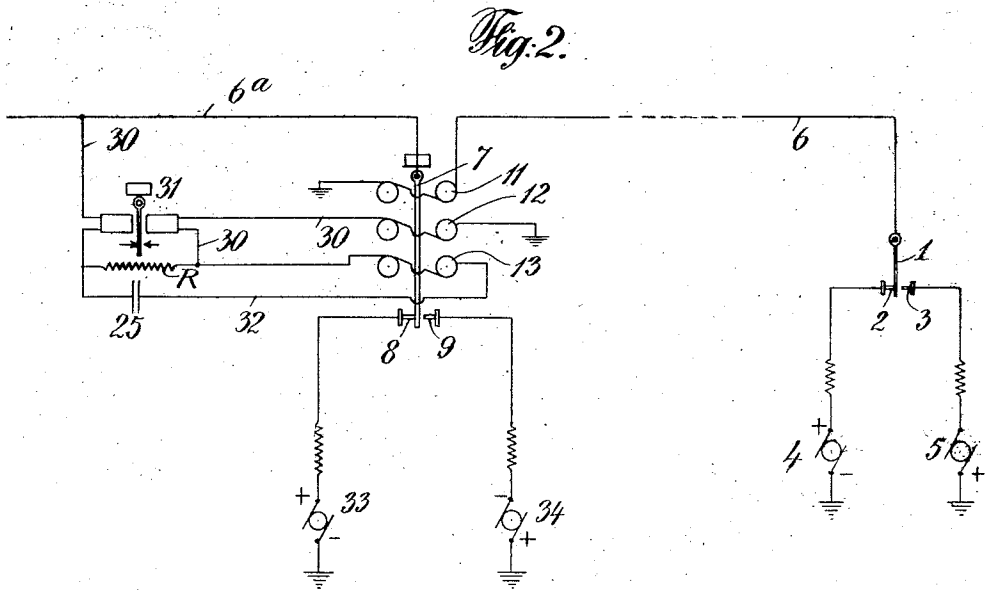
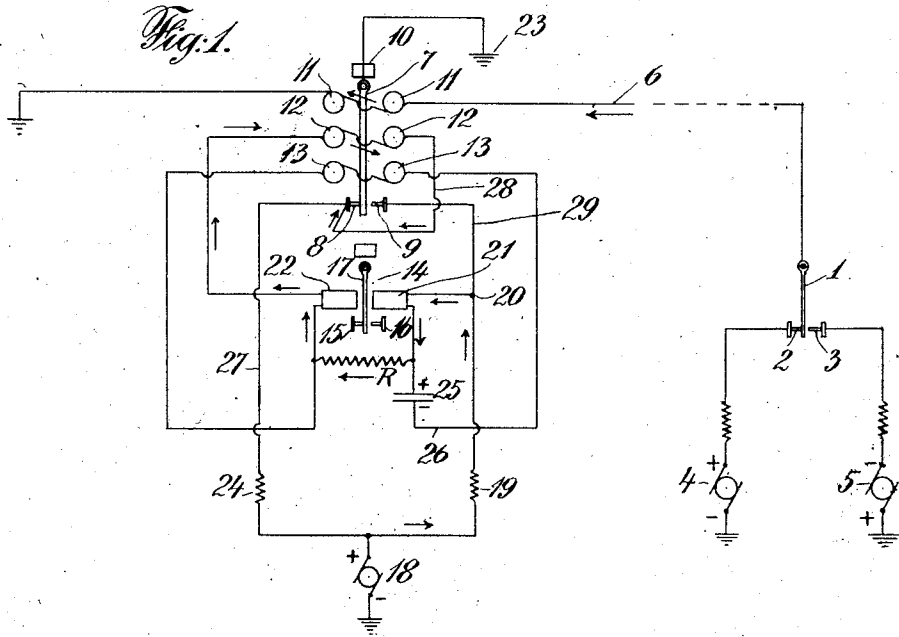


W. FINN.
RELAY AND REPEATER.
APPLICATION FILED DEC. 21, 1914.

1,164,273.

Patented Dec. 14, 1915.



