No. 798,335. PATENTED AUG. 29, 1905.

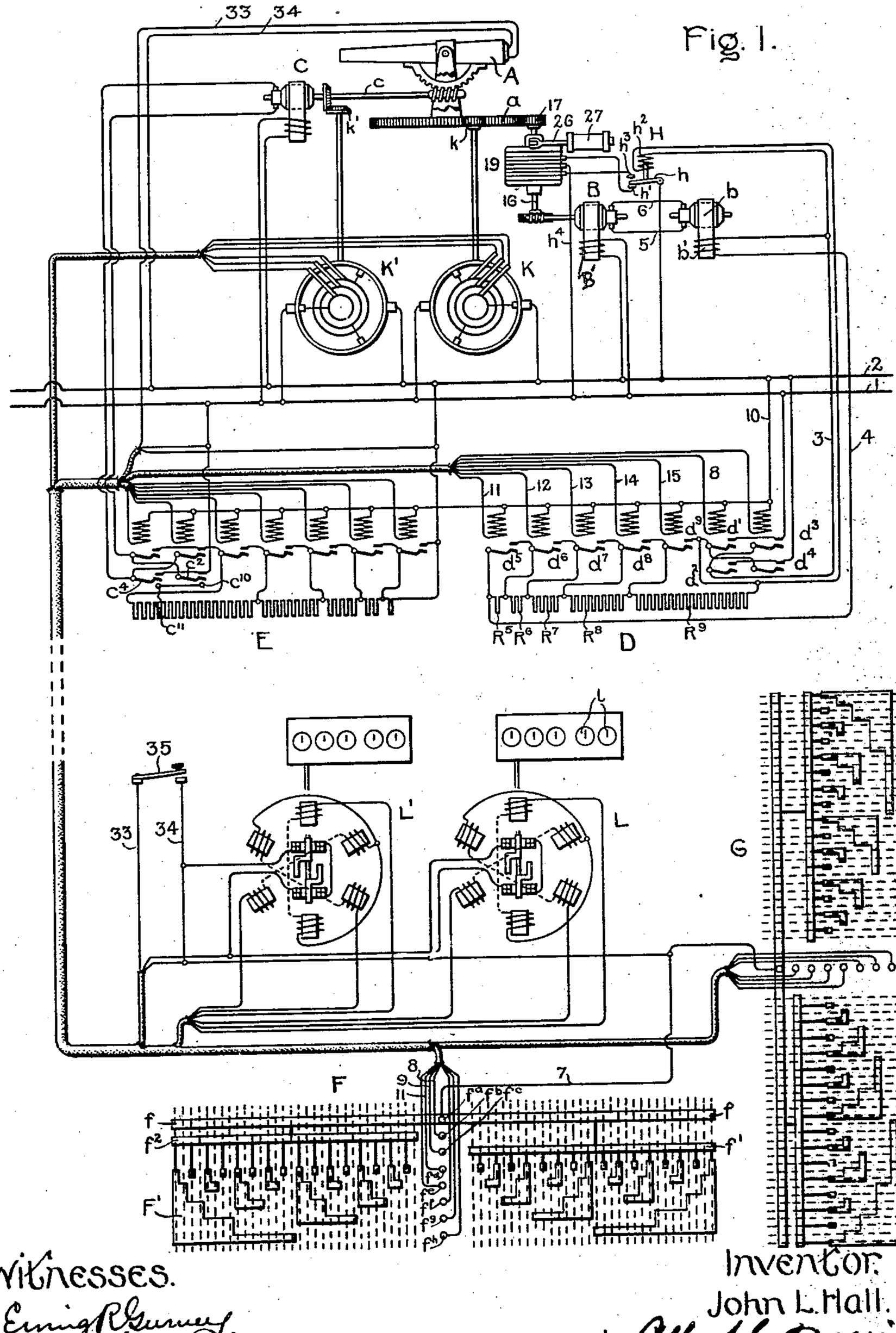
J. L. HALL.

SYSTEM OF GUN CONTROL.

APPLICATION FILED NOV. 28, 1904.

2 SHEETS—SHEET 1.

Fig. 1.



