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SYSTEM OF MOTOR CONTROL.

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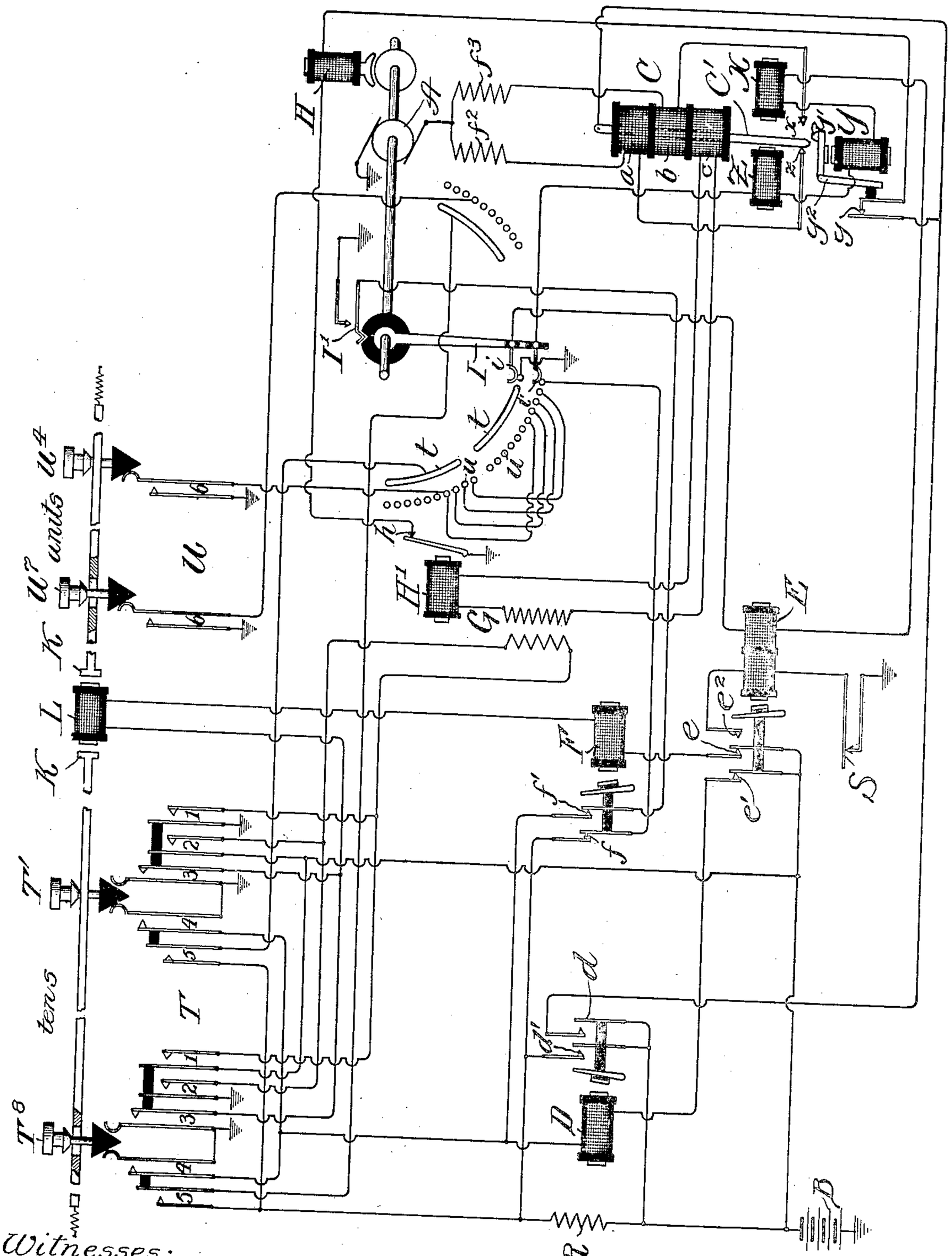

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UNITED STATES PATENT OFFICE.

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SYSTEM OF MOTOR CONTROL.

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To all whom it may concern:

Be it known that I, GEORGE F. ATWOOD, a citizen of the United States, residing at New York, in the county of New York and State of New York, have invented a certain new and useful Improvement in Systems of Motor Control, of which the following is a full, clear, concise, and exact description.