Witnesses:
Paul H. Frank
A. J. Jones

Inventor
William Finn

By his Attorney
H. M. Marble

UNITED STATES PATENT OFFICE

WILLIAM FINN, OF BLOOMFIELD, NEW JERSEY, ASSIGNOR TO THE WESTERN UNION TELEGRAPH COMPANY, OF NEW YORK, N. Y., A CORPORATION OF NEW YORK.

RELAY AND REPEATER.

REISSUED

1,132,273.

Specification of Letters Patent.

Patented Dec. 14, 1915.

Application filed December 21, 1914. Serial No. 872,402.

To all whom it may concern:

Be it known that I, WILLIAM FINN, a citizen of the United States of America, and a resident of Bloomfield, county of Essex, and State of New Jersey, have invented certain new and useful Improvements in Relays and Repeaters, of which the following is a specification.

My invention relates to improvements in relays and repeaters, particularly relays and repeaters intended for high speed operation.

The relays and repeaters herein illustrated and described are particularly intended for use in automatic telegraph systems, wherein current impulses succeed each other through the line at rates far in excess of those of hand transmission; but my invention is not limited to use in automatic telegraph systems, but is adaptable for use wherever relays and repeaters are or may be employed.

In high speed telegraph systems and other systems of electrical transmission and reception of signals, involving rapid current fluctuations, the speed of signaling is affected, and to some extent limited, by line conditions, such for example, as the mechanical and electrical inertia of the apparatus employed, also by what is known as the KR factor of the line (K representing the distributed electrostatic capacity of the line, and R the ohmic resistance of the line, it having been proved by extensive experiments that the length of time required for a current to reach its maximum strength at the distant end of the line varies directly as a product of the capacity K and the resistance R). These conditions prevent the recording of a signaling pulse at the receiving station until some appreciable time after that signaling pulse has started from the transmitting station.

Before a signaling impulse can actuate the ordinary main line magnetic signal receiving devices, the main line current, and the magnetism created thereby in the main line signaling device, must necessarily rise to a value such as is required to effect transfer of the armature of that signal receiving device from one to the other of its contact stops. If the time interval here involved can be reduced in any way through the medium of local appliances, materially higher speed of transmission becomes possible together with better signals.

Heretofore repeaters have always, in their operation, lagged slightly behind the operation of the corresponding transmitters. In the operation of the repeater herein described there is no such lag; the repeater begins to operate the instant the corresponding transmitter begins to operate, and in general the repeater will have completed its operation before the transmitter has completed the corresponding operation. Thereby the lagging effect of the former repeater is entirely overcome. It is obvious that the avoidance of this lag very greatly quickens the operation of the circuits comprising repeaters.

My invention comprises means whereby the armature of the receiving instrument is carried over positively from the one stop to the other once that armature has been started in motion; the completion of such movement of the armature from the one contact stop to the other being assured, even though the impulse which started such movement terminate before the conclusion of such movement; and further comprises means whereby such movement of the armature is started, by local means, upon the diminution of the main line current which previously held that armature stationary against one or the other of its stops, and whereby the armature is caused to anticipate in its operation, the arrival of the next succeeding line signaling impulse. And my invention comprises various other features, all as hereinafter described, and particularly pointed out in the appended claims.

The objects of my invention are to increase the effective speed of transmission of signals over telegraph circuits and the like, to avoid lag in reception and repetition of signals, to obtain improved and sharper signals, particularly on high speed lines, to avoid the disturbing effects of induction and other influences tending to produce false signals, and to make the apparatus very simple and easy of construction and operation, and free from liability to derangement.

I will now proceed to describe my invention with reference to the accompanying drawings, and will then point out the novel features in claims.

In said drawings: Figure 1 shows diagrammatically a telegraph line comprising transmitting apparatus (illustrated diagrammatically, and a receiving relay, the lat-

ter embodying my invention. Fig. 2 is a similar view illustrating the use of my relay as a telegraph repeater.

Referring first to Fig. 1, numeral 1 designates a transmitting key having contact stops 2 and 3 and current supply means 4 and 5 connected to stops 2 and 3 respectively. The particular current supply means indicated are dynamo electric machines of opposite polarities; though as is well understood, other sources of current supply may be employed; the particular arrangement shown being a common arrangement for transmission by current impulses of alternately opposite direction. The key 1 may be vibrated either by hand or by any suitable means, and I do not limit myself to any particular means for vibrating that key in accordance with telegraphic or other signals. The key 1 may be, for example, the movable contact arm of a Wheatstone transmitter or any other suitable type of automatic or machine transmitter. 6 designates the line conductor.