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2 SHEETS—SHEET 2.

Fig. 2.

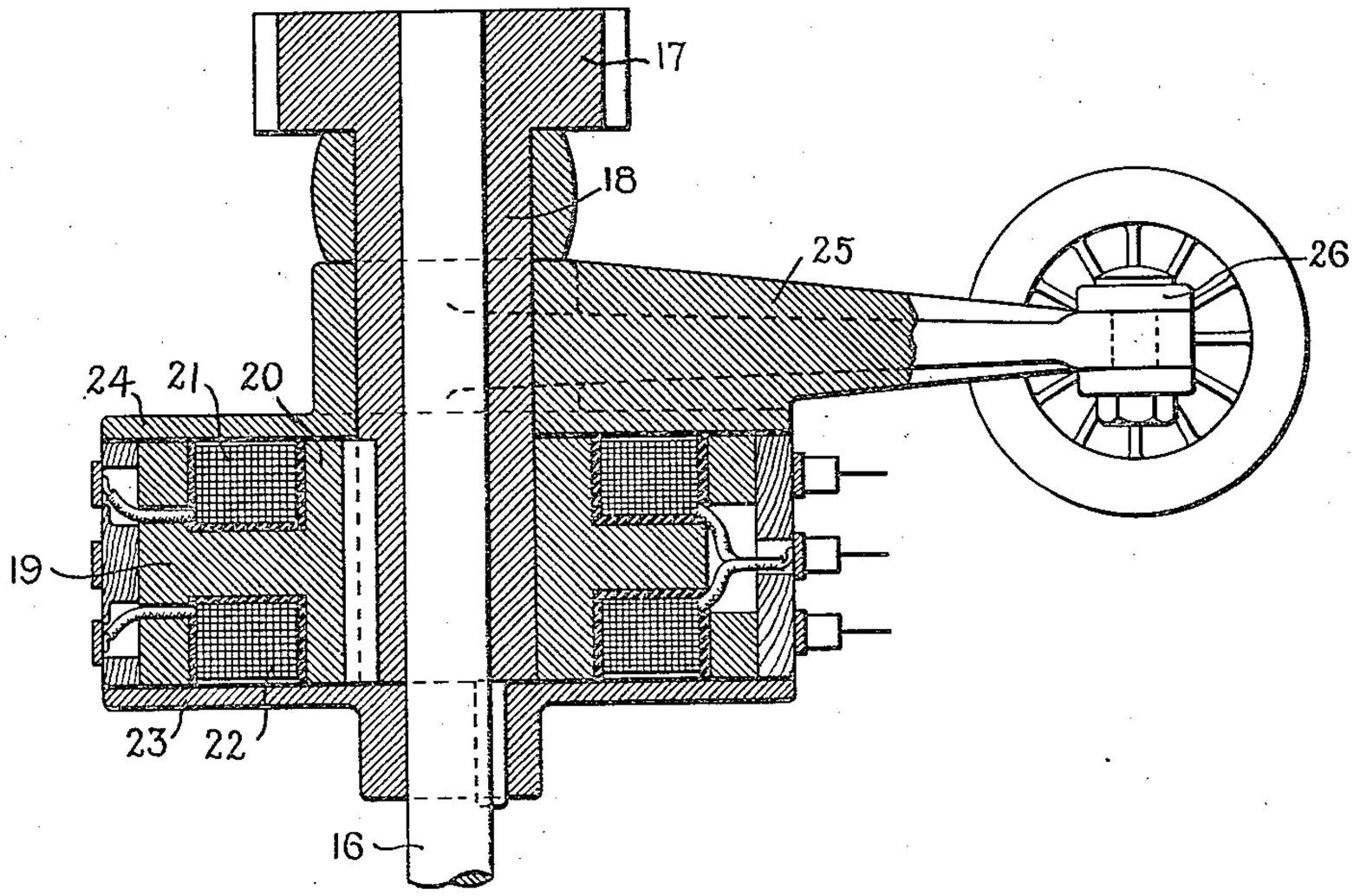
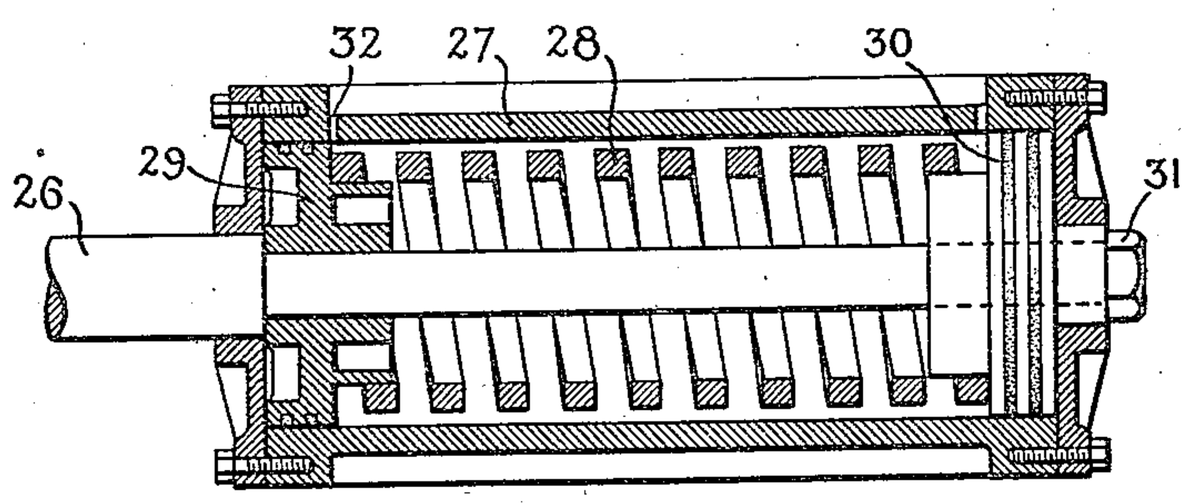


