable brushes, is operated by means of coils O^4 and O^5, which are connected, respectively, to brushes 13 and 14 of the master reversing-switch N'. If the motors are propelling the car forward, the brushes will rest on the vertical line of contacts now situated on the left. If the motors are propelling the car backward, the brushes will rest on the line of contacts now situated on the right. The circuit for these coils, assuming the car to be propelled forward, is from battery F to wire 23^a, by cross-connected contacts to brush 13, to coil O^4 to ground. This will establish the relation of contacts and brushes which is shown in the figures. Assuming that it is desired to reverse the motors, cylinders N and N^2 are brought to the off position and reversing-switch N' is moved to a point where the brushes will rest on the contacts now situated on the right. The circuit will then be from battery F by wire 23^a to brush 23, by cross-connected contact to brush 14, through coil O^5 to ground. This will energize the magnet and its core will be attracted and the reversing-switch moved to the point where the upper line of contacts will be in engagement with the first row of brushes and the third line of contacts in engagement with the lower row of brushes. For operating the power-brake switch O^2, I have shown a slightly-different arrangement of the circuits, the object being to cut the actuating-coils out of circuit as soon as they have performed their work. Assuming that the parts are as shown in the diagram Fig. 7 and that it is desired to move the switch O^2 to a position where it will establish proper braking connections, the master-controller brake-switch N^2 is moved to a point where the brushes will rest on line 1 1, and the circuit is from battery F or generator E′, or both, as the case may be, by wire 23^a to brush 23^b, by cross-connected contacts to brush 15^b, to cable-wire 15^c, by wire 15^a, through a contact on switch O^2, to coil BC, to ground. As soon as coil BC is energized it will attract its core and throw the switch to a position where the upper line of contacts will be in engagement with the stationary row of brushes. As soon as the switch assumes its new position the circuit of the coil BC is interrupted, as the switch-contact will pass from underneath the brushes, and the circuit of the coil PC is partially completed by the contact now situated directly above the brush connected to coil PC. With this arrangement the coil PC is in position to receive current as soon as it is desired to throw the switch O^2 to its power position; yet neither of the switch-coils is consuming energy. By this arrangement I can make the coils comparatively small and of low self-induction, so that there will be no time lost between the closing of the circuit and the actuation of the switch O^2. While I have not shown this arrangement applied to the reversing-switch, it is of course evident that such an arrangement can be applied, or the arrangement shown in connection with the reversing-switch could be employed for actuating the power brake-switch. Assuming that it is desired to arrest the movement of the train, switch N is brought to the off position and the brake-circuit closed by advancing the master-controller brake-switch N^2 to a point where the stationary brushes rest on line 1 1. The circuit is then as follows: from the battery F, by wire 23^a, to brush 23^b, by cross connection to brush 12^b, to cable-wire 12^c, to wire 12^a and its switch-coil, to ground. This closes contact 12^d, which connects one end of the field of motor M to ground. A second circuit is from brush 23^b by cross connection to brush 16^b, to cable-wire 16^c, thence through the auxiliary resistance R^4, to switch O^2, thence through the brake-shoes M^3 in the direction indicated by the full-line arrow, to the switch O^2. The circuit divides here at point 33, one path being through the field of motor M′ to ground, the second path being, by way of connection 30, through the field of motor M, to contact 12^d to ground and to the negative side of the battery. With the circuits thus arranged the two fields are connected in multiple and grounded at one end and united at the other end and connected to the brake-shoes M^3, the battery F and generator E′ supplying current to energize the brake-shoes and field-magnets, as indicated at 53, Fig. 11. A further movement of the brake-switch N^2 to the left will cut out one section after another of the auxiliary resistance R^4, which increases the power of the brakes. When the brake-cylinder N^2 has advanced to a position where the vertical row of brushes rests on line 4 4, the motors M M′, which have been converted into generators by the shifting of switch O^2, are coupled in a local circuit with a certain amount of resistance, and the circuit of the master-controller is as follows: from battery F and generator E′, by wire 23^a to brush 23^b, by cross-connected contacts to brush 2^b, to cable-wire 2^c, wire 2^a, to its switch-coil, to ground. This closes contact 2^d and the circuit of first section of resistance R. A second circuit is from brush 23^b, by cross-connected contacts to brush 10^b, to cable-wire 10^c, wire 10^a and its switch-coil, to ground. This closes the circuit at contact 10^d, and the circuit of