The receiving relay comprises an armature lever 7, indicated in this instance as a pivotally supported lever playing between contact stops 8 and 9. This armature lever 7 may be understood to be a magnetized lever, similar to the magnetized armature levers employed in so-called "polar" relays, and the rectangle 10 may be understood to represent one pole of a magnet energizing this relay armature lever 7. On opposite sides of the lever 7 (in the particular arrangement shown) are electro magnets 11—11, 12—12 and 13—13, each pair of magnet spools arranged to influence the lever 7 just as the magnet spools of an ordinary polar relay actuate the armature lever of such relay. While I have shown the spools 11—11, 12—12 and 13—13 as separate spools, for clearness of diagrammatic illustration, it will be understood that in practice only one pair of spools may, and commonly will, be employed, such spools each having three different windings corresponding to the windings 11, 12 and 13. It is not uncommon in polar relays to provide each spool with two or more separate windings; but it is common for clearness of illustration, to indicate such separate windings, in diagrammatic drawings, as if such separate windings were on different spools.

14 designates a local relay which may be understood to be a polar relay and to be capable of operating, by means of contact stops 15 and 16, and its armature 17, any desired local signal receiving or signal repeating or translating apparatus; or the armature 17 may operate such signal receiving or signal repeating or translating apparatus mechanically; this being, for present purposes, an immaterial detail; or the instrument 14 may be itself a sounder; and for

present purposes, the relay 14 may be regarded as the local receiving instrument of the telegraph system.

In this specification I will term the windings 11 "main line coils," the windings 12 "opposing coils" and the windings 13 "accelerating coils." The windings 11 are, as shown, in the main line circuit 6; the windings 12 are in a local circuit (traced hereafter) and controlled by the contact stops 8 and 9 and armature lever 7; and the windings 13 are also in a local circuit. The particular function of the opposing windings or coils 12 is to develop a polarity of magnetism that shall always be opposed to the magnetism created by the main line coils 11, the magnetism created by the opposing coils 12 not being so strong, however, as that created by the working current of the main line 6 in coils 11. The particular function of the accelerating coils 13 is, to carry the armature 7 across the gap between stops 8 and 9, once the armature lever 7 has been set in motion as hereinafter described.

Fig. 1 shows the apparatus with its movable parts in the positions occupied with the transmitting key 1 in contact with contact stop 2 and with the apparatus at rest. Arrows indicate the relative directions of flow of current with the parts at rest in the positions shown. As indicated by such arrows, the current from generator 4 in main line 6 tends to hold armature lever 7 to the left in contact with stop 8.

There is a local generator 18 supplying current to the opposing coils 12, as follows:—From the positive pole of generator 18 (negative pole grounded, in the arrangement shown) through balancing resistance 19 to 20 and thence through coil 21 of local relay 14 to resistance R, thence through such resistance R and coil 22 of relay 14 to opposing coils 12, and through those coils to contact stop 8, and thence through armature lever 7 to ground at 23. The current from generator 18 through the opposite balancing resistance, 24, passes directly to ground at 23 through armature lever 7, and does not affect the "opposing" coils 12; but because of resistance 24, the circuit through such resistance 24 does not completely "short" the circuit, as traced above, through resistance 19. The current through opposing coils 12 causes those coils to oppose, with respect to the armature 7, the action of the main line current in coils 11 on that armature; but since the influence of coils 12 upon armature lever 7 is normally less than that of coils 11, energized by the main line current, armature 7 remains stationary in the position shown. Normally, there is no current through "accelerating" coils 13. But when the predominating influence of the main line current is removed (as when the transmitting key 1 is moved toward stop 3 and there-

fore an interval of "no current" in the line exists during the transition period), the magnetization induced by "opposing" coils 12 forces armature lever 7 away from the stop 8 and toward the stop 9. There is a condenser 25 bridged across the resistance R by the local circuit conductor 26, which local circuit passes through accelerating coils 13. The instant armature lever 7 leaves contact stop 8 the current energizing opposing coils 12 ceases, and therefore at this instant condenser 25 discharges, energizing accelerating coils 13 and carrying the armature lever 7 over to its stop 9 with a force that not only insures solidity of contact with that stop but renders the armature indifferent to inductive disturbances in line 6 or elsewhere that would otherwise affect movement of said armature lever 7.

It will thus be seen that the movement of the armature lever 7 may be completed before the movement of the transmitting key 1 is completed; that the movement of armature lever 7 may actually begin before transmitting key 1 has made contact with its stop 3, and before the next signaling impulse in the line, to which impulse such movement of the armature lever 7 corresponds, has even begun. Brief as the "no current" interval in the line is, it is a measurable interval. Former signal receiving apparatus have, necessarily, remained stationary (except as affected falsely by induced currents and the like) during the no current interval, and have commenced their operation only after the conclusion of the "no current" interval and after the succeeding main line impulse has risen to the value necessary to actuate the armature of the receiving instrument. In contradistinction to the operation of former signal receiving apparatus my signal receiving apparatus begins to operate immediately upon the beginning of the "no current" interval, and may complete its operation before the end of that "no current" interval. There is, therefore, an entire absence of the lag heretofore obtaining with receiving apparatus as compared with the corresponding transmitting apparatus. But whether or not the operation of the receiving instrument be completed before the end of the "no current" interval is unimportant, as no derangement of the apparatus will result from completion of the movement of the armature 7 before the current impulses resulting from contact of transmitting key 1 with stop 3, has risen to a value sufficient to affect coils 11. The fact that the armature lever 7 begins to move immediately upon the beginning of the "no current" interval renders that armature substantially immune to the action of induced currents and the like in the main line 6, during such no current interval, because the armature 7 is, during

such movement, under the influence of coils 13 energized by the discharge from condenser 25, which discharge is sudden and relatively strong.

Armature lever 7 having made contact with stop 9, the current from generator 18 through the "opposing" coils 12 and the magnet coils of relay 14, is established in a direction opposite to its former direction; *i. e.*, is established through balancing resistance 24, conductors 27 and 28, coils 12, coil 22 of relay 14, resistance R, coil 21 of relay 14, and conductor 29, to contact stop 9 and thence through armature lever 7 to ground at 23; the armature 17 of relay 14 is thereby reversed, and the coils 12 now tend to move armature lever 7 away from stop 9; but by this time the signaling impulse in line 6, due to contact of transmitting key 1 with stop 3, will have been established; or, if not, the discharge from condenser 25 still passing through coils 13, will be sufficient to maintain armature lever 7 against stop 9, even against the influence of opposing coils 12. The capacity of condenser 25 is regulated, with reference to the normal speed of operation of transmitting key 1, so that, if necessary, the discharge from the condenser 25 will persist until, after the no current interval in the line, the succeeding signaling impulse rises to sufficient value to overcome the influence of opposing coils 12. The condenser 25 of course charges immediately upon the reestablishment of current flow through the opposing coils 12, and thus is in condition to act again upon reverse movement of transmitting key 1 from stop 3 to stop 2. In such reverse movement the action is precisely similar to that above described, the current in the "opposing" coils 12 being cut off the instant armature lever 7 leaves the stop 9, and the condenser 25 discharging through the accelerating coils 13, the instant the circuit through coils 12 is broken, so carrying the armature 7 over against the contact stop 8.

In Fig. 2 I illustrate an application of my invention as above described to a telegraph repeater. In this figure, 1 designates a transmitting key or equivalent instrument, as in Fig. 1, such key 1 playing between stops 2 and 3 to which are connected sources of current supply 4 and 5 having opposite poles connected to stops 2 and 3 respectively. 6 designates the line leading from this transmitting 1 to the repeater, 7, and 6^a designates the other line leading to the repeater. Instrument 7 is provided, as in Fig. 1, with main line coils 11 opposing coils 12 and accelerating coils 13; also with contact stops 8 and 9. In this arrangement I have indicated the coils 12 as located in a leak circuit or derived circuit 30 leading from line 6^a through coils of a so-called "leak" relay 31 to ground; such circuit 30 containing a re-

sistance R; and I have shown the condenser 25 bridged across the terminals of this resistance R in a circuit 32 passing through the "accelerating" coils 13. To the contact stops 8 and 9 of repeater 7 are connected sources of current supply 33 and 34, having opposite poles connected to said stops.

It will be apparent that with the transmitting key 1 in the position shown, and the current from generator 4 through that key and through main line coils 11 of repeater 7 holding the armature of that repeater against stop 8, there will be current from the positive pole of generator 33 through stop 8 and the armature of repeater relay 7 and line 6^a to the end of that line; and that from the line 6^a there will be a leak current through the magnets of leak relay 31 and "opposing" coils 12, such leak current energizing the coils 12 to tend to move the armature of instrument 7 to the right, though no such movement takes place while key 1 is in the position shown. But the instant that key 1 is moved to the right, breaking the current from generator 4, the leak current from generator 33 through circuit 30 will start the armature of instrument 7 to the right; and while the current in the leak circuit will immediately cease upon the starting of that movement of the armature of instrument 7, condenser 25 will discharge through accelerating coils 13, so carrying the armature of the instrument 7 over to the right. This movement of the armature of the instrument 7 will probably be completed before key 1 has made contact with stop 3 and therefore before the next signaling impulse in line 6 from generator 5, has been established. Upon the establishment of the next signaling impulse viz:—that from generator 5, coil 11 will be energized, holding the armature of relay 7 to the right; and current from generator 34 having already been established through stop 9 and armature of relay 7 and line 6^a, there will be a current through the leak circuit 30 and "opposing" coils 12 tending to move the armature of relay 7 to the left, such tendency, however, being weaker than the tendency of main line coils 11 to hold the armature to the right. Condenser 25 will recharge and upon the beginning of the next movement of transmitter key 1 to the left, the "opposing" coils 12 will start the armature of relay 7 toward the left, such armature being carried over against stop 8 by the discharge of condenser 25 through circuit 32 and accelerating coils 19.

It will thus be seen that the repeater 7 will repeat into line 6^a, the signals received from line 6. It will also be apparent that the leak relay 31 will operate in accordance with the signals transmitted as described through line 6^a and that this relay 31, like the relay 14 of Fig. 1, may operate local signal receiving

or signal repeating or translating apparatus, or may itself be a sounder.

Because, during its movement, the armature 7 of either the instrument shown in Fig. 1 or the instrument shown in Fig. 2 is under the influence of the accelerating coils during its movement, these instruments are practically free from disturbance due to inductive interference and the like. Because the armatures of these instruments start to move, in correspondence with any movement of the corresponding transmitter, the instant that transmitter begins to move, lag in the operation of these instruments is entirely avoided and thereby the defects of line capacity are in large measure eliminated and the operation of the circuit is very greatly quickened. In practical applications of these instruments to automatic Wheatstone circuits the speed of these circuits has been increased by more than 100% of what was attainable under the ordinary method of working. These instruments are highly sensitive to weak signaling impulses and are also relatively insensitive to extraneous disturbing influences, and, therefore, can be operated successfully over longer lines than former instruments for the same service, and can be worked at higher than the usual rates of speed. A further important advantage of these instruments is that there is absolutely no tendency to spark, or arc, at the relay contact points; which contact points can, therefore, be adjusted more closely for high speed work than is the case with ordinary relays. This immunity from sparking and its consequences, is due to the fact that in addition to the single polarity arrangement in the contacts of the relay, there are two continuous paths through which the shunted condenser may discharge, viz:—one around the high resistance shunt and the other through the relay 14 and opposing coils 12; therefore the tendency to discharge across the break points of the relay (which is a characteristic of the ordinary shunted condenser arrangement), is entirely obviated.

In the accompanying drawings for the sake of simplicity the connections are shown for simplex working; but it is obvious that the relay may be provided with differential coils, in the ordinary manner, to adapt it to duplex working.

What I claim is:—

1. A polarized relay or like electric instrument adapted for actuation by reversal of polarity in a main circuit to which it may be connected and comprising a movable polarized armature, main-circuit electro-magnetic means arranged to influence said armature, and other means for reversing the position of such armature arranged to move such armature from either of its two normal positions to the opposite position upon de-

crease of magnetization of such main circuit armature-influencing means incident to reversal of magnetism of such main circuit means, and in advance of the reversal of magnetism of such main circuit means.

2. A polarized relay or like electric instrument adapted for actuation by reversal of polarity in a main circuit to which it may be connected and comprising a movable polarized armature, main-circuit electro-magnetic means arranged to influence said armature, and other means for reversing the position of such armature arranged to move such armature from either of its two normal positions to the opposite position upon decrease of magnetization of such main circuit armature-influencing means incident to reversal of magnetism of such main circuit means, and in advance of the reversal of magnetism of such main circuit means, in combination with automatic means for reversing the action of such armature reversing means upon such armature upon the completion of movement of the armature in either direction.

3. A polarized relay or like electric instrument adapted for actuation by reversal of polarity in a main circuit to which it may be connected, and comprising a movable armature, main-circuit electro-magnetic means controlling such armature and other electromagnetic means for actuating such armature and a circuit therefor which is closed when said armature is in either of its extreme positions, said other electro-magnetic means arranged to move the armature from either of its two normal positions to the opposite position upon a predetermined decrease of magnetization of such main circuit armature-influencing means.

4. A polarized relay or like electric instrument adapted for actuation by reversal of polarity in a main circuit to which it may be connected, and comprising a movable armature, main-circuit electro-magnetic means controlling such armature and other electromagnetic means for actuating such armature and a circuit therefor which is closed when said armature is in either of its extreme positions, said other electromagnetic means arranged to move the armature from either of its two normal positions to the opposite position upon a predetermined decrease of magnetization of such main circuit armature-influencing means, in combination with automatic means for reversing the action of such armature reversing means upon reversal of position of such armature.

5. A relay or like electric instrument comprising a movable polarized armature, in combination with main circuit magnet coils, and local magnet coils and means controlling the same arranged to cause the armature to move to a reverse position upon decrease of magnetization of the main line

coils, and in anticipation of a next succeeding opposite magnetization of such main line coils.

6. A relay or like electric instrument comprising a movable polarized armature, in combination with main circuit magnet coils, and local magnet coils and means controlling the same arranged to cause the armature to move to a reverse position upon decrease of magnetization of the main line coils, and in anticipation of the next succeeding opposite magnetization of such main line coils, and comprising automatic means for reversing the action of such local magnet coils upon reversal of the position of such armature.

7. A polarized relay or like electric instrument adapted for actuation by reversal of polarity in a main circuit to which it may be connected, and comprising a movable polarized armature, main circuit electro-magnetic means arranged to influence said armature, and other opposing electro-magnetic means, normally opposing as to such armature, but exerting an influence weaker than, the influence of said main-circuit electro-magnetic means, upon said armature.

8. A polarized relay or like electric instrument adapted for actuation by reversal of polarity in a main circuit to which it may be connected, and comprising a movable polarized armature, main-circuit electro-magnetic means arranged to influence said armature, other opposing electro-magnetic means, normally opposing as to such armature, but exerting an influence weaker than, the influence of said main-circuit electro-magnetic means, upon said armature, in combination with automatic means for reversing the action of such opposing means upon the armature upon the completion of movement of the armature in either direction.

9. A polarized relay or like electric instrument adapted for actuation by reversal of polarity in a main circuit to which it may be connected, and comprising a movable polarized armature, main-circuit electro-magnetic means arranged to influence said armature, and other opposing electro-magnetic means, normally opposing as to such armature, but exerting an influence weaker than, the influence of said main-circuit electro-magnetic means, upon said armature, means for terminating the influence of such opposing means upon the beginning of movement of the armature, and accelerating means arranged to influence the armature in the same sense in which that armature was previously influenced by such opposing means and arranged to begin to influence such armature when the opposing means ceases to influence such armature.

10. A polarized relay or like electric in-

strument adapted for actuation by reversal of polarity in a main circuit to which it may be connected, and comprising a movable polarized armature, main-circuit electro-magnetic means arranged to influence said armature, and other opposing electro-magnetic means, normally opposing as to such armature, but exerting an influence weaker than, the influence of said main-circuit electro-magnetic means, upon said armature, means for terminating the influence of such opposing means upon the beginning of movement of the armature, and accelerating means arranged to influence the armature in the same sense in which that armature was previously influenced by such opposing means and arranged to begin to influence such armature when the opposing means ceases to influence such armature, in combination with automatic means for reversing the action of said opposing means and said accelerating means upon completion of the movement of the armature in either direction.

11. A relay or like electric instrument comprising a movable polarized armature and main circuit magnet coils influencing the same, in combination with opposing magnet coils and accelerating magnet coils also influencing said armature, and circuits, circuit control means, and sources of current supply causing the opposing coils to exert on said armature normally an influence in opposition to, and weaker than, the influence of the main circuit magnet coils on the armature, and causing such influence of the opposing coils to cease when the armature moves to a reverse position, and causing the accelerating coils to exert upon such armature, during such movement to a reverse position, an influence tending to so move such armature to its reverse position.

12. A relay or like electric instrument comprising a movable polarized armature and main circuit magnet coils influencing the same, in combination with opposing magnet coils and accelerating magnet coils also influencing said armature, and circuits, circuit control means, and sources of current supply causing the opposing coils to exert on said armature normally an influence in opposition to, and weaker than, the influence of the main circuit magnet coils on the armature, and causing such influence of the opposing coils to cease when the armature moves to a reverse position, and causing the accelerating coils to exert upon such armature, during such movement to a reverse position, an influence tending to so move such armature to its reverse position, and means for reversing the direction of influence of the opposing and accelerating coils.

13. A relay or like electric instrument comprising a movable polarized armature

and main circuit magnet coils therefor, in combination with opposing magnet coils and a local circuit normally energizing such opposing coils in opposition to the main circuit coils, and circuit control means operated by such armature and arranged to reverse the action of such opposing coils upon each reversal of position of said armature.

14. A relay or like electric instrument comprising a movable polarized armature and main circuit magnet coils therefor, in combination with opposing magnet coils and a local circuit normally energizing such opposing coils in opposition to the main circuit coils, circuit control means operated by such armature and arranged to reverse the action of such opposing coils upon each reversal of position of said armature, and accelerating coils and circuit means therefor which energize such accelerating coils in such sense as to cause such accelerating coils to influence the armature to carry it across from one extreme position to the other.

15. A relay or like electric instrument comprising a movable polarized armature and main circuit magnet coils therefor, in combination with opposing magnet coils and a local circuit normally energizing such opposing coils in opposition to the main circuit coils, circuit control means operated by such armature and arranged to reverse the action of such opposing coils upon each reversal of position of said armature, and accelerating coils and circuit means therefor which energize such accelerating coils in such sense as to cause such accelerating coils to influence the armature to carry it across from one extreme position to the other and including means for reversing the direction of influence of the accelerating coils upon said armature with each reversal of position of such armature.

16. A relay or like electric instrument comprising a movable polarized armature, and main circuit magnet coils therefor, in combination with opposing magnet coils and circuit means therefor causing said opposing magnet coils to influence such armature in opposition to the main magnet coils, accelerating coils adapted also to influence said armature, and circuit means for energizing such accelerating coils comprising a condenser charged from the energizing circuit of the opposing coils and arranged to discharge through the accelerating coils, upon the commencement of movement of such armature, and in a direction to cause such opposing coils to tend to move such armature in the direction of its movement.

17. A relay or like electric instrument comprising a movable polarized armature and main circuit magnet coils therefor, and contact pieces for said armature on opposite sides thereof, in combination with opposing

magnet coils and a circuit therefor passing through the armature and the said contact pieces, and arranged to reverse the magnetization of said opposing coils with each reversal of the position of such armature, and to magnetize such opposing coils in opposition to, but weaker than, the existing magnetization of the main coils, and accelerating coils adapted also to influence said armature, and a circuit for said accelerating coils constituting a loop from the circuit of the opposing coils and including a condenser arranged to be charged from the circuit of the opposing coils and to discharge through the accelerating coils, upon interruption of the circuit of the opposing coils, and in a direction to magnetize said accelerating coils to carry the armature in the direction in which it is already moved.

18. A relay or like electric instrument comprising in combination a movable polarized armature, main circuit magnet coils therefor, opposing magnet coils and means for controlling and energizing the same causing the opposing coils to exert an influence upon the armature in opposition to, but weaker than, the influence of the main coils, and accelerating coils and means operating the same causing such accelerating coils to influence the armature to complete any movement already begun.

In testimony whereof I have signed this specification in the presence of two subscribing witnesses.

WILLIAM FINN.

Witnesses:

FRANK KITTON,
HERBERT W. DRAKE.