Fig. 3.



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UNITED STATES PATENT OFFICE.

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SYSTEM OF GUN CONTROL.

No. 798,335. Specification of Letters Patent. Patented Aug. 29, 1905.

Application filed November 28, 1904. Serial No. 234,470.

To all whom it may concern:

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

The present invention relates to systems for operating and controlling guns or similar mechanism, and particularly to systems of remote control for the same.

It is now the practice to determine at a range-finding station the range of the ship or other object at which it is desired to fire and to telephone or otherwise communicate the range to the control-stations adjacent the gun or guns of a battery or batteries. Not only must the range be communicated to the control-stations from the distant range-finding stations, but the orders for firing any particular gun or guns must also be transmitted from the battery commander's station to the man in charge of each gun. It is evident that in the confusion of actual warfare there is danger of misunderstanding telephonic or other communications, necessitating, perhaps, serious delays or causing orders to be executed improperly. The guns must be directed to fire from points within the zone of operation of opposing guns, and where the number of guns is large it is difficult to control them perfectly, so as to secure the most rapid and efficient operation and coöperation of all of the guns.

In one of its aspects the present invention consists in controlling one or more guns from a distant point, such as a range-finding station or the battery commander's station, which may be situated entirely out of the danger zone, thereby enabling individual guns to be directed and discharged at will and permitting perfect coöperation between the several guns.

In another of its aspects the present invention consists in the arrangement of parts of a system of control whereby a wide range of resistance changes may be obtained through the use of a small number of main switches or contactors.

In another of its aspects the present invention relates to a control system in which the object or machinery to be moved is accurately brought to rest in the desired position upon the interruption of the motor-current.

The present invention in its various enumerated aspects and in other aspects will be more clearly understood in connection with the following description of one embodiment thereof.

In the accompanying drawings, Figure 1 is a diagrammatic representation of one form of the present invention. Figs. 2 and 3 are details illustrating the mechanism for clutching the gun-carriage to the motor or to a fixed support or stop.

Similar reference characters will be used throughout the specification and drawings to indicate corresponding parts.