My invention relates to a system of motor control, and its object is to provide an electric motor, which drives a connecting brush or other carrier, with a system of control whereby said brush or carrier may be moved to a predetermined point at a relatively high rate of speed and stopped quickly and with precision. Heretofore in moving the carrier to a predetermined position, such result has been obtained by comparatively slow "step by step" mechanism, or else by employing various methods of balancing resistance or inductance, or by opposing one electromotive force with another of equal value when the motor has moved to the desired position. These various methods are, under many conditions of use, objectionable owing to their limitations in speed, accuracy or range of travel.

My invention contemplates a system of control in which the motor moves with comparative rapidity to the selected position, the direction and supply of current to the motor being regulated in such manner as to quickly bring the motor to a stop at such position.

More specifically stated, my invention consists in providing means for supplying the motor with current to cause its armature to rotate in a given direction to the predetermined position, thereupon automatically reversing the current until said motor comes to rest, and then cutting off the supply of cirrent.

My invention also contemplates means by which under given conditions current is supplied which causes the motor to return to its initial position.

A further feature of my invention consists in arranging the system in such a manner that the motor can be caused to rotate in either direction from its initial position, so as to take the shortest route to a selected position.

My invention is capable of use for various purposes, but it is particularly suitable for use in connection with an automatic or semi-automatic telephone system for controlling the movement of the usual selector arm. I will therefore describe such application of my invention.

The accompanying drawing is a diagram of the circuit and apparatus employed to control the rotation of a shaft such as is commonly used for driving the ordinary arm of a selector employed in an automatic or semi-automatic telephone system. For sake of clearness I have shown only the circuits and apparatus employed in my invention, no part of the usual telephone circuit being shown, it being understood that the telephone selector arm may be mounted upon the motor shaft to sweep over the line terminals in the usual manner. It must be understood, therefore, that the swinging arm carried by the motor shaft and the concentrically arranged terminals shown in the drawing are those forming a part of my control system and not to be confused with somewhat similar parts (not shown) forming the part of a well known type of automatic or semi-automatic telephone circuit.

The motor A is provided with two field windings f^2 f^3 in series with the motor armature, adapted to be energized one at a time, and to drive the motor armature in opposite directions. The circuit through the one or the other of said field windings is controlled by suitable reversing mechanism. Said mechanism is shown as comprising magnets X, Z, arranged to present to each other poles of opposite polarity, as for example an S and an N pole respectively, and an armature C^1, pivoted at its upper end and adapted to oscillate between the opposing poles of the electromagnets X and Z, said structure in operation being somewhat similar to a polarized electromagnet. The armature C^1, however, is made of material, as for example, soft iron, the magnetization of which may be readily controlled by a reversing magnet C provided with three windings, *a*, *b* and *c*. The windings *a* and *b* are such as to oppositely magnetize the armature C^1, which extends through the coils of magnet C and is free to swing between the poles of the magnets X and Z. The polarization of the armature C^1, and consequently its position, depends upon which of the windings of the magnet C is energized. The motor circuit may be traced from the battery B, one pole of which is grounded, through the contact *d* of starting relay D, to the armature C^1, and from thence through one or the other of the parallel

branches, including either contact *z*, winding *a* and field f^2 or contact *x*, winding *b* and field f^3, respectively, through the motor armature to ground. The motor circuit is normally open at contact *d*, its closure being controlled by starting relay D.

An electromagnetically operated brake H may be employed to assist in stopping the motor in the desired position. The electromagnet controlling said brake may be in a branch in parallel with the motor, said branch being controlled at contact *y* by a magnet Y, said magnet also performing other functions hereinafter described.

Rotating with the shaft of the motor is an arm I carrying brushes *i*, i^1, adapted to sweep over concentrically arranged groups of control terminals *t u*. Only three groups of each are shown, although ordinarily ten of such groups would be employed. Each of the units groups *u* comprises ten terminals representing digits, the corresponding digits being connected together, as shown. For one hundred positions of selection there would be employed ten of each group of terminals. A larger number might be provided for, in a manner well understood.

A bank of keys comprising a row of ten units keys U, and a row of ten tens keys T may be provided. For sake of clearness of illustration, only two of each of said keys, controlling circuits extending to opposite sides of the circle of control terminals, are shown. A locking magnet L, energized when one of said keys is operated, controls locking mechanism K which holds said key depressed.

The stopping relay E (which among other things controls the circuit of the starting relay D), the resetting relay F, the induction coil G, the normally closed switch S and other features illustrated may be most conveniently described in connection with a detailed description of the operation of the system.

The magnets C, X, Y and Z, forming in effect a polarized relay apparatus, are quick acting.

