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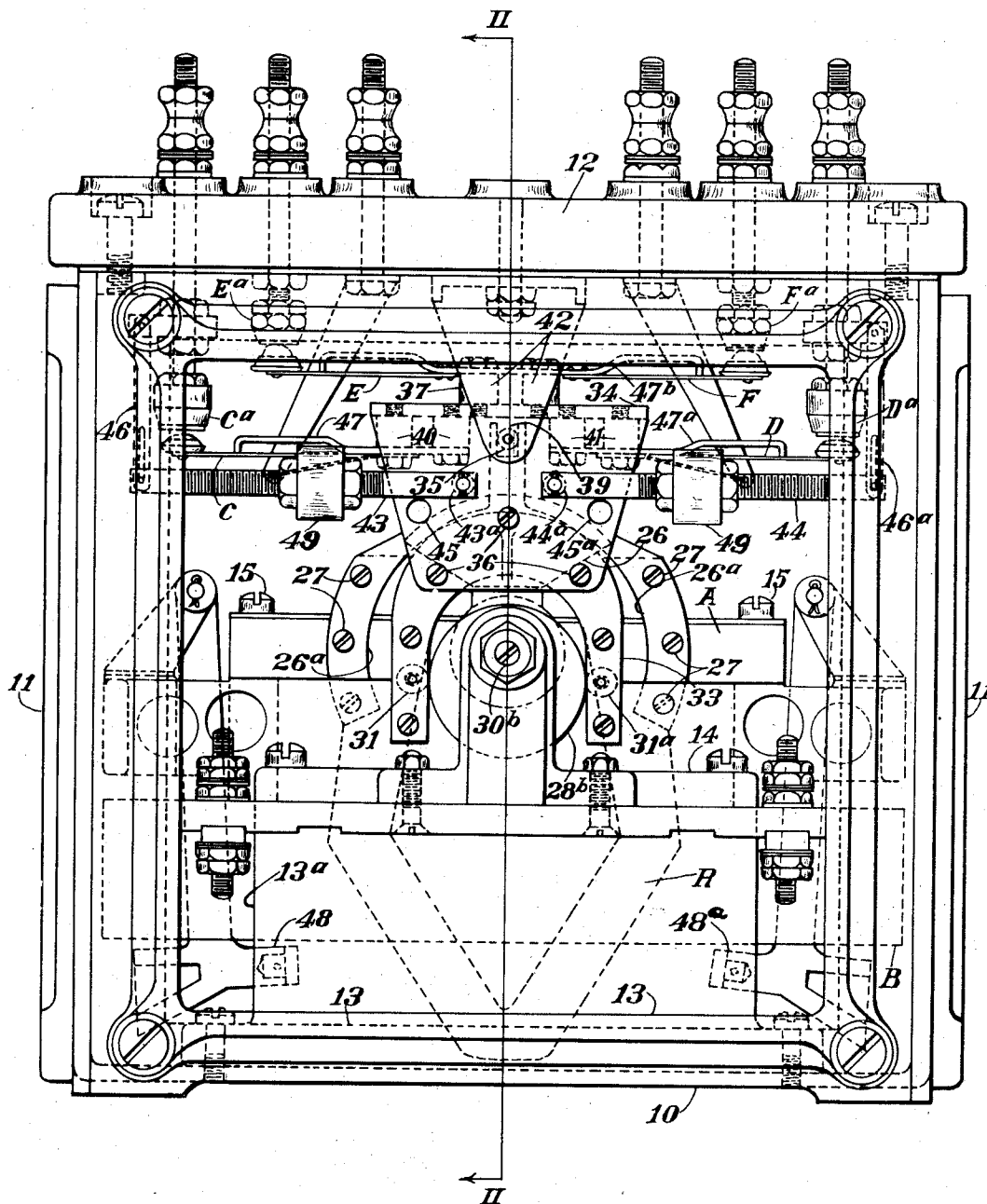
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W. D. HAILES