Reference being had to Fig. 1, A represents a gun of any suitable type mounted upon a carriage *a*. B is a motor adapted to rotate the carriage, and C is a motor arranged to elevate or depress the muzzle of the gun. These elements, together with the connections from the motors B and C to the parts driven thereby, may be of any suitable character, since the specific construction thereof forms no part of the present invention, except as will be hereinafter indicated, and they are therefore shown simply in conventional forms. Instead of controlling the motors B and C from points adjacent the motors and gun I have located the controlling mechanism at a distant safe point connected to the motors by means of an electric cable or cables. Any suitable system of motor control may be employed; but in the preferred form the motor-controllers proper, consisting of the main contacts and resistances, are arranged at a convenient point near the motors themselves, these motor-controllers being in turn controlled by master-controllers at the distant station. By this means the necessity of carrying heavy currents in the controller-cable is obviated, since the flow of current through the master controller or controllers need be only sufficient to operate the main switches, and by making the actuating-coils of the switches of a considerable number of turns only small currents are required to energize them. The motor-controllers may control the motors directly, or they may control the action of the generators which supplies current to the motors, both systems being illustrated.

The control systems for the motors illustrated are as follows: D is a controller for the motor B and controls this motor indirectly

through the generator b in the manner disclosed in Patent No. 644,666 to Maxwell W. Day, granted March 5, 1900. E is a controller for motor C and, as illustrated, controls this motor directly. The motor-controllers D and E are connected, respectively, to the master-controllers F and G at the distant station. The motor-controller D consists of a set of contactors d', d^2, d^3, and d^4, which constitute a reversing-switch for reversing the direction in which the current flows through the field b' of the generator, together with a series of switches or contactors d^5 to d^9, which control sections of resistances R^5 to R^9. The fixed members of contactors d' and d^3 are connected to line 1, and the fixed members of contactors d^2 and d^4 are connected to line 2, lines 1 and 2 being, respectively, the positive and negative leads from the source of electric current-supply. A lead 3, passing to one terminal of the field b', is connected, respectively, to the movable members of the contactors d^2 and d^3, whereby current is made to flow through the generator-field in one direction or the other, according as contactors d' and d^2 or d^3 and d^4 are closed, the opposite terminal of the field b' being connected to one terminal of the resistances by means of a lead 4. It is seen that when contactors d^5 to d^9 are open the current passing through lead 4 must flow through the whole of the resistance-sections R^5 to R^9 and thence through the reversing-switch to lines 1 or 2, according as lead 3 is connected to line 2 or 1. A pair of leads 5 and 6 connect together the brushes of the motor B and generator b, while the field B' of the motor is connected directly across the main lines 1 and 2. The direction of current-flow through the field of motor B therefore remains constant, and the direction of rotation of the motor is governed by the direction of current-flow through the field b' of the generator, the speed of the motor being determined by the amount of resistance included in series with the field b' of the generator. The contactors d' to d^9 may be of any usual type, but consist, preferably, of any of the well-known forms of electromagnetically-actuated switches, and since the particular construction of these contactors forms no part of the present invention they are illustrated diagrammatically only by means of switches and an actuating-coil for the movable member of each switch.

