No. 654,130. Patented July 24, 1900.

H. W. BUCK.

ELECTRIC STEERING GEAR.

(Application filed Mar. 20, 1899.)

(No Model.)

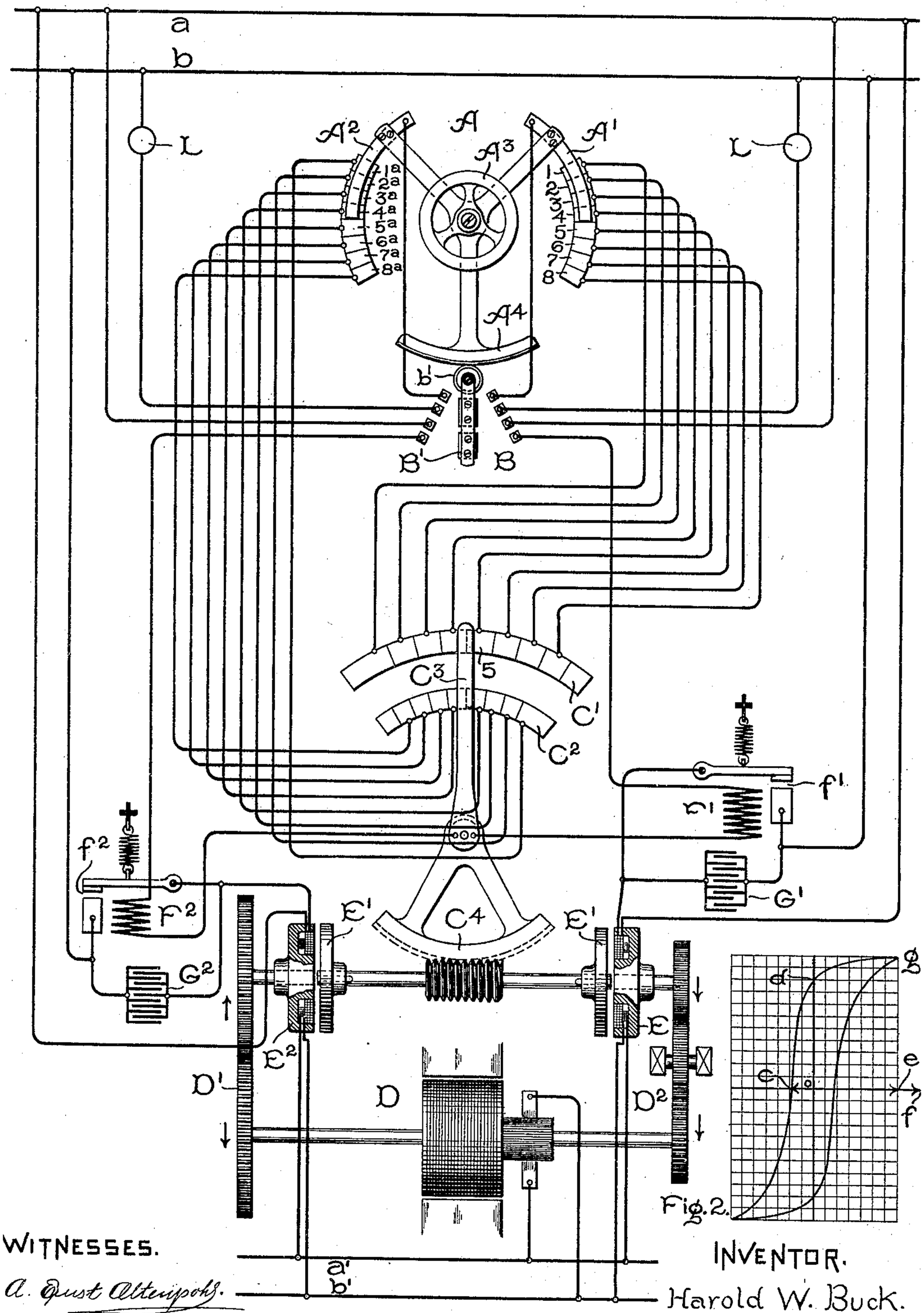

Fig. 1.

Fig. 2.

WITNESSES.

A. Quast Altenpohl.

A. F. Macdonald.

INVENTOR.

Harold W. Buck.

by Albert G. Davis.

Att'y.

UNITED STATES PATENT OFFICE.

HAROLD W. BUCK, OF SCHENECTADY, NEW YORK, ASSIGNOR TO THE GENERAL ELECTRIC COMPANY, OF NEW YORK.

ELECTRIC STEERING-GEAR.

SPECIFICATION forming part of Letters Patent No. 654,130, dated July 24, 1900.

Application filed March 20, 1899. Serial No. 709,702. (No model.)

To all whom it may concern:

Be it known that I, HAROLD W. BUCK, 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 Electric Steering-Gear, (Case No. 767,) of which the following is a specification.

The invention which is the subject of my present application is herein described as relating to electric steering-gear, but is not restricted to such use, as it is in some of its aspects of far wider application. It relates to that class of apparatus capable of reproducing at a distant point, with or without change in amount and with or without increase in power, the motion of an operating or controlling handle.

Many devices have been invented for such purposes, but those with which I am familiar are defective in one way or another. In electric steering apparatus for large ships, for example, it is necessary that any movement of the steering-handle should be followed by a practically instantaneous and corresponding movement of the rudder, to effect which a motor capable of developing as much as fifty-horse power is sometimes needed. This motor may be a steam-engine, and my invention may by obvious modifications be employed for operating the valves of such an engine; but I prefer to use an electric motor of some well-known and approved type—such, for example, as the shunt-wound direct-current motor. It has been proposed to control such motors electrically from the steering-wheel, starting and stopping them at will; but the time and the current required to start such a motor are very considerable, and therefore such a system of control is objectionable.

According to my invention the operating-motor is run constantly and is coupled to the device to be operated (the rudder or the valves of an engine) by clutches capable of causing movement in either direction at will, and these clutches are electrically controlled in such a way that the movement of the controlled device will reproduce the movements of the controlling wheel or handle in a manner to be more fully described hereinafter. Such a system of control is simple, effective, and reliable, as is demonstrated by practical tests.

I have also found in practice that clutches of the electromagnetic type are apt to stick when current is shut off from them owing to what is sometimes called the "coercive force" of the metal. This effect I avoid, and thereby produce an extremely-reliable clutch capable of wide application by constantly exposing the metal to a magnetomotive force equal (or substantially equal) and opposite to the coercive force of the metal—in other words, sufficient to instantly wipe out when the ordinary excitation is removed the remanent magnetism of the clutch.

In the application of my invention as herein shown I provide a constantly-running motor which, although of ample power to move the rudder under all conditions of service, may be very much smaller than the motors ordinarily used, inasmuch as it has full-speed torque and only takes a current limited by its high speed. It is of course designed to be adapted to its service and to be maintained directly in circuit across the power-mains of the ship at full voltage and without ohmic resistance. The motor is connected to the body to be moved through the medium of electromagnetic clutches positioned one at each end of a counter-shaft connected to the rudder through suitable gearing. These clutches are oppositely geared at the two ends of the counter-shaft, and it is designed to have only one of them in operation at a given time.

By this arrangement when one clutch is engaged the counter-shaft rotates clockwise. When the other is engaged, it rotates counter-clockwise. This counter-shaft drives the rudder, preferably through a worm-gear or some other non-reversible gearing, so designed that the friction loss is great enough to hold the rudder in any position in which it may be left. I further arrange a series of contacts in the pilot-house connected by wires, (which may be of quite small size—in fact, of only sufficient size for mechanical strength,) with other contacts located adjacent to the rudder and the connection of which is controlled by the motion of the rudder or other driven part. The relation of these sets of contacts is such

that as the wheel is moved certain circuits are completed through the electromagnetic clutches, and as the rudder moves these circuits are modified until they are all opened and the clutch is thrown out of action. Inasmuch as the clutch may at all times require considerable current to hold it securely, I have preferred to "relay" its operation, and therefore in addition to the contacts to which I have referred I provide a switch connected to the wheel, which controls the connections of two electrically-actuated devices which constitute relay-switches, one for each of the electromagnetic clutches. When one of these is closed, one clutch receives current, and when the other is closed the other clutch is energized. Of course the connections are so arranged that only one relay may act at a time.

With the arrangement of apparatus thus described it is of importance to prevent the clutches sticking after they should be released by the motion of the rudder as it opens the relay-circuit. To this end I expose the metal of each clutch to a constant magnetomotive force opposed to the magnetomotive force produced by the energizing-coils by providing in each clutch or differential coil acting against the main coil and so adjusted, as above described, that it provides a differential effect sufficient to overcome remanent magnetism. Thus as soon as the circuit of the clutch is opened the current passing in the differential coil brings the magnetomotive force of the clutch to zero. It is then entirely released.

In many cases it is important (and especially on shipboard) to prevent sparking. This is more particularly liable to occur at the relay-contacts, which I therefore bridge by a condenser, which takes up or opposes the extra current arising when the relay is opened and which is largely due to the inductive winding of the clutch.

In the drawings attached to this specification, Figure 1 is a diagram of the connections in the best form which I have as yet devised, and Fig. 2 is an explanatory diagram.

The power-mains of the ship are shown at a b and a' b'. These two sets of mains may, if convenient, be supplied from the same generator.

D is a constantly-running motor, which by the gearing D′ rotates the clutch E^2 in one direction, as shown by the arrow, and by the gearing D^2, which has an idler-wheel, rotates the clutch E in the opposite sense. Disks E′ E′ coöperate with the clutches and are respectively mounted upon the worm-shaft, being splined upon the shaft, so as to slide back and forth readily.

At C^4 is a segment of a worm-wheel which controls the motion of the rudder. (Not shown.) Fastened to the rudder or to the segment C^4 is an arm C^3, which bridges two sets of contacts C′ C^2, presently to be referred to. This arm C^3, together with the sets of contacts C′ C^2, constitutes what I have termed a "circuit-interrupting switch," its function being to interrupt the circuit controlling the magnetic clutch when the rudder has reached the desired position. The main winding of the clutches E E^2 is supplied with current from the mains a b through relay-switches f' f^2, controlled by the clutch-actuating coils F′ F^2, respectively. Condensers G′ G^2 shunt the relay-contacts for reasons above set forth.

At A is the controlling device or switch operated by the wheel A^3. Upon the lower part is a sector A^4, actuating the reversing or direction switch B, the arm B′ of which has insulated contacts registering with the fixed contacts on the right and left, respectively, of its illustrated position. It will be noted that the wheel b' makes rolling contact with the arm A^4, so that when the switch-arm B′ has been thrown to one or the other of the sets of contacts and stopped by mechanical engagement therewith the sector A^4 and the wheel A^3 are still free to turn, there being a frictional engagement between the wheel b' and its shaft carrying the arm B′. Therefore the first motion of the wheel A^3 in either direction closes one or the other of two sets of circuits, determining the direction of rotation of the controlled device. The amount of the rotation is determined by the position in which segments A′ A^2 are left. These segments bear on the contacts 1 to 8 and 1^a to 8^a, respectively, and the said contacts are individually connected to corresponding contacts on the segments C′ C^2, already referred to. The motion of the sector C^4 in one direction is controlled entirely by the contacts upon one side of the wheel and its opposite motion by those upon the other side. For instance, in the illustrated position no current passes in any of the apparatus except the motor D, which runs idle. If, however, the wheel A^3 be rotated clockwise until the segment A′ touches the contact 5, the first movement of the wheel actuates the sector A^4 and throws the switch-arm B′ to the right, and a circuit is completed to the corresponding contact 5 of the row C′ through the arm C^3. This circuit may be traced as follows: starting from the main b through the lamp L and the upper contacts of the switch B to the segment A′, thence through segment 5 and the conductor connected therewith to the arm C^3, thence through the actuating-coil F′ of the relay-switch f' to the lower contacts of the switch B and back to the main a. With this combination of circuits the contact f' is closed at the relay and current passes from the upper mains a b through the clutch E, which grips the disk E′, causing the arm C^3 of the circuit-interrupting switch to move to the right as the worm is rotated until this arm passes off contact 5 of the row C′ to the next or dead contact. When this position is reached, the circuit of the relay is opened and the clutch E is released. A lamp L is connected upon each side so as to show

in which direction the rudder is moving. By tracing the circuits it will be found that the lamp-circuit is opened as soon as the rudder ceases to move. For the lamp any suitable indicator may be substituted.

When now the rudder is to be thrown in the opposite direction, the wheel A^3 is rotated counter-clockwise, and the contact 5^a will be touched, as in the illustrated position, completing a similar circuit with the row of contacts C^2 to that which has already been described with reference to C'. The rudder then starts in the other direction, inasmuch as the clutch E^2 now engages with its disk E' and similar actions take place upon that side. It will be observed that the last contact of the row C' is an idle one and the corresponding contact on the left of the row C^2 is also idle, these being the limits of motion of the device in each direction.

Of course in the commercial installation of the device suitable resistances may be employed, and any desired form of auxiliary switches for connecting in the different parts and cutting them out, as may be required. The resistance of the leads themselves may be so selected as to fulfil any part of these functions. These things are well understood in the art and do not require extended explanation.

In Fig. 2 I have shown the hysteresis curve, or, as it is usually called, the "BA" curve of the clutches. If a magnetomotive force *oe*, generated by the main coils, be applied to a clutch, the magnetism will rise to the value shown by the line *eg*. If now this magnetomotive force be removed, as by the opening of the relay, the magnetism will fall to the value *od*, and if the iron is not jarred will tend to remain constant at that value. I therefore provide the additional coils above mentioned, constantly producing the counter-magnetomotive force *oc*, which is equal to the coercive force of the metal and sufficient to destroy the remanent magnetism, as is clear from the diagram. This will cause the clutch to release and then the small magnetomotive force *oc* will not be enough to cause it to catch again, as the magnetic circuit will be more open and the air-gap longer. Of course this renders it necessary that a slightly-greater magnetomotive force should be generated by the main coils than would otherwise be required—that is, a magnetomotive force *of*, equal to the arithmetical sum of *oe* and *oc;* but this is not a serious disadvantage.

I make no claim in this application to the improvement in magnetic clutches herein disclosed, since this constitutes the subject-matter of a divisional application filed May 26, 1900, Serial No. 18,046.

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

1. In combination, a body to be moved, a plurality of oppositely-rotating clutches operatively related thereto, actuating-coils for throwing said clutches into operation, means for positively demagnetizing the magnetic clutches as soon as the circuit of the actuating-coil is interrupted, a circuit-interrupting switch operatively related to the body to be moved, and means for closing a circuit through said interrupting-switch to either of said actuating-coils.

2. In combination, a body to be moved, a plurality of oppositely-rotating clutches operatively related thereto, actuating-coils for throwing said clutches into operation, a controlling-switch having a series of contacts, a circuit-interrupting switch having a series of contacts, electrical connections between the corresponding contacts of the controlling and circuit-interrupting switches, means for closing a circuit to either of the clutch-actuating coils through the contacts of said controlling and circuit-interrupting switches, and means actuated by the body to be moved for opening said circuit at the circuit-interrupting switch.

3. In combination, a body to be moved, a plurality of oppositely-revolving magnetic clutches operatively related thereto, a controlling-switch, comprising numerous contact-points, for determining the extent of movement of said body, a circuit-interrupting switch having contact-points electrically connected with the contact-points of the controlling-switch, means whereby a movement of the controlling-switch to one side or the other closes a circuit through said controlling and said interrupting switches to the energizing-coil of one or the other of said magnetic clutches, and means whereby a corresponding movement of the body to be moved opens said circuit at the circuit-interrupting switch.

4. An electric steering apparatus comprising a constantly-running motor, a counter-shaft connected by a worm-gear to the rudder, clutches operated in opposite directions by the motor, electromagnetic means for actuating said clutches, a circuit-interrupting switch, having a series of contacts, controlled by the rudder, and means located at a desired point for closing a circuit to a plurality of the contacts of said circuit-interrupting switch, and, through said switch, to one or the other of said electromagnetic clutch-actuating means.

5. An electric steering apparatus comprising a constantly-running motor, clutches rotated in opposite directions by said motor, a controlling-switch at a desired point, an operating-handle therefor determining by its position the extent of movement of the rudder, a circuit-interrupting switch controlled by the rudder and electrically connected to the controlling-switch, means for closing a circuit through said switches to energize one or the other of said clutches, and means for breaking the circuit through said switches when the rudder reaches the determined position.

6. An electric steering-gear, comprising a constantly-running motor, electromagnetic clutches geared to the motor and run thereby in opposite directions, a reversing or direction switch for connecting to the line either clutch at will, a controlling-switch determining by its position, the extent of movement of the rudder, and a circuit-interrupting switch controlled by the rudder and electrically connected to the controlling-switch for breaking the circuit of the connected clutch when the rudder reaches the position determined by the position of the controlling-switch.

7. In an electric steering-gear, a controlling-switch comprising a set of contacts on either side of the central position of the wheel and two switching-contacts operated by said wheel, a circuit-interrupting switch comprising two sets of contacts adjacent to the rudder and switching-contacts operated by said rudder, connections joining each contact in each of the sets at the ruddder to a corresponding contact in one of the sets at the wheel, rudder-operating means, two electromagnetic devices for connecting the rudder-operating means to the rudder, and a switch operated by the first movement of the wheel for supplying current to actuate one or the other of said electromagnetic connecting devices through the contacts of the said controlling and circuit-interrupting switches.

8. The combination with a controlling-handle, of a switch, having a series of operative positions, connected to said handle, a single constantly-operated source of power, a body to be controlled, a switch, having a corresponding series of operative positions, connected to said body and electrically connected to the switch at the controlling-handle, and means in circuit with said switches for operatively connecting the source of power to the body to be controlled.

9. In a device for transmitting motion, a constantly-rotating motor, controlling and controlled parts, clutches rotated in opposite directions by the motor, mechanism operated by the clutches for driving the controlled part in either direction, means at the controlling part for closing a circuit to actuate one or the other of said clutches, said means determining by its position the extent of movement of the controlled part, and means at the controlled part for breaking said circuit when the said part has reached a position corresponding to the position of the controlling part.

10. In an electric steering-gear or similar device, the combination with the rudder-operating shaft and the electromagnetic clutches oppositely geared to a single motor, of a switch operated by the wheel for closing a circuit to actuate either of said clutches, said switch determining by its position, the extent of movement of the rudder-operating shaft, and a switch operated by the rudder for interrupting said circuit when the rudder reaches a position corresponding to the position of the switch operated by the wheel.

11. In an electric steering-gear, the combination with a shaft operating with the rudder and connected to a constantly-rotating motor by oppositely-driven electromagnetically-operated clutches, of relays for completing the circuit of the clutches, a switch, for connecting in either relay, operated by the wheel and determining by its position the extent of movement of the rudder-operating shaft, and means actuated by the movement of the rudder for opening the relay-circuit when the rudder assumes a position corresponding to the position of the switch operated by the wheel.

12. In an electric steering-gear, the combination of a constantly-rotating motor, electromagnetically-operated clutches driven in opposite directions by the motor, a rudder-operating shaft, relay-switches for completing the circuits of the clutches as may be desired, a switch operated by the wheel to close a circuit for actuating either relay in accordance with the direction of movement of the wheel, the said switch determining by its position the extent of movement of the rudder-operating shaft, and a switch operated by the rudder for interrupting the relay-actuating circuit when the rudder assumes a position corresponding to the position of the switch operated by the wheel.

13. In combination, a body to be moved, a motive device for moving said body, means for connecting said motive device to said body to be moved, a source of current-supply, an electrically-actuated device for controlling the operation of said connecting means, a controlling-switch for determining the extent of movement of the body to be moved, a circuit-interrupting switch operatively connected to said body, and circuits connecting said electrically-actuated device to said source through the contacts of said controlling and circuit-interrupting switches.

14. In a device for transmitting motion, a controlling wheel or handle, a direction or reversing switch operated thereby, a switch comprising two sets of contacts in operative relation to the controlling-handle, a controlled body, a switch comprising two sets of contacts in operative relation to the controlled body, electric circuits joining individual contacts of the two pairs of sets, two oppositely-rotating magnetic clutches for operating the controlled body, and electrical connections such that the direction or reversing switch connects one or the other of said clutches into circuit through the circuits joining one of the sets of contacts at the wheel and at the controlled body.

In witness whereof I have hereunto set my hand this 15th day of March, 1899.

HAROLD W. BUCK.

Witnesses:

BENJAMIN B. HULL,

MABEL E. JACOBSON.