ALTERNATING CURRENT RELAY

Filed Oct. 21, 1921

4 Sheets-Sheet 1



INVENTOR

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William D. Nails

BY

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ALTERNATING CURRENT RELAY

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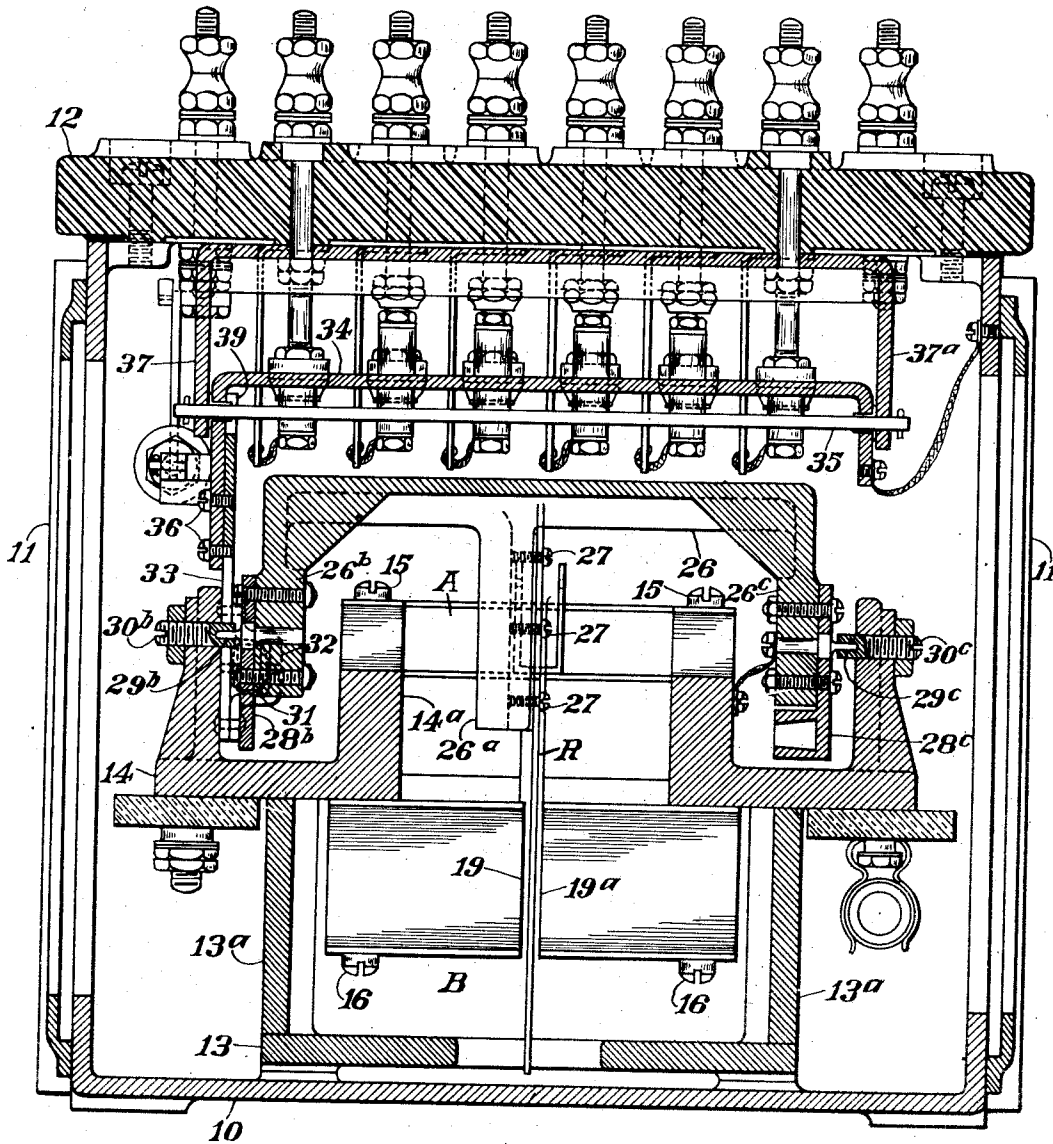


Fig. 2.