The master-controller F consists, preferably, of a rotatable cylinder provided with a series of contacts which are adapted to engage in a predetermined order with a series of stationary fingers or brushes. The master-controller is shown diagrammatically in a developed form, as is usual in constructions of this type, the angular contacts F' representing metallic segments on the cylinder and the circles f^a f^h indicating the fixed fingers or brushes past which the contacts F' are carried. Two sets of contacts F' are shown, these being arranged on opposite sides of the "off" point of the cylinder for the purpose of causing the motor B to turn in one direction or the other, according as the master-controller is moved to one side or the other of its off position. The contacts F' comprise segments f, f', and f^2, together with a number of auxiliary segments electrically connected thereto. The segment f is continuous and extends throughout the entire arc through which the master-controller may be turned, and f' f^2 are each less than one-half as long as segment f and are arranged on opposite sides of the off point of the cylinder and in staggered relation to each other. As the controller is turned to the right segment f engages with fixed contact f^a and segment f^2 engages with fixed contact f^b; while upon turning the controller to the left contact f^a still engages with segment f, but segment f' engages with contact f^c. Contact f^a is connected to line 1 through wire 7, which passes through the control-cable. Contacts f^b and f^c are connected to leads or wires 8 and 9, respectively, wire 8 passing to the actuating-coil of contactors d' and d^2 through wire 10 to line-wire 2, and wire 9 passing through actuating-coil of contactors d^3 and d^4 through wire 10 to line-wire 2. When the master-controller is turned to the right, bringing contact f^c into engagement with segment f', a circuit is completed through the actuating-coil of contactors d^3 and d^4, closing them and permitting current to flow from line-wire 1 to contactor d^3, lead 3, field b', lead 4, resistance-sections R^5 to R^9, contactor d^4, to line-wire 2. The generator now supplies current to the motor-armature; but since the field of the generator is weak the current will be impressed at a very low potential. If a master-controller is turned in the opposite direction, bringing contact f^b into engagement with segment f^2, current flows from line 1 to wire 7 through wire 8, instead of through wire 9, as before, through the actuating-coil of contactors d' and d^2, through wire 10 to line 2, thereby energizing the actuating-coil of contactors d' and d^2 and closing said contactors. In this position of the master-controller the flow of current between the generator and motor is in the reverse direction from that which flows when the master-controller is turned in the opposite direction. Assuming that the master-controller has been moved to the right, causing contactors d^3 and d^4 to be energized, the motor B being supplied with current at a low potential, a further rotation of a master-controller to and through its successive running positions reduces the resistance in series with the field b' of the generator b and causes the voltage of the generator-current to rise. As the voltage of the generated current increases the speed of the motor likewise increases.

It is desirable that the motor may be started

at a very low speed, which is increased gradually in order that the starting of the gun or other object to be moved may be smooth and uniform. In order to provide a wide range of speeds for the motor, I have arranged the motor-controller so that the potential of the current impressed upon the motor may be varied through a fairly wide range by means of numerous small steps, these changes in voltage being accomplished by varying the resistance in series with the field of the generator correspondingly. To this end the resistance-sections R^5 to R^9 are preferably proportioned so as to have resistance values varying in geometric progression, each section having, preferably, twice the resistance of the preceding one, and the master-controller is arranged so that each contactor associated with the resistance-sections is operated a number of times during the cutting out of the resistance. Each resistance-section is therefore alternately cut in and cut out of circuit at various stages during acceleration in such a manner that the whole resistance in series with the field is varied by small steps which, in the arrangement shown, are equal in value to that of the smallest resistance-section R^5. In the controller illustrated only five resistance-controlling contactors are employed, while the number of resistance steps obtained thereby is more than six times that number.

One terminal of each of the actuating-coils of the resistance-controlling contactors d^5 to d^9 is connected to line-wire 2 through wire 10, and the opposite terminals are connected, respectively, to fixed contacts f^d to f^h of the master-controller by means of wires 11 to 15, inclusive.

The vertical dotted lines in the diagram of master-controller F indicate the lines of contact between the fixed and movable contacts in the various running positions of the master-controller. As we have seen, when the controller is in its first running position all the resistance is in series with the field of the generator. Upon moving the master-controller to its second running position contact-segment f' is electrically connected to fixed contact f^d, thereby completing the circuit from line 1, wire 7, contact f^a, contact f f', contact f^d, wire 11, actuating-coil of contact d^5, wire 10, to line-wire 2, thus energizing the actuating-coil of contact d^5 and closing said contact. The closing of contact d^5 short-circuits resistance-section R^5 and decreases the resistance in series with the field of the generator by that amount. In the third running position contact is broken at f^d, thereby deënergizing the actuating-coil of contact d^5 and allowing that contact to open, reinserting resistance-section R^5. At the same time, however, contact is made at f^e, and a circuit may now be traced through the actuating-coil of contact d^6, this contact being closed and cutting out resistance-section R^6. The resistance now in series with the field of the generator differs in value from that in circuit when the master-controller was in its second running position only by an amount equal to the difference in value between resistances R^6 and R^5. In the fourth running position contact is retained at f^e and is again established at f^d, thereby again cutting out resistance-section R^5. In the fifth running position contact is broken at f^d and f^e and is established at f^f, thereby reinserting resistance-sections R^5 R^6 and cutting out resistance-sections R^7. In a similar manner upon moving the master-controller successively through the whole of its thirty-two running positions resistance-sections R^5 to R^9 are so manipulated that after each step the entire resistance in series with the field of the generator has been varied by an amount equal to resistance R^5, and since it is obvious how the various circuits are established for accomplishing this result no attempt will be made here to trace the entire cycle of circuits. When the master-controller is turned in the opposite direction, exactly the same cycle of steps is performed, except that the direction of current-flow through the generator-field is changed.