the motors now acting as generators is as follows: starting at point 30 on switch O^2, to reversing-switch O′, to the armature of motor M, to the reversing-switch, to point 31 on switch O^2, where the circuit divides. One path is through wire 32 to the first resistance-point, through the first section of resistance, through contact 10^d, wire 22, switch O^2, by cross-connected contacts to ground. A second path is from point 30 to the field of motor M, to contact 12^d, to ground. A third path is from contact 34 on switch O^2 to the reversing-switch O′, to the armature of motor M′, to reversing-switch O′, to switch O^2, to point 31, where it unites with the current from the armature of motor M and passes through the resistance to ground. A fourth path is from point 33 on switch O^2 to the field of motor M and to ground. With this arrangement of circuits the motors are grounded at one end and connected in multiple with an equalizer *f* between the fields and armatures. The two motors are controlled by the resistance R, which is grounded on one end. The circuit of the brake-shoes remains unchanged, so that further description is unnecessary. A further movement of the cylinder N^2 to the left will decrease the resistance of the brake-circuit by cutting one section after another of resistance into multiple with the one already in circuit. The circuits as described above are illustrated at 54 in Fig. 11. When the cylinder N^2 has advanced to a position where the brushes rest on line 13 13, the power of the brake-shoes is decreased by cutting in the first two sections of the resistance R^4. It will be noticed that as soon as the brake-cylinder N^2 is thrown the field-magnets of both motors are energized from the battery F and generator E′. This provides for a certain amount of field excitation at all times in a direction to assist the excitation due to the armature-current. As only a small current is required to deënergize the brake-magnets, the resistance R^4 is of considerable amount, and in order to decrease the effect of said resistance when it is employed for regulating the brake-shoes without increasing the number of cable-wires and controller-brushes a short-circuiting contact 35 is mounted on switch O^2, and when the switch is thrown by energizing-coil BC the last section of resistance R^4 is cut out of circuit. The circuit is normally complete through the master brake-switch N^2 by the contacts thereon and brushes 23^b and 20^b. By this arrangement the power brake-switch O^2 will be returned to the proper position for establishing the power-circuit of the motors as soon as the brake-circuit is interrupted. Assuming that the power brake-switch O^2 is at the brake position, as soon as brush 20^b engages with contact 37 a circuit is completed from battery F and generator E' to wire 23^a, brush 23^b, by cross-connected contacts to brush 20^b, to cable-wire 20^c, to contact 38 on switch O^2, coil PC, and to ground. This will cause coil PC to attract its core, and the power brake-switch O^2 will be moved to its power position, the circuit of coil PC interrupted, and the circuit of coil BC completed at this point and in readiness to receive current for throwing switch O^2 to its brake position. In the ordinary arrangement of electric brakes the brake-magnets are connected in circuit with the motors in such manner that the current from the armature passes through them. With a construction of this kind the power of the brakes decreases as the speed of the vehicle decreases; but by my invention I am enabled to maintain any predetermined braking effect by utilizing the battery F and generator E'. This will hold the car or train upon a grade after the generators have ceased to work. By employing braking-generator and brake-magnets energized from a separate source and operating them in conjunction—as, for example, in the manner described above—I am enabled to obtain a much smoother braking effect than heretofore, besides furnishing a certain field excitation for the motors, so that they will be ready to act instantly as braking-generators. Assuming that battery F and generator E' are designed to furnish one hundred and twenty-five volts and that the circuit is closed through the brake-shoes and motor-fields, there will be a certain drop in voltage due to the resistance of the field magnet-coils amounting to one or two volts; but when the armature-circuits of the braking-generators are coupled in series with the fields and are forcing a large current through the magnet-coils there will be a drop of potential across the terminals of the field-magnets which will be proportional to the current flowing therein, and the effective voltage of the separate source of supply will be decreased by an amount depending upon said drop. This will cause a decrease in the retarding effect of the brake-magnets by an amount corresponding to the increase of current in the armatures. As soon, however, as the braking effect of the generators decreases, due to variations in speed of the vehicle and changes of resistance in the armature-circuits, the retarding effect of the brake-magnets will again increase. By this arrangement it will be seen that the total braking effect of a train can be made much more smooth and gradual than in the ordinary manner.

In changing the motors from series to parallel relation there is a certain amount of danger of short-circuiting of the motors, due to careless manipulation of the controller-cylinders. To prevent this, I provide an electromagnetic interlock between certain of the switches or contacts, so arranged that their operation is automatic, and the improper connections cannot be established no matter how carelessly the controller is handled.

In Fig. 10^a I have illustrated the connections of the motors at the time they are going from series to parallel. It will be seen that a shunt is momentarily thrown around the second motor by ground-wire 12 before the motors are connected in parallel, as shown by the dotted line 36. If by reason of improper manipulation wire 36 is connected from the second motor to the trolley before the circuit at contact 11^d is opened, there will be a short circuit from the resistance R to ground through wire 36 and contact 11^d and wire 12. To avoid this, I use special switches for contacts 10^d and 11^d. These are shown in detail in Figs. 8, 9, and 10. Switch-arm B and its actuating-core A^4 are constructed the same as already described. In addition to this a piece of insulating material e, carrying the conducting-strip e', is mounted on the under side of weighted arm B^4 and is arranged to open and close the circuit of the contacts g g', which are secured to one side of the insulating-block A^7.

In Fig. 10 the arrangement of the circuits is shown. Current enters by wire 11^a, passes from contact g to contact g', through strip e' to coil 11^e, to ground. This will energize coil 11^e, which will attract its core and open the circuit between the contacts h and h'. This will also close the circuit between switch-blade B and brush B', and so long as coil 11^e remains energized the circuit of coil 10^e cannot be closed, even though brush 10 rests upon the contact-cylinder. As soon, however, as coil 11^e is deënergized the weighted arm B^4 will cause the switch to open and close the circuit between the contacts h and h'. After this the circuit of coil 10^e may be energized in the ordinary manner. If, on the other hand, the controller-cylinder is traveling in the opposite direction and the circuit of coil 10^e is completed, the circuit between this switch-blade and brush will be closed, and the circuits of coil 11^e will remain open until coil 10^e is deënergized.

In Fig. 12 is shown the means employed to prevent the simultaneous operation of two switches on the same train. I have shown this device applied to the reversing-switch, for it is customary to provide a mechanical interlock between the reversing-switch and the other controller-switches so arranged that when the reversing-switch is at its off position all the circuits are interrupted. Assuming that switch N' is located on the controlling-car and that it is moved to a position where the contacts rest on the proper brushes, to establish a forward movement of the train the notched disk n, which is rigidly secured to the operating-shaft of N′, will take the position shown. A magnet 37 is provided for each switch and is provided with a pivoted armature 38, which is retained in the raised position by spring 39 as long as no current flows in magnet-coil 40. The hooked end of armature 38 is arranged to engage, when the magnet-coil is energized, with the notch 41 in disk n and retain the switch in the open-circuit position.

It is desirable to employ two reversing-switches on each car and to locate them at opposite ends. With this arrangement the coils 40 are connected in series, and if the power-circuit is closed current flows from battery F or motor-generator E′ through the coils 40 to cable-wire 19^c, to wire 23^a, Fig. 7, brush 23, by cross-connected contacts to brush 13, to coil O^4, and to ground or to brush 23^b if the brake-circuit is closed or brush 19 if the power-circuit is closed.

Normally any one of the master-controllers may be operated as the armatures 38 are raised by the springs 39; but when one of the switches N′—for example, the one located at the head of the train—is thrown to an operative position current flows from all the batteries and motor-generators on the train in multiple through cable-wire 19^c and energizes the magnet-coils 40, which attract the armatures 38 and lock all the master-controllers on the train, excepting only the one in actual operation. (Shown on the left in Fig. 12.) As soon as the circuit of wire 19^c is interrupted the armatures will assume their normal position and release the switches. By this arrangement any switch on the train may be operated and the remaining switches locked against improper manipulation.

It will be seen that I divide the motors of the train into a number of sets, each operated by a separate controller. In the form shown two motors constitute a set; but my invention is not limited thereto, as each controller may operate one, two, four, or any desired number of motors. In general I prefer to provide a separate controller for each car whatever may be the number of motors mounted thereon.