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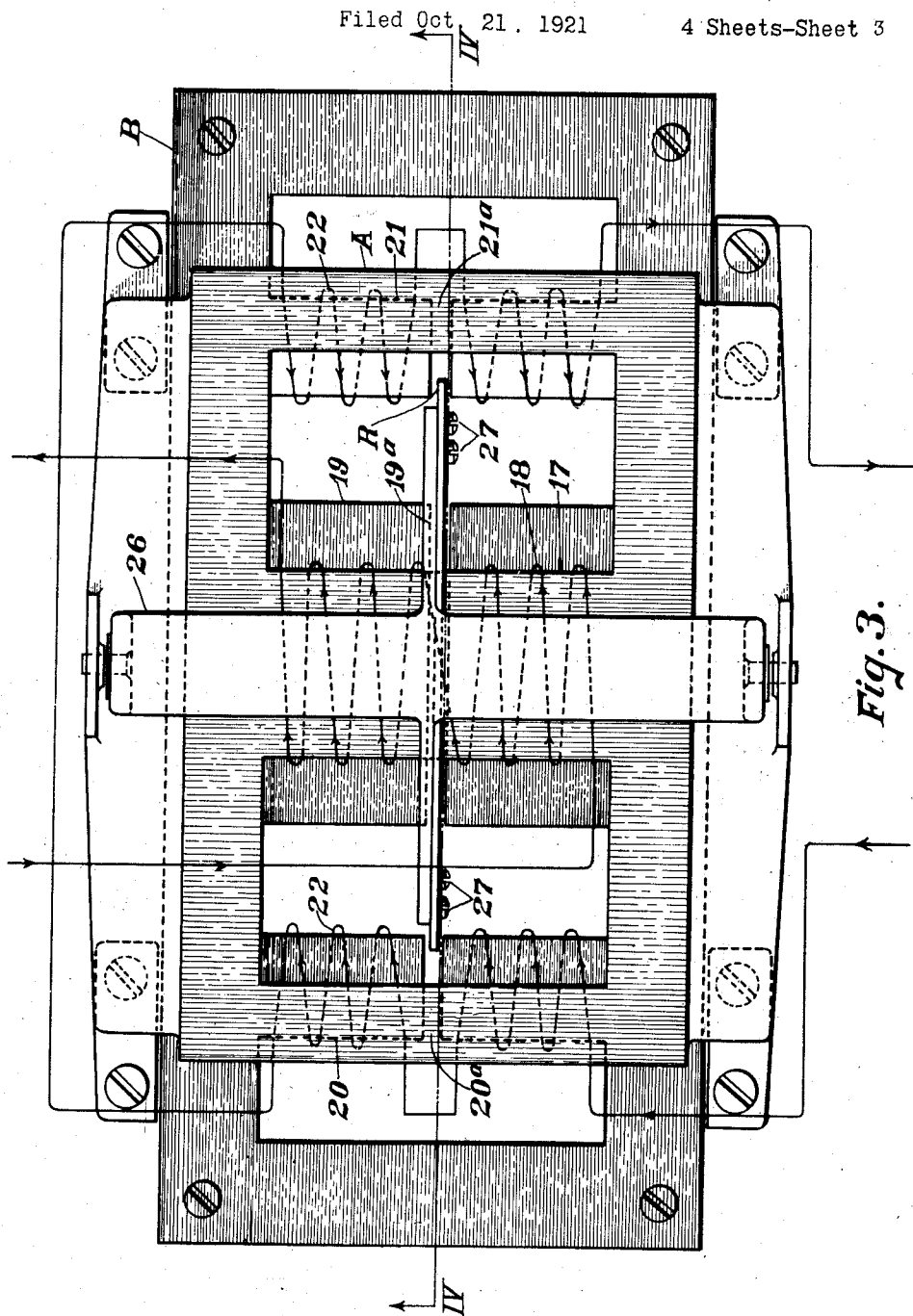


Fig. 3.