It is evident that by means of the controller just described the motor may be started at a low speed and may be accelerated at a slow and uniform rate peculiarly adapted to moving a heavy mass, such as a gun and its carriage, from a position of rest, the acceleration of the motor being such that its speed increases only with sufficient rapidity to enable the motor to apply its power most efficiently. The motor may be slowed down gradually as the gun approaches the proper azimuth by gradually cutting in resistance, so that the gun may be moved and brought to rest again with smoothness and precision. Moreover, the parts of the controller are few in number, making the controller compact and of such simplicity that it may be safely used in situations where it is not desirable to have complex apparatus of this character.

In order that the operator of the controller may be able to properly position the gun, there is provided indicating mechanism consisting of a commutating device K, suitably connected to the gun-carriage, as by means of a shaft and a pinion k, together with a synchronous motor L, adjacent to master-controller, the synchronous motor being preferably geared to an instrument having a series of dials l for accurately indicating the position of the gun-carriage in degrees, minutes, seconds, and fractions of seconds. This indicating mechanism may be of any suitable construction and the commutating device and the synchronous motor any of the usual types. Reference may be had to my Patent No. 706,554, granted August 12, 1902, for a com-

plete explanation of a commutating device and synchronous motor adapted for use in the present system.

The motor-controller E is similar to the controller D, but controls the resistance in series with the armature of the motor C instead of controlling the action of a generator, as in the arrangement previously described in connection with motor B. The controller E has in addition to the contacts corresponding to the contact of controller D two fixed contacts c^{10} and c^{11}, which engage, respectively, with movable contacts c^2 and c^4 (corresponding to d^2 and d^4) when the latter are open. Contacts c^{10} and c^{11} are electrically connected, thereby short-circuiting the armature of motor C as soon as the current thereto is interrupted. Since the armature-brushes are connected to contacts c^2 and c^4 just as the terminals of the field b' are connected to d^2 and d^4, no current can be supplied to the armature while short-circuited, since either contact c^2 or contact c^4 must be raised for that purpose. The short-circuiting of the armature of motor C produces a braking action, which aids in bringing the gun to rest. The master-controller G is similar in every respect to the master-controller F, and therefore no detailed description of the motor-controller E and the master-controller G need be given. A commutating device K', similar to the commutating device K, is suitably geared to the elevating mechanism of the gun, as by means of gears k', connecting the commutating device with the operating-shaft c. The commutating device K' is operatively connected to an indicator L', similar to the indicator L. Both of the indicators L and L' are arranged adjacent the master-controllers, whereby the operator may be informed at all times of the exact position which the gun occupies, enabling him to stop the motors and bring the gun to rest trained properly as to azimuth and elevation.

A firing-circuit comprising wires 33 and 34 may extend from the gun to the distant station, where the circuit is normally kept open by means of a push-button switch 35. After the gun has been properly trained pressure upon the push-button 35 serves to fire the gun.