I can and preferably do wind the contact magnet-coils A′ in such direction that their magneto motive forces assist the magnetization of the blow-out magnets.

An additional advantage of my system is that it allows the brakes to be fed from a source of supply of fairly constant potential as distinguished from the ordinary method of feeding them with current from the braking-generators. In the last-mentioned arrangement the current in the brake-shoe falls off at just the time when the braking action of the generator decreases, which may be objectionable.

It should also be noticed that in my improved system of control the motor-controllers and master-controllers are in positive synchronous relation, so that when the master-controller is placed in any position the motor-controllers instantaneously assume the corresponding position without any appreciable time interval intervening and that any motion of the master-controller forward or back one notch or several notches will be instantaneously and accurately responded to by the motor-controllers.

Certain types of train-control systems have been proposed in which upon an interruption or upon an interruption and restoration of the main current-circuit the motor-controllers are automatically brought back to zero. The result of such an arrangement is that at or after every slight momentary interruption of the power-circuit of any car the controller of that particular car begins to run back. It follows that upon the restoration of the power-circuit the controller of that particular car may be placed in a position different from the position of controllers on other cars of the train, so that the different cars receive different accelerations and a "pulling-and-hauling" action takes place, which is exceedingly disagreeable and wasteful of current. It will be seen that with my improved system I supply current to the motor-controllers at all times from the auxiliary source and maintain them in operative condition whether the power-circuit is open or closed.

The claims in this application, drawn on the particular arrangement of motors, brake-shoes, &c., shown in the last position of Fig. 11, are to be regarded as subordinate to my pending application, Serial No. 699,587, filed December 17, 1898.

I have not claimed in this case the method of disrupting arcs disclosed herein, since claims for said method are embodied in a divisional application, Serial No. 139,518, filed January 19, 1903.

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

1. In a controller system for dynamo-electric machines employed for propelling and braking purposes, the combination of a set of separately-actuated contacts for controlling the machines when employed for propelling and braking purposes, and a master-controller for regulating the operation of said contacts.

2. In a controller system, the combination of a master-controller comprising power, reversing and brake switches, a motor-controller comprising power, reversing and brake switches, and means controlled by the master-controller for regulating the action of the motor-controller.

3. In a controller system, the combination of a master-controller comprising power, reversing and brake switches, a motor-controller containing a plurality of separately-actuated contacts, and means controlled by the power and brake switches for actuating the contacts.

4. In a controller system for dynamo-electric machines employed for propelling and

braking purposes, the combination of a master-controller comprising a plurality of switches, a motor-controller comprising a plurality of separate electromagnetically-actuated contacts, a reversing-switch, a power brake-switch separate therefrom, and electromagnets controlled by the master-controller for controlling the switches.

5. In a controller system for dynamo-electric machines employed for propelling and braking purposes, the combination of a master-controller comprising power, reversing and brake switches, a motor-controller composed of corresponding switches, and means connecting the master and motor controllers, whereby the operation of a master-controller switch produces the operation of a corresponding motor-controller switch.

6. In a controller system for dynamo-electric machines employed for propelling and braking purposes, the combination of a master-controller comprising power, reversing and brake switches, each provided with a separate operating-handle, a motor-controller comprising power, reversing and brake switches for changing the motor connections, and electrical connections between similar switches of the master and motor controllers, whereby the closing of a master-controller switch produces the closing of a similar motor-controller switch.

7. In a controller system for electric motors, the combination of a plurality of separately-actuated contacts for controlling and regulating the motors when they are employed for propelling and braking purposes, a switch controlling the operation of the separate contacts when the motors are connected for propelling, and a second switch mechanically separate from the first, for controlling the action of the separate contacts when the motors are connected for retarding.

8. In a controller system for electric motors, the combination of a plurality of separately-actuated contacts for controlling and regulating the motors when they are employed for propelling and braking purposes, a switch controlling the operation of the separate contacts when the motors are connected for propelling, a second switch mechanically separate from the first, for controlling the action of the separate contacts when the motors are connected for retarding, and means for connecting said motors for propelling or for braking.

9. In a train system, the combination of a number of motor-cars, each motor-car forming a separate unit and provided with a master and a motor controller, each of said controllers being provided with power, brake and reversing switches, electrical connections between the corresponding switches of the master and motor controllers, whereby the closing of a master-switch produces a similar closing of a motor-switch, and electrical connections extending through the train to which the master-controllers are connected, the arrangement being such that the closing of a master-switch causes the closing of all the corresponding motor-switches on the train.

10. In a controller system for dynamo-electric machines, the combination of a plurality of separately-actuated contacts for controlling said machines both when they are operating as propelling-motors and when they are operating as braking-generators, a switch for connecting said machines for propelling or for braking, and a master-controller for controlling the operation of said switch and said separately-actuated contacts.

11. In a system of motor control, the combination of a master-controller, a motor-controller regulated by the master-controller for regulating the motors, a source of supply for the motors, and an additional source of supply for supplying current for controlling the motor-controller.

12. In a system of train control, in combination, a number of motor-cars, a motor-controller for each motor-car, electrically-actuated means for operating said controllers, sources of current-supply carried by one or more cars, a master-controller, and circuit connections such that upon operation of the master-controller current from said sources flows through said master-controller to said controller-operating means.

13. In a system of train control, in combination, a number of motor-cars, a motor-controller for each motor-car, electrically-actuated means for operating said controllers, sources of current-supply carried by one or more cars, a plurality of master-controllers, and circuit connections such that upon operation of any master-controller current from said sources flows through said master-controller to said controller-operating means.

14. In a system of motor control, the combination of a master-controller, comprising a plurality of switches, a motor-controller comprising a plurality of similar switches for regulating the action of the motors when employed for propelling and braking purposes, a source of supply for the motors, and an additional source of supply for supplying current for actuating the motor-switches, and means whereby the action of the motor-switches is controlled by the master-switches.

15. In a system of train control, the combination of a number of motor-cars, provided with master-controllers consisting of power, brake and reversing switches, and a motor-controller for each motor-car, consisting of corresponding brake, power and reversing switches, electrical connections between corresponding switches, a source of supply for each motor-car, independent of the current supplied to the motors, for actuating the motor-switches, and a cable connecting all of the master-controller switches, the relation of the controllers and separate sources of supply being such that the closing of a master-switch at any point on the train causes the closing of all corresponding motor-switches on the train.

16. In an electrically-propelled vehicle, the combination of a controller for converting the motor or motors into generators and including them in a local circuit, one or more electric brakes mounted in a suitable manner, and means for energizing the brake-magnets from a source of supply independent of the current induced in the generators, during the time that the motors are acting as generators to retard the progress of the vehicle, and means for controlling the said controllers and energizing means from a distance.

17. In an electric-train system, the combination of a number of motor-cars each provided with means for converting the motors into generators for braking the train, and magnetically-controlled brakes supplied from a separate source of energy, and a master-controller located at a selected point on the train for controlling the action of the braking-generators, and also of the brakes.

18. In a system of electric brakes, the combination of a braking-generator, magnetically-operated brakes, a separate source of power for the brakes, means for closing the generator on a local circuit, and means for maintaining the circuit of the brakes closed during the time that the generator is acting to brake the vehicle.

19. In a system of electric brakes, the combination of a braking-generator and a storage-battery brake, and means for closing the generator on a local circuit, the circuit of the storage-battery brake and the generator being so arranged that the power of the battery-brake decreases at the time the power of the generator-brake increases, and increases as the power of the generator-brake decreases, due to the slowing of the car.

20. In a system of electric brakes, the combination of a dynamo-electric machine, an electrically-controlled brake, a source of supply for the brake independent of the dynamo-electric machine, and means for closing the circuit of the brake through the field-magnet of the dynamo-electric machine.

21. In a system of electric brakes, in combination, a dynamo-electric machine, an electrically-controlled brake, a source of current-supply for actuating said brake, and means for closing the circuit of the brake-controlling means through the field-magnet of the dynamo-electric machine to apply the brake.

22. In a system of electric brakes, in combination, a dynamo-electric machine, an electrically-controlled brake, a source of current-supply for actuating said brake, means for closing the circuit of the brake-controlling means through the field-magnet of the dynamo-electric machine to apply the brake, and means for closing the circuit of the dynamo-electric machine on itself.

23. In a system of electric brakes, a plurality of dynamo-electric machines, an electromagnetically-controlled brake or brakes, a source of current-supply for actuating said brakes, means for closing a circuit from said source through the brake magnet or magnets and the field-magnets of the dynamo-electric machines to apply the brakes, and means for converting the dynamo-electric machines into generators for braking.

24. In a system of electric brakes, the combination of a plurality of dynamo-electric machines, electromagnetically-controlled brakes, a source of supply for the brakes independent of the dynamo-electric machine, means for converting the machines into generators for braking purposes, and means for closing the circuit between the separate source of supply and the fields of the generators to provide them with an initial excitation.

25. In a system of electric brakes, the combination of a plurality of dynamo-electric machines, electromagnetically-controlled brakes, a source of supply for the brakes independent of the dynamo-electric machines, means for converting the machines into generators and connecting them in multiple in a local grounded circuit, contacts for closing the circuit between the separate source of supply and the brake-magnets, and contacts for connecting the separate source of supply to ground in such manner that the current passes through the magnets of the brakes and the fields of the generators.

26. In a system of electric brakes, the combination of a controller for regulating the motors, a master-controller for regulating the motor-controller, electrically-controlled brakes, and contacts on the master-controller for regulating the passage of current from the battery to release the brakes.

27. In a system of electric brakes, the combination of a controller, for converting the motors into generators for braking the vehicle and for regulating them when so connected, brake-magnets, a storage battery, and contacts on the controller for completing the battery-circuit through the brake-magnets in a direction to deënergize them.

28. In an electric switch, the combination of fixed and moving contacts, a magnet for blowing the arc formed between the contacts in a direction at an angle with the plane of movement of the contacts, and an arc-restraining chute situated at one side of the contacts, into which the arc is blown.

29. In an electric switch, the combination of fixed and moving contacts, a magnet for blowing the arc formed between the contacts in a direction at an angle with the plane of movement of the contacts, and an arc-restraining chute situated at one side of the contacts and provided with open ends, into which the arc is blown.

30. In an electric switch, the combination of fixed and moving contacts, a chamber in which the contacts are mounted, an arc-restraining chute provided with an opening, and a blow-out magnet for blowing the arc from the chamber into the arc-restraining chute.

31. In an electric switch, the combination of fixed and moving contacts, an open-ended chamber in which the contacts are mounted, an open-ended arc-restraining chute, a passage between the chamber and the chute, and a magnet for blowing the arcs formed at the contacts through the passage into the chute.

32. In an electric switch, the combination of fixed and moving contacts, situated outside of the arc-restraining chute, arcing projections on the contacts, an arc-restraining chute into which the projections extend, and a magnet for blowing the arc along the projections into the chute.

33. In an electric switch, the combination of fixed and moving contacts, arcing projections on both contacts arranged to protect the contact-surfaces, an insulated chamber surrounding the contacts, an arc-restraining chute extending parallel to the chamber, and an opening connecting the chamber and chute through which the projections extend.

34. In an electric switch, the combination of fixed and movable contacts, means for producing a magnetic field at the said contacts, and an arc-restraining chute situated at one side of said contacts, said chute being provided with an opening adjacent to the contacts and having a closed wall opposite to said opening in the direction of travel of the arc.

35. In an electromagnetically-actuated switch, the combination with a resilient or spring-supported contact, of a moving contact arranged to make a wiping or sliding contact therewith, and an actuating-coil for said moving contact located in a circuit separate and distinct from the circuit controlled by said contacts, the arrangement of said contacts being such that when the moving contact is released by the deënergizing of said coil, the resilient contact assists in opening the circuit controlled by said contacts.

36. In combination, a control-circuit, an actuating-coil located in said circuit, a controlled circuit, and switch-contacts located in said controlled circuit, one of said contacts being moved by said actuating-coil, and the other of said contacts being resiliently mounted so that as the contacts are brought into engagement by the energizing of said coil a sliding connection between the parts is obtained and said resiliently-mounted contact assists in opening the controlled circuit when the coil is deënergized.

37. In an electromagnetically-actuated switch, the combination of fixed and moving contacts, an actuating-coil for said moving contact located in a control-circuit independent of the circuit controlled by said contacts, and a resilient mounting for one of said contacts so arranged that the said contacts will make a wiping or sliding connection with one another and will tend to be forced apart when the moving contact is released.

38. In an electromagnetically-actuated switch, the combination of a fixed terminal, a moving terminal, and a resilient connection between one of said terminals and the support on which it is mounted, an actuating-solenoid for the support upon which said moving terminal is mounted, said solenoid being located in a circuit independent of the circuit in which said terminals are located, the two terminals being so constructed and arranged that as the support carrying the moving terminal is moved to cause said terminals to engage, the resiliently-mounted terminal will be displaced in such a manner as to make a sliding or wiping contact with the other terminal.

39. A series-multiple controller having separate electromagnetically-controlled contacts in combination with means operated by a series contact for opening the controlling-circuit of a multiple contact or contacts.

40. A series-multiple controller having separate electromagnetically-controlled contacts in combination with means operated by a series contact for opening the controlling-circuit of a multiple contact or contacts, and means operated by a multiple contact for opening the controlling-circuit of a series contact or contacts.

41. In combination, a plurality of motor equipments, a motor-controller for each motor equipment, master-controllers located at a plurality of separate points, and means actuated upon the operation of any one of said master-controllers, for locking the other master-controllers against movement.

42. In a system of train control, in combination, a plurality of cars carrying motors, a plurality of switches located at different points on the train for controlling the operation of said motors, and means actuated upon the operation of any one of said switches for locking the other switches against movement.

43. In a train-control system, in combination, a motor or motors, a plurality of switches mounted on separate vehicles for controlling said motors, an electromagnetically-controlled locking device for each of said switches, and circuit-closing devices so arranged that when one of said switches is in operation the remainder are locked against movement; said circuit-closing devices on the several vehicles being in multiple with each other.

44. In a train system, the combination of a plurality of switches mounted on separate cars, a wire extending through the train, an electromagnetically-controlled locking device for each switch, an energizing-coil for each of said devices, a source of supply derived from each car for energizing the coil or coils of that car, and means for closing the circuit of all the coils from a selected point.

45. In a system of electric brakes, the combination of a braking-generator, a brake-magnet which is supplied at all times from a separate source of power, and means controlled by the current flowing in the generator-circuit, for regulating the action of the brake-magnet.

46. In a system of electric braking, the combination of a braking-generator, a brake-magnet supplied from a separate source of power, and an electrical connection between the braking-generator and the magnet, so arranged that the effect of the brake-magnet is varied in a manner corresponding to changes in the braking effect of the generator.

47. In a system of electric braking, the combination of a braking-generator, a brake-magnet supplied from a storage battery, means for completing the circuit of the braking-generator, and means for closing the circuit of the brake-magnet through the field of the generator, so that changes of current in the field of the generator will produce corresponding changes in the braking effect of the magnet.

48. The combination, with a series-wound motor and an independent source of current-supply, of a controller adapted to close the motor on itself and adapted to direct current from said independent source through the same series field of such motor which energizes it in running at the same time that the armature-current from the motor as a generator is flowing through that field, whereby the motor-current may instantly apply the brake without waiting to build itself up, but after built up energizes its field, substantially as described.

49. The combination, with a series-wound motor and an independent source of current, of a controller adapted to close the motor on itself and adapted to direct the current from said independent source through the main field of such motor, and an artificial resistance in the path of the current from such source to the field of the motor whereby the reduced current from the said source causes the motor-current to instantly build up when closed as a brake without interfering with the motor-current energizing its field when built up, substantially as described.

50. The herein-described means for braking by a series-wound motor without an extra field provided for braking, which consists of the combination of such motor, a conductor from a source of current-supply, a reducing resistance therefor, means for directing the current from said conductor through such resistance and through the ordinary field of the motor, and means for directing the current produced by the motor as a generator through such field, substantially as described.

51. In an electrically-actuated switch, a supporting-frame, a solenoid-winding mounted thereon, a switch-contact rigidly mounted at one side of said frame and insulated therefrom, a relatively movable switch-contact carried by an arm pivoted to the supporting-frame, a solenoid-core operatively connected to said pivoted arm, a blow-out chute mounted on the side of said supporting-frame, and a blow-out magnet having its poles embracing the contacts of said switch.

52. In an electrically-actuated switch, a supporting-frame, a relatively fixed switch-contact carried by said frame, a relatively movable switch-contact mounted on an arm pivoted to said frame, an actuating-coil for said arm carried by said frame, a blow-out magnet supported by said frame the poles of which embrace said switch-contacts, and a blow-out chute into which the arc from said contacts is adapted to be blown.

53. In an electrically-actuated switch, a supporting-frame, a solenoid-winding mounted thereon, a relatively fixed switch-contact mounted on said frame at one side thereof, a relatively movable switch-contact carried by an arm pivoted to said frame and adapted to engage said fixed contact at one side of said frame, a solenoid-core operatively connected to said arm, a blow-out magnet carried by said frame, and a blow-out chute mounted on one side of said frame between the poles of said blow-out magnet.

54. In an electrically-actuated switch, a supporting-frame, a solenoid-winding mounted on said frame, a relatively fixed contact carried by said frame at one side thereof, a relatively movable switch-contact supported from said frame and adapted to engage said fixed contact at one side of the frame with a wiping movement, a solenoid-core operatively connected to said movable contact, a blow-out magnet having its poles embracing said switch-contacts, and a blow-out chute carried by said frame at one side thereof into which the arc formed between said contacts is adapted to be blown.

55. In a train system, the combination of a plurality of cars equipped with motors and motor-controllers, one or more master-controllers for operating the motor-controllers, and means for preventing an interruption of the power-circuit from affecting the position of the motor-controllers.

56. In a system of electric brakes, the combination of an electric motor, means for converting the motor into a generator for braking purposes, and for regulating the motor when so connected, a brake-magnet, a separate source of power, means for connecting the magnet in circuit with the source of power, and means for simultaneously regulating the braking effect of the generator and brake-magnet.

57. The combination in an electrically-actuated switch device of an iron frame, a solenoid inclosed within said frame, a core in inductive relation to said solenoid, a pivoted switch member mechanically connected to said core, a projection from the frame constituting the core of a second coil, and a pivoted pole-piece for said second coil.

58. The combination in an electrically-actuated switch device of a cast-iron frame, a switch member pivoted in said frame and actuated by a solenoid carried by said frame, a second switch member fastened to said frame through a spring connection, a blow-out coil, and a pivoted pole-piece serving to direct the

lines of force from the blow-out coil across the active terminals of the switch members.

59. In an electrically-actuated switch, a supporting-frame, an actuating-winding in the form of a solenoid mounted thereon, a switch-blade pivotally mounted on the support and connected to a core in inductive relation to the solenoid, a movable terminal mounted on the switch-blade, a fixed terminal adjacent thereto, and a chamber provided with insulating-walls inclosing the switch-terminals.

60. In an electrically-actuated switch, a supporting-frame, an actuating-winding in the form of a solenoid mounted thereon, a switch-blade pivotally mounted on the support and connected to a core in inductive relation to the solenoid, a movable terminal mounted on the switch-blade, a fixed terminal adjacent thereto, a chamber provided with insulating-walls inclosing the switch-terminals, and a blow-out magnet arranged to create a magnetic field at said terminals.

61. In a train system, a main controlling-switch on one or more cars of the train, a plurality of electromagnets for controlling the operation of each of said switches, a plurality of train-conductors, connections from each of said train-conductors to the corresponding electromagnets of the main switches, one or more master-switches arranged to supply current from a suitable source to one or the other of said train-conductors, and contacts operatively related to each main switch arranged to open the circuit of the actuating-electromagnet before the switch reaches the extreme limit of its movement, and to partially complete a similar circuit through the other electromagnet and its corresponding train-conductor.

62. In a train system, a main controlling-switch on one or more cars of the train, a plurality of electromagnets for controlling the operation of each of said switches, a plurality of train-conductors, connections from each of said train-conductors to the corresponding electromagnet of each main switch, one or more master-switches arranged to supply current from a suitable source to one or the other of said train-conductors, and contacts on the main switch so arranged that in either operative position of the switch a circuit between one side of the source of supply and the electromagnet which is in a position to operate the switch is maintained closed and a circuit from the same side of the source to the other electromagnet open.

In witness whereof I have hereunto set my hand this 21st day of February, 1898.

FRANK E. CASE.

Witnesses:
DALLAS FLANNAGAN,
I. L. KEELER.