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4 Sheets-Sheet 4

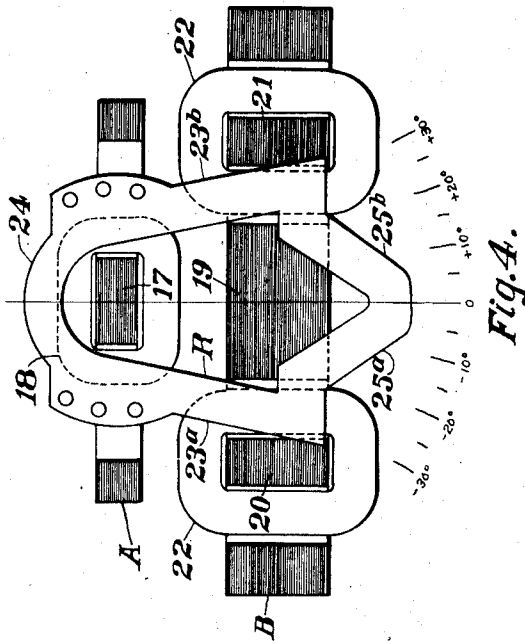


Fig. 4.

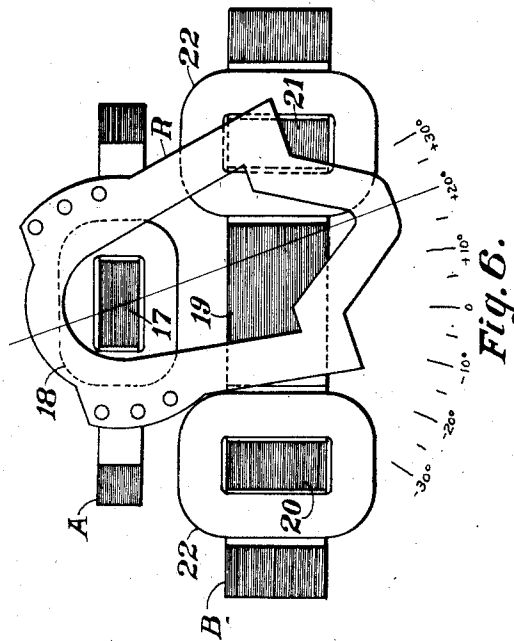


Fig. 6.

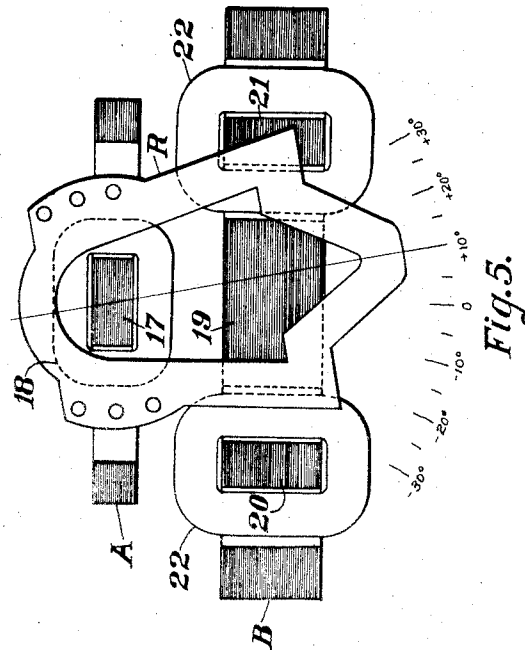


Fig. 5.