Difficulty is experienced in stopping the gun at the exact point desired on account of the momentum of the massive structure, which invariably carries the gun past the proper point no matter how slowly the gun may be brought into position. One of the features of the present invention consists in means for accurately positioning the gun upon the desired azimuth without the exercise of extreme care, and to this end there is associated with the gun-carriage a yielding stop and clutch mechanism which clutches the gun-carriage to the stop at the instant the motor-current is interrupted, the stop being provided with powerful springs or similar means which initially yields as it absorbs the momentum of the gun and carriage, but which returns the gun and carriage to the position which they occupied at the instant of clutching the stop. The details of this mechanism are shown in Figs. 2 and 3. 16 is a shaft geared to the motor in any suitable way and provided with a pinion or other gear element 17, which engages with a complementary element on the gun-carriage for the purpose of driving the same. The pinion 17 is normally loose upon the shaft and is provided with a sleeve 18, which surrounds the shaft. Splined to the sleeve 18 is the movable element 19 of a double clutch, preferably electromagnetic in character. As illustrated, the clutch member 19 consists of the magnetic core 20, having two sets of energizing-coils 21 and 22 on opposite sides thereof. Coöperating with the clutch member 19 is a magnetic disk 23, splined or otherwise secured to shaft 16, and a second disk 24, which loosely surrounds the sleeve 18, the clutch member 19 being disposed between these two disks. If coil 22 is energized, clutch member 19 coöperates with disk 23, thereby locking the sleeve 18 and its pinion to the shaft 16 and coupling the motor to the gun-carriage. If coil 21 is energized, disk 24 is clutched to the gun-carriage. Disk 24 is provided with a radially-extending arm 25, having pivoted thereto at its outer end one end of a rod 26, the opposite end of the rod 26 extending into a fixed frame or casing 27, within which is arranged a powerful spring 28. A follower-plate 29 is placed between one end of the spring 28 and a shoulder 29 and rod 26, and a similar follower 30 engages, respectively, at the opposite end of the spring at the nut 31 on the end of rod 26. It is seen that the application of force in either direction longitudinally of the rod 26 compresses the spring 28. By making this spring sufficiently strong and placing it under a considerable initial tension it may be employed to absorb any momentum which the gun and carriage may have when the clutching engagement is effected and return the gun and carriage to a point which will enable the spring to assume its normal position—namely, return the gun and carriage to the exact point they occupied when brought into engagement with the stop. The compressed spring may be considered as a source of energy adapted to oppose the energy of the moving gun and finally overcome it. The casing 27 may be made in the form of a closed cylinder and the followers 29 and 30 in the form of pistons slidable within the cylinder, the pistons and cylinder serving as a dashpot to absorb the energy of the gun and carriage, but not preventing the spring from returning the gun to its proper position in case it overruns. If desired, the cylinder 27 may be provided with suitable openings 32 to limit the resistance of the fluid within the cylinder. It may well happen that if the gun-carriage has any considerable momentum when it is

clutched to the stop the spring will be compressed to such an extent that in its reflex action it will move the gun-carriage backward beyond the proper position, in which case the spring will be again compressed, but from its opposite end, and after one or more oscillations the gun-carriage will be brought to rest properly positioned.

In order to effectively operate the clutch mechanism, I have provided a relay H, which comprises a movable arm h, permanently connected to line-wire 2 and adapted normally to engage with one terminal h' of the clutch-energizing coil 21, together with an electromagnet h^2, adapted when energized to move the arm h into engagement with one terminal h^3 of the coil 22 of the clutch. Coils 21 and 22 have a common terminal h^4, connected to line 1. The electromagnet h^2 is preferably arranged in shunt with the field b' of the generator, so that upon the instant the circuit of the generator-field is broken the electromagnet h^2 becomes deënergized and permits the arm h to drop into engagement with the terminal of clutch-coil 21, and since the opposite terminal of coil 21 is connected to line-wire 1 the coil will be energized, clutching the gun-carriage to the fixed stop in the manner described. Upon closing the circuit through the generator-field electromagnet h^2 is energized, breaking the circuit of coil 21 and completing the circuit of coil 22, thereby unclutching the gun-carriage from the stop and clutching it to the motor.

Although I have described one embodiment of the present invention in detail in order to clearly disclose the invention, the present invention is not limited to the details illustrated and described except as they may be included in the appended claims. The resistance in controllers D and E need not be adapted for insertion in series with the field of a generator or the armature of a motor, but may be utilized in any usual manner for regulating the current in a circuit. Neither need these resistances be short-circuited, as described, to increase the current in the controlled circuit; but they may operate in the reverse manner. The mechanism for accurately securing the gun after it has been brought into position may be employed with or without the particular type of controller herein disclosed and for other purposes than that of positioning a gun-carriage, and many other changes may be made without departing from the spirit and scope of the present invention.

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

1. In a system of gun control, a gun, means for training the gun both horizontally and vertically, control apparatus controlled from a point remote from the gun, and means controlled from said remote point for firing the gun.

2. In a system of gun control, a gun, a motor for training the gun horizontally, a second motor for training the gun vertically, control apparatus for said motors controlled from a point remote from the gun, a firing-circuit, and means at said remote point for controlling said firing-circuit.

3. In a system of gun control, a gun, motors for training the gun horizontally and vertically, motor-control apparatus adjacent the motors, master controller apparatus located at a point remote from the gun, a firing-circuit, and means at said remote point for controlling said firing-circuit.

4. In a system of gun control, means for moving a gun horizontally and vertically, a control-station at a point remote from the gun, and means for indicating the horizontal and vertical positions of the gun at said control-station.

5. In a system of gun control, a gun, motors for training the gun horizontally and vertically, control apparatus for said motors controlled from a point remote from the gun, indicators at said remote point, and means operatively connected to said gun for controlling said indicators, whereby the gun is controlled from and the horizontal and vertical positions are indicated at the remote point.

6. In a system of gun control, a gun, motors for training the gun horizontally and vertically, control apparatus for said motors controlled from a point remote from the gun, azimuth and elevation indicators at said remote point, motors for operating said indicators and control apparatus for said latter motors operatively connected to the gun.

7. In a system of gun control, a gun, motors for training the gun horizontally and vertically, control apparatus for said motors controlled from a point remote from the gun, means for indicating the horizontal and vertical positions of the gun at said remote point, a firing-circuit, and means at said remote point for controlling said firing-circuit.

8. In a system of gun control, a gun-carriage, a motor, a stop, and means for alternately locking the gun-carriage to the motor and to the said stop.

9. In a system of gun control, a motor, a yielding stop, and means for alternately clutching the gun-carriage to the motor and to said yielding stop.

10. In a system of gun control, a motor, a controller, a stop, means for clutching the motor to the gun-carriage upon moving the controller to an operative position and for clutching the gun-carriage to said stop upon moving the controller to its "off" position.

11. In a system of gun control, a motor, and means for alternately simultaneously energizing the motor and clutching it to the gun-carriage and simultaneously deënergizing the motor and clutching the gun-carriage to said stop.

12. In a system of gun control, a motor, a stop, and means for automatically disconnect-

ing the gun from the motor and connecting it to said stop upon interruption of the motor-current.

13. In a system of gun control, a gun, a motor, a source of energy and means for alternately connecting said gun to said motor and to said source of energy.

14. In a system of gun control, a gun, a motor, a spring engaging a fixed support and having an initial tension, and means for alternately clutching the gun to the motor and to said spring.

15. In a system of control, an electric circuit, a resistance comprising a group of sections varying in geometric progression, a switch for each resistance-section, and means for operating said switches for inserting or eliminating said resistance in said circuit by successive increments equal to one of said resistance-sections.

16. In a system of control, an electric circuit, a resistance comprising a group of sections varying in geometric progression, a switch for each resistance-section, and means for operating said switches for inserting or eliminating said resistance in said circuit by successive increments equal to the least of said resistance-sections.

17. In a system of control, an electric circuit, a resistance comprising a series of varying sections, a switch for each section, and means for causing each switch to operate a plurality of times during the insertion of the whole of said resistance in said circuit.

18. In a system of control, an electric circuit, a resistance comprising a series of varying sections, a switch for each section, and means for causing each switch to operate a plurality of times during the elimination of the resistance from said circuit.

19. In a system of control, an electric circuit, a resistance therefor comprising a series of varying sections, a switch for each section, and means for opening and closing each switch a plurality of times during each cycle of resistance changes.

In witness whereof I have hereunto set my hand this 25th day of November, 1904.

JOHN L. HALL.

Witnesses:

BENJAMIN B. HULL,

HELEN ORFORD.