The drawing illustrates the normal or idle condition of the system, the arm I being shown at zero position. Under such condition a small current flows from battery B, through resistance R, normally closed contact *f*, zero units control terminal, brush i^1, and lead, through magnets Z, Y, X, and one winding of relay E, and from thence to brush *i* and zero tens control terminal to ground. The function of the small flow of current at the zero position is to obtain a magnetic field in the coils X and Z to react upon the armature C^1 in the starting of the motor, and thus to determine the direction of rotation of said motor in order to reach the terminal wanted by the shortest route.

Let us suppose the line 14 is wanted. The tens key T^1 and the units key U^4 are then depressed. The locking magnet L thereupon operates the bars K and holds said keys depressed, the circuit of said locking magnet being closed from ground through contact springs 3 closed by the operation of key T^1, relays L and F, contact *e* to battery B. Simultaneously with the closure of the circuit through relay L, several other circuits are completed, which will be described according to their sequence of operation. By the closure of contacts 1 and 2 of the key T^1, a circuit is completed through the primary winding of the induction coil G, said circuit extending from battery, through contact 2, primary winding of coil G, contact 1 to ground. It will be observed that one half of the tens keys, represented by T^1, connected with the left side of the circle of control terminals are adapted to send current through the coil in one direction, and that the other half of the tens keys, represented by T^8, connected with the control terminal at the right are so connected to battery as to send a current in a reverse direction through the primary of the coil G. The flow of current through the primary of coil G determines the direction of rotation of the motor in the following manner. The flow of current in the primary induces a momentary flow of current in the circuit of the secondary of the coil G, said circuit including the winding *c* of the relay C. The momentary energization of the coil *c* magnetizes the armature C^1 and causes it to be attracted to the magnet X or Z, as the case may be, thus moving it into position to control the direction of rotation, in case it does not happen to be already in the proper position. This action precedes others due to the operation of the keys, since, as before stated, the action of this relay apparatus is very quick. By the operation of key T^1 the armature C^1 is moved to the left, if not already in said position, and being once in said position is held there even when demagnetized by reason of the attraction of the magnet Z being greater than the then slightly more distant magnet X. The closure of the contact 4 of key T^1 causes next in sequence a flow of current from battery through contact e^1 of relay E, relay D, contact 4 to ground. This flow of current energizes the starting relay D, and its contacts *d* and d^1 are closed. The motor circuit is thus closed from battery through contact *d*, armature C^1, contact *z*, winding *a* of magnet C, field winding f^2, motor armature to ground, and results in the rotation of the motor, and the arm I carried thereby, toward the left from the zero position. The arm I, by leaving its zero position, opens the circuit through magnets X, Y, Z. The armature C^1 is thereupon mechanically locked in its position against contact *z* by a latch y^1 upon the armature y^2 of the magnet Y, said armature y^2 being retracted upon the de-

energization of said magnet. Coincident with the closure of the motor circuit, potential is established at the control terminals *t* and *u*, corresponding to the keys depressed. The contact 5 being closed in the operated position of key T^1, a circuit may be traced from battery through a short circuit of resistance R, now closed by contact d^1, contact 5, to the tens control terminal *t* associated with the key T^1, establishing a potential at said control terminal. The contact 6 being closed in the operated position of key U^4, a circuit may be traced from the ground side of the battery, through contact 6 to the number 4 unit control terminal, that is, the one associated with the key U^4, which establishes a ground potential at said unit control terminal. Upon the arm I reaching the selected terminals, a flow of current takes place through the circuit which is completed by the brush *i* bearing on the tens control terminal, through the lead from said brush to and through one of the windings of stopping relay E (but not necessarily operating it at this time, for the reason that the relay E is somewhat sluggish and the contact of the brush *i* may be but momentary) from thence through the coils of relays X, Y, Z, to the lead to the brush i^1 making contact with the selected units control terminal. The flow of current may be but momentary, however, since the arm I may make a very short duration of contact, owing to the acceleration of the motor even if the distance traveled by the arm is very short. This momentary flow of current, however, energizes the coils X, Y, Z. The coil Y thereupon operates its armature y^2, unlatching the armature C^1, and also closes contact *y* in a circuit to be considered hereinafter. The field set up in the coils X and Z react upon the armature C^1, which is magnetized by the winding *a* of the magnet C, moving said armature C^1 to the right against contact *x*, in which position it is held by the latch y^1 of the armature y^2 upon the deënergization of the coils X, Y, Z. The circuit of the motor is now closed through coil *b* of magnet C, and through the field f^3, the effect of which is to reverse the direction of rotation of the motor. The motor being reversed, the arm I is brought back under lowered acceleration to the energized control terminals. But assuming that the speed of the motor is still too high to permit its being stopped at the energized terminals in the manner hereinafter described, the flying contact made would again reverse the motor. This is due to the fact that the coils *a* and *b* are connected in opposition to each other, so that if the lower end of armature C^1 was magnetized with N polarity by the current flowing through coil *a*, it is now an S pole due to the current flowing through the coil *b*. The effect of the momentary flow of current in coils X, Y, Z, would now be therefore to move the armature to the left against contact *z* and thus reverse the direction of rotation of the motor.

It will be seen that each time a flying contact is made with the control terminals at which a difference of potential has been established, a momentary flow of current operates magnets X, Y, Z, and thus reverses the motor. As a means of helping to bring the arm I to rest quickly, an additional stopping device may be used. Any well known form of braking means may be used, but the additional stopping device which I preferably employ consists of a magneto brake H. As the arm I comes back to the terminal under low acceleration, a second momentary flow of current through coils X, Y and Z again reverses the motor, and thereupon contact *y* is closed by the operation of the armature y^2 of the relay Y. A flow of current is thus established from the battery lead of the motor, through contact *y*, magneto brake 4 to ground. Said magneto brake thereupon operates upon the armature shaft of the motor, stopping the motor at the point selected. The brushes *i* and i^1 being now in contact with the selected tens and units terminals, a circuit is completed, as hereinbefore described, through one winding of relay E. Said relay thereupon operates to open contacts *e* and e^1 and to close contact e^2. The opening of contact *e* breaks the circuit of resetting relay F and locking relay L, thus restoring them to normal. Upon the deenergization of relay L the lock bar K is retracted, and keys T^1 and U^4 are released from their operated positions. The opening of contact e^1 breaks the circuit through the starting relay D, which in turn results in opening the motor and brake circuit at contact *d*. The closing of contact e^2 permits a current to flow from battery through a locking coil of relay E, through the normally closed switch S to ground, thus holding contacts *e* and e^1 open. The arm I has been rotated and remains in the position to make the connection with the line wanted.

I will now describe the manner in which the arm I is returned to the zero position at the termination of the call. A switch I^1 is normally open only at the zero position of the arm I, being closed at all other positions. If when the arm I is in position upon the selected control terminals the switch S be opened, the locking circuit of relay E is opened, and consequently the back contacts *e* and e^1 are closed. A circuit is thereupon closed from ground through contacts closed by switch I^1, the now closed contact f^1 of relay F, relay D, the now closed contact e^1 to battery B. The consequent operation of starting relay D closes the motor circuit, as before described, the particular direction of rotation of the motor being accidental, that is to say, being dependent upon the position of

the armature C^1. The operation of the starting relay D short-circuited the resistance R, a circuit being closed from battery through contacts d^1, f, to units zero control terminal, establishing a potential at that point. The tens zero control terminal is directly connected to ground. Thus there is a difference of potential established at the zero terminals, which will cause a flow of current when the arm I reaches the zero position. The stopping of the motor will now be accomplished in the same manner as its stoppage, hereinbefore described, upon the selected control terminals. Upon the arm I coming to rest at zero position, the switch I^1 is opened and the stopping relay E operates, either or both operations causing the circuit through the starting relay D to be opened. The circuits of the motor A and the brake H are thereupon opened. The resistance R is introduced and the flow of current through said resistance is not strong enough to cause relay E to hold up its armature, and the contacts e, e^1, e^2 controlled thereby are restored to normal position. The cycle of operations has been completed and the parts are all in their initial positions, with a small current flowing through the coils X, Y Z.

The ground connection of the magnet H is preferably controlled by a relay H^1 in the secondary circuit of the induction coil G. The circuit of the magneto brake H is therefore opened at contact h by the induced current in induction coil G at the starting of the motor, thus removing the possibility of a braking action at this time. This opening of contact h is only momentary, but after the arm I has left the zero position, the circuit of the magnet H is open, as before described, at contact y until the selected terminals are reached. Hence, obviously, it is not until said selected terminals are reached that the braking action can take place in the manner hereinbefore described. Moreover, with this arrangement, the brake, although inoperative when the contact brushes i, i^1, are leaving their zero position, is operative when said brushes contact with the zero terminals on their return to normal position, thus acting, as is desirable, to bring the arm I quickly to rest in its zero position.

It will be noted that the motor cannot stop at any other line than the one wanted. For example, should the motor drive the arm I past the predetermined point, a reversal of rotation will bring it back. If the speed still be too high or the braking action too weak, and the arm pass the predetermined point a second time, another reversal will bring it back again, and so on, each reversal causing the arm to oscillate through a smaller amplitude. In practice not more than one reversal is necessary as a rule, and the action is very quick, the arm moving but a short distance beyond the selected point, being then reversed and stopped at the selected position.

I claim:

1. In a system of motor control, the combination with an electric motor, of a carrier driven thereby, and means for bringing said carrier to rest at a predetermined position, said means comprising braking means automatically applied to the motor and means for reversing the direction of rotation of the motor, whereby said carrier is caused to oscillate about said position until brought to rest thereat.

2. In a system of motor control, the combination with an electric motor, of a selector arm driven thereby, control terminals, and means whereby at each momentary contact of said arm with a selected terminal or terminals the direction of rotation of the motor is reversed.

3. In a system of motor control, the combination with an electric motor, of a selector arm driven thereby, control terminals, means whereby at each momentary contact of said arm with a selected terminal or terminals the direction of rotation of the motor is reversed, and means for opening the motor circuit upon said arm remaining at rest upon said selected terminal or terminals.

4. In a system of motor control, the combination with an electric motor, of a selector arm driven thereby, control terminals arranged in the path of movement of said arm, and means for automatically braking said motor upon the contact of said arm with a selected terminal or terminals.

5. In a system of motor control, the combination with an electric motor, of a selector arm driven thereby, control terminals arranged in the path of movement of said arm, and means for automatically braking said motor and for reversing the direction of rotation thereof at each momentary contact of said arm with a selected terminal or terminals.

6. The combination with an electric motor, of concentrically arranged control terminals, a selector arm mounted to rotate with said motor and to make a sweeping contact with said terminals, and means whereby at a predetermined position the contact of said arm causes a reversal of rotation of said motor.

7. The combination with an electric motor, of concentrically arranged control terminals, a selector arm mounted to rotate with said motor and adapted to be brought under quick acceleration to a selected terminal or terminals, and means whereby at each momentary contact of said arm with said selected terminal or terminals the direction of rotation of said motor is reversed.

8. In a system of motor control, the combination with an electric motor, of a selector arm driven thereby, control terminals ar-

ranged in the path of movement of said arm, contact means carried by said arm, adapted to make sweeping contact with said terminals, means for establishing a potential at any desired terminal, a circuit controlled by the contact of said contact means with a selected terminal, and electromagnetically controlled mechanism in said circuit for successively reversing the direction of rotation of the motor upon each closure of said circuit.

9. In a system of motor control, the combination with an electric motor, of concentrically arranged control terminals, means for establishing a potential at any desired terminal, a selector arm mounted to rotate with said motor, contact means carried by said arm, said arm and contact means being adapted to be brought under quick acceleration to the selected terminal, a circuit controlled by the contact of said contact means with a selected terminal, and electromagnetically controlled mechanism in said circuit for successively reversing the direction of rotation of the motor upon each closure of said circuit.

10. The combination with an electric motor, of a plurality of rows of control terminals, each row representing digits of a different order, means for establishing a potential at the control terminals representing a desired number, a selector arm driven by said motor and adapted to be brought under quick acceleration in contact with the selected terminals, and means whereby at each momentary contact of said arm with said selected terminals the direction of rotation of said motor is reversed.

11. In a system of motor control, the combination with an electric motor, of a plurality of rows of concentrically arranged control terminals, each row representing digits of a different order, means for establishing a potential at the control terminals representing a desired number, a selector arm mounted to rotate with said motor, brushes carried by said arm and adapted to make sweeping contact with said terminals, a circuit closed by the momentary contact of said brushes with the selected terminals, and electromagnetically controlled mechanism in said circuit for successively changing the circuit of the motor upon each closure of said circuit, whereby the direction of rotation of the motor is successively reversed.

12. The combination with an electric motor having alternative fields adapted to cause the rotation of the motor armature in opposite directions, of a selector arm driven by said motor, control terminals in the path of movement of said arm and arranged to be swept thereby, means for selecting a desired terminal, and means whereby at each successive contact of said arm with a selected terminal the field of the motor circuit is changed so as to reverse the direction of rotation of said motor.

13. In a system of motor control, the combination with a motor, of a carrier adapted to be driven by said motor in either of two directions, control terminals arranged upon opposite sides of the normal position of said carrier, means for selecting a desired terminal, and means for determining the direction of rotation of said motor to move said carrier to said selected terminal.

14. The combination with an electric motor, of circularly arranged control terminals, a radially extending selector arm mounted to rotate with said motor in the path of said terminals, and means for determining the direction of rotation of said motor to move said carrier to a selected terminal by the shortest route.

15. The combination with an electric motor having alternative fields adapted to cause the rotation of the motor armature in opposite directions, of a selector arm carried by and rotating with said motor armature, control terminals arranged circularly in the path of movement of said arm, means for selecting a desired terminal, and means, controlled by the selection of said terminal, for determining the direction of rotation of said arm by the shortest route to the selected terminal.

16. In a system of motor control, the combination with an electric motor having alternative fields adapted to cause the rotation of the motor armature in opposite directions, of a selector arm carried by and rotating with said motor armature, contact means carried by said arm, contact terminals arranged circularly in the path of movement of said contact means, means for selecting a desired terminal, and means for determining the rapid rotation of said arm by the shortest route to the selected terminal and for quickly stopping said arm with said contact means in engagement with the selected terminal.

17. In a system of motor control, the combination with an electric motor provided with alternative field windings arranged to produce opposite directions of rotation of said motor, of opposing electromagnets arranged to produce poles of opposite polarity, an armature pivoted to vibrate between said poles, and in its extreme positions to close the circuit through one or the other of said field windings, a plurality of energizing coils arranged to control the polarity of said armature and thereby to determine the position said armature will assume, a carrier driven by said motor, circuits for said motor, electromagnets and coils, and a plurality of keys for controlling the initial closing of said circuits.

18. In a system of motor control, the combination with an electric motor provided

with alternative field windings arranged to produce opposite directions of rotation of said motor, of opposing electromagnets arranged to produce poles of opposite polarity, an armature pivoted to vibrate between said poles, two energizing coils for said armature arranged in parallel and wound in opposite directions, one of each of said coils being in series with one of each of said field windings, contacts controlling the circuit of said coils adapted to be alternately closed by said armature, a plurality of keys for controlling the circuit of said motor, electromagnets and coils, and a carrier driven by said motor.

19. In a system of motor control, the combination with an electric motor provided with alternative field windings arranged to produce opposite directions of rotation of said motor, of opposing electromagnets arranged to produce poles of opposite polarity, a hollow spool provided with alternative coils adapted when energized to produce opposing magnetic fields, an armature extending through said hollow spool and arranged to vibrate between said poles, contacts controlling the current flow through said coils and said field windings, said contacts being arranged on opposite sides of said armature and adapted to be alternately closed in the movement of said armature from one of its attracted positions to the other, a carrier driven by said motor, and a plurality of keys for controlling the circuits of said motor, electromagnets and coils.

20. In a system of motor control, the combination with an electric motor provided with alternative field windings arranged to produce opposite directions of rotation of said motor, of opposing electromagnets arranged to produce poles of opposite polarity, an armature pivoted to vibrate between said poles, an electromagnet having its windings in series with the windings of said first-named electromagnets, an armature for said last-mentioned electromagnet arranged when retracted to hold said other armature in either of the alternative positions which it may have assumed, said armature, when so held, closing the circuit through one or the other of said field windings, a carrier driven by said motor, and a plurality of keys for controlling the electrical circuit conditions.

21. In a system of motor control, the combination with an electric motor provided with alternative field windings f^2, f^3, arranged to produce opposite directions of rotation of said motor, opposing electromagnets Z, X, arranged to produce poles of opposite polarity, a hollow spool provided with alternative coils a, b, in series respectively, with field windings f^2, f^3, said coils being adapted when energized to produce opposing magnetic fields, an armature C^1 extending through said hollow spool and arranged to vibrate between said poles, contacts controlling the current flow through said coils, said contacts being arranged on opposite sides of said armature and adapted to be alternatively closed in the movement of said armature from one of its attracted positions to the other, an electromagnet Y having its windings in series with the windings of said electromagnets Z, X, an armature y^2 for said electromagnet Y, a latch carried by the armature y^2 and adapted when said electromagnets are deënergized to engage the armature C^1 to hold the same in either of the alternative positions which it may have assumed, a plurality of keys for controlling the energization of said electromagnet, and a selector arm driven by said motor.

In witness whereof, I, hereunto subscribe my name this first day of June, A. D., 1907.

GEORGE F. ATWOOD.

Witnesses:
W. B. WALLACE,
J. F. BOLAND.