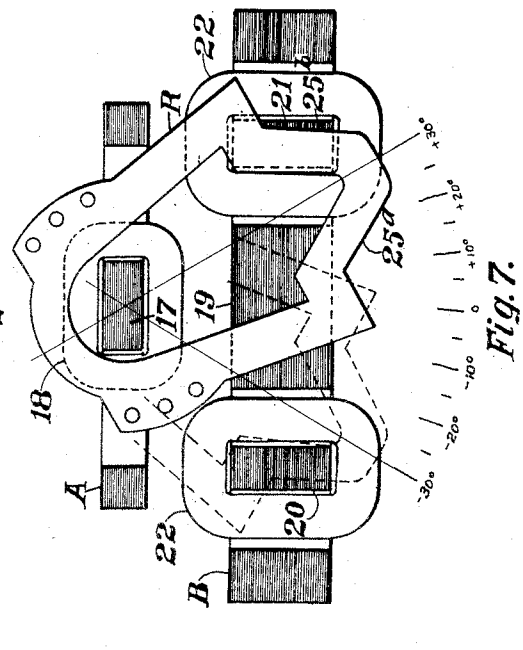


Fig. 7.

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UNITED STATES PATENT OFFICE.

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ALTERNATING-CURRENT RELAY.

Application filed October 21, 1921. Serial No. 509,284.

To all whom it may concern:

Be it known that I, WILLIAM D. HAILES, a citizen of the United States, residing in the city of Albany, county of Albany, and State of New York, have invented certain new and useful Improvements in Alternating-Current Relays, of which the following is a specification.

My invention relates to alternating current relays of the type wherein currents in two co-operating windings or sets of windings are required to shift the movable member to an operated position.

One object of my invention is the provision of a relay of this type in which all tendency of the movable member to "creep" or "drift" is eliminated, thereby avoiding any possibility of this member falsely assuming or remaining in an operated position.

Another object of my invention is the provision of a relay which is so constructed that when only one winding or set of windings is excited, an electro-magnetic force is exerted on the movable member tending to move it to the neutral position, this force being in addition to the usual mechanical counterweighting force exerted on this member. This electrical counterweighting force is present and effective under abnormal as well as normal conditions of voltage, frequency and phase relation of the current in the excited winding, and under abnormal as well as normal conditions of the circuit for the unexcited winding.

I will describe one form of relay embodying my invention, and will then point out the novel features thereof in claims.

In the accompanying drawings, Fig. 1 is a view showing in elevation one form of relay embodying my invention. Fig. 2 is a vertical sectional view taken on the line II—II of Fig. 1 and looking in the direction indicated by the arrows. Fig. 3 is a top plan view showing the electro-magnetic portions of the relay shown in Figs. 1 and 2, the other parts being omitted and the windings being illustrated somewhat diagrammatically. Fig. 4 is a vertical sectional view on the line IV—IV of Fig. 3 looking in the direction indicated by the arrows and showing the movable member or rotor in its neutral or biased position. Fig. 5 is a view similar to Fig. 4 but showing the rotor

one-third of the way towards one operated position. Fig. 6 is a view similar to Figs. 4 and 5 but showing the rotor two-thirds of the way towards the said full operated position. Fig. 7 is a view similar to Figs. 4, 5 and 6, but showing the rotor in the said full operated position and indicating in dotted lines the other full operated position of the rotor.

Similar reference characters refer to similar parts in each of the several views.

Referring first to Figs. 1, 2 and 3, the operating parts of the relay are enclosed by a bottom plate 10, side walls 11 and a top plate 12.

Attached to the bottom plate 10 is a base member 13 provided with two upstanding end plates 13^a, 13^a which in turn support a metallic frame 14. This frame carries the magnetizable cores of the relay, as well as the rotor and the other movable parts immediately attached thereto.

The relay is provided with two magnetizable cores, viz., an exciter core A and a stator core B, each of which, in conformity with usual practice, is made up of a large number of laminations of magnetizable material such as soft iron. The exciter core A is attached by screws 15 to the upstanding arms 14^a on frame 14 as best shown in Fig. 2, while the stator core B is similarly attached to the under side of this frame by screw 16. The shapes of the cores are best shown in Fig. 3. The exciter core A is in the form of a hollow rectangle provided with a middle connecting leg 17, which leg carries an exciting winding 18. This core has no air gap either in the rectangular portion or the connecting leg. The stator core B also comprises a hollow rectangle having a central pole-piece 19 provided with an air gap 19^a, and two motor pole-pieces 20 and 21 provided respectively with air gaps 20^a and 21^a. Each motor pole-piece of this core carries a coil 22, which coils as here shown are connected in series and together constitute the stator winding of the relay. The movable member of the relay includes a rotor designated R, of non-magnetizable, electro-conductive material such as copper or aluminum, of such shape as to form a closed circuit in which current flows, as distinguished from forming a series of circuits for local "eddy" currents.

It is preferably in a single sheet and of a shape similar to that shown in Figs. 4, 5, 6 and 7, from which it will be clear that it comprises (see Fig. 4) two limbs 23^a and 23^b connected at their upper ends by a member 24 and at their lower ends by two arms 25^a and 25^b. The rotor R is carried by a rotor support 26 having a central vertical forked arm 26^a to which the upper or arc-shaped portion of the rotor is attached by screws 27. This rotor support also comprises two vertical end arms 26^b and 26^c carrying end plates 28^b and 28^c which, together with the end arms, constitute suitable mountings for two pivot pins 29^b and 29^c. The two pivot pins are journaled to turn in recessed bearing screws 30^b and 30^c respectively which are mounted in upstanding end plates of the frame 14 as is clearly illustrated in Fig. 2, so that it will be evident that the movable member comprising the rotor R and support 26 is free to oscillate as a unit in the frame 14. The rotor is so located that it passes freely through the air gaps 19^a, 20^a and 21^a in the stator core B. The rotor R is biased, as will hereinafter appear, to the position shown in Figs. 1 and 4, and its movements in opposite directions from this position are limited by suitable energy-absorbing stops 48 and 48^a so located as to be engaged by the rotor arms 25^a and 25^b respectively.

The end plate 28^b on rotor support 26 constitutes an operating eccentric as best shown in Fig. 1, and this eccentric co-acts with two rollers 31 and 31^a pivotally mounted in an operating fork 33 and in pivot brackets 32 which are attached to this fork. The operating fork extends upwardly and is rigidly attached to a contact finger support 34 by screws 36, which support is mounted to oscillate on a rod 35 carried by brackets 37 and 37^a attached to the top plate 12. The upper end of the operating fork is in the form of a yoke 39 which straddles the rod 35.

The contact finger support 34 carries four sets of contact fingers C, D, E and F, each set comprising a plurality of parallel fingers arranged side by side as viewed in Fig. 2 and directly behind each other as viewed in Fig. 1. For convenience I will term fingers D the normal fingers, fingers C the reverse fingers, and fingers E and F the back contact fingers. The contact fingers C are attached to arms 47 which in turn are mounted on studs 40 of insulating material supported on the underside of the finger support 34. Each contact finger D is similarly attached to an arm 47^a mounted on studs 41, while each contact finger E and F is attached to an arm 47^b which is mounted on insulating studs 42 located on the upper surface of the finger support 34. Each contact finger C co-acts with a fixed

contact member C^a fixed in the top plate 12 while each contact finger D co-acts with a similar fixed contact member D^a also supported in the top plate 12. Similarly the contact fingers E and F cooperate with fixed contact members E^a and F^a respectively which project downwardly from the top plate 12.

The finger support 34 is biased to the neutral or intermediate position, in which it is shown in Fig. 1, by counterweights 43 and 44 each comprising a threaded rod carrying an adjustable weight 49. These counterweight rods are pivotally attached to the contact support 34 at points 43^a and 44^a respectively, and their downward movements with respect to the support are limited by studs 45 and 45^a carried by the support. The free ends of the counterweight rods 43 and 44 are provided with pins which co-act with slotted arms 46 and 46^a supported by and depending from the top plate 12.

The operation of the contacts by the movable member is as follows: The normal or neutral position of the movable member is the position in which it is shown in Fig. 1, the member being primarily biased to this position due to the fact that the center of gravity of the rotor R is below the line of the pivot screws 30^b and 30^c. When the movable member occupies this position, the contact support 34 occupies the intermediate or neutral position wherein it is shown in Fig. 1, being held in this position by the action of eccentric 28^b on the rollers 31 and 31^a as well as by the biasing forces exerted by the counterweights 43 and 44. With the contact support in this position contacts C—C^a and D—D^a are open while contacts E—E^a and F—F^a are closed. I will now assume that rotor R is swung to the right, that is, in counterclockwise direction as viewed in Fig. 1. This causes counterclockwise rotation of the eccentric 28^b which in turn causes counterclockwise movement of the operating fork 33 and the contact finger support 34 around the rod 35. This movement of the finger support 34 causes contacts D—D^a to close and contacts E—E^a to open, the other contacts remaining in the conditions in which they are shown in Fig. 1. This movement of the contact support 34 also elevates the right hand counterweight 44, such movement of the counterweight being unopposed owing to the slot in the restricting arm 46^a. Counterweight 43 performs no function at this time owing to the fact that its free end is supported by the left hand restricting arm 46.

When the torque tending to swing the rotor R in counterclockwise direction is removed, this rotor together with the rotor support 26 returns to the intermediate or neutral position owing to the biasing forces

acting on the rotor, and the finger support 34 also returns to its neutral position owing to the action of the eccentric 28^b and the action of the counterweight 44.

5 When a torque is exerted on the rotor R in the opposite direction so that this rotor swings in clockwise direction as viewed in Fig. 1, it will be obvious that the finger support 34 is likewise turned in clockwise direction thereby elevating counterweight 43; the
10 tion thereby elevating counterweight 43; the result of this movement is that contacts C—C^a are closed while contacts F—F^a become open. When the torque on rotor R is removed, the movable member and the finger
15 support 34 return to their intermediate or neutral positions, so that the parts of the relay are restored to the positions in which they are shown in Fig. 1.

Referring now to Figs. 3, 4, 5, 6 and 7 the
20 operation of the rotor R by the electro-magnetic members of the relay is as follows. As long as alternating current is supplied to exciter winding 18, an alternating current flow is induced in the rotor R due to trans-
25 former action, it being noted that this rotor constitutes a closed secondary of a transformer of which the primary is the exciter winding 18 and the magnetic core is the exciter core A. There being no air gap in the
30 exciter core, it is obvious that this transformer action is highly efficient so that a comparatively small amount of current in the winding 18 will induce a comparatively heavy current in the rotor R. I will now assume that while the exciter winding is supplied with alternating current, another alternating current of the same frequency and preferably in phase with the exciter current is supplied to the stator winding 22. The
35 magnetic flux passing through the motor pole pieces of the stator core will cooperate with the magnetic flux due to the current in the rotor R to swing this rotor in one direction or the other depending on the relative
40 instantaneous polarities of the currents in the two windings. Assuming that this relative instantaneous polarity is such as to swing the rotor in counterclockwise direction, the rotor will move to the position in
45 which it is shown in Fig. 7 in which position its movement will be arrested by the stop 48^a shown in Fig. 1. If the currents in the two relay windings are of opposite relative instantaneous polarity, the rotor R will be
50 swung to the position indicated by the dash lines in Fig. 7, in which position its movement will be arrested by the stop 48 of Fig. 1. When the rotor swings in the first mentioned direction it will of course close contacts D—D^a of Fig. 1, while when it swings
55 in the second mentioned direction it will close contacts C—C^a of Fig. 1.

As already pointed out, the operating parts of the relay are biased by gravity to
60 the neutral or intermediate position. Fur-

thermore, when the rotor R is not in the neutral position and either the stator winding alone or the exciter winding alone is receiving alternating current, an electro-magnetic force is exerted on the rotor tending to
70 return it to the neutral position, regardless of whether the de-energized winding is on open circuit or short circuit. The reasons for this electro-magnetic bias are as follows:

I will first assume that the rotor R is in
75 the operated position shown in full lines in Fig. 7, and that the exciting winding 18 becomes de-energized and is on open circuit, while the stator winding 22 continues to be energized. Under this condition there is
80 an electro-magnetic force acting on the arm 25^b of the rotor R which arm is standing in the air gap of the motor pole piece 21, and which force is the well known blow-out force which accompanies an attempt to
85 enter a sheet of electro-conductive material between a pair of pole pieces carrying alternating magnetic flux. It will be noted from Fig. 7 that the arm 25^b fulfills the conditions of such a sheet entering a magnetic
90 field for when this arm is in the position shown, its center of gravity has not yet passed the geometrical center of the pole pieces 21 and the arm is therefore still entering the magnetic field. This arm will consequently, unless opposed, move out of the
95 magnetic field in the direction from which it entered. Since this blow-out force is in the direction of the gravity bias of the rotor, the rotor will be urged by the electro-magnetic force to return towards its neutral
100 position. On approaching the neutral position (see Figs. 6, 5 and 4 in the order named) it will be observed that the blow-out force acting on the arm 25^b constantly
105 decreases in intensity, while a similar opposing small electro-magnetic blow-out force will be exerted on the arm 25^a as the latter arm approaches the motor pole pieces 20. This opposing blow-out force together with
110 the gravity bias will bring the rotor to rest in its neutral position because the whole structure of the relay is symmetrical about a vertical axis through the rotor when in the neutral position, and so in this position
115 the two arms 25^a and 25^b are equidistant from the geometrical centers of the motor pole pieces 20 and 21. In this neutral position therefore the mechanical bias is satisfied and the two blow-out forces are equal
120 and opposite.

The electro-magnetic biasing force which I have just described is present for exactly
125 the same reasons if the exciting winding 18 is placed on short circuit after being de-energized. Furthermore this electro-magnetic biasing force will be increased by an increase in the field strength of the motor pole pieces such as would occur in the event
130 that an abnormal voltage is applied to the

stator winding 22; the reason for this, of course, is that the blow-out action of the motor pole pieces will be increased by an increase in the intensity of the magnetic flux in the pole pieces. Again, this biasing action will occur should the stator winding 22 receive alternating current or pulsating current of a frequency other than the current for which the relay is designed. This is obvious because the blow-out action is present regardless of the character of the current supplied to the stator winding, provided only that this current be of varying intensity.

I will now consider the condition in which the stator winding 22 becomes de-energized while the rotor is in the position shown in full lines in Fig. 7, and while the supply of alternating current to the exciter winding 18 continues. Under these conditions there is an electro-magnetic force acting on the rotor and tending to urge it to include a magnetic path whose reluctance is the minimum of all the paths which it is free to select. In the present structure the impedance of the exciting winding 18 varies with changes in the impedance of the rotor R for the same reason that the primary of any transformer varies with variations of the impedance of the secondary. For a given total flux to be carried through the aperture in the rotor the reluctance of the magnetic path through the rotor will be lowered when the cross-section available to carry such flux is increased. It follows that the impedance of this rotor will be maximum when the maximum area of the central pole piece 19 is presented to the aperture in the rotor. Since this condition exists when the rotor occupies its neutral position, it follows that the impedance of the rotor and therefore of the exciting winding will be maximum when the rotor occupies the neutral position, and so the rotor will be driven to this position by the electro-magnetic forces under the conditions which I have stated.

The electro-magnetic biasing action under the conditions last assumed will also exist for the same reasons and to the same extent if the stator winding or any part of it is placed on short circuit after becoming de-energized. The biasing force will also exist in the case of abnormal voltage on the exciting winding.

It will be noted that to move the rotor from the neutral position to an operated position there must be present simultaneously a suitable current in the rotor and a suitable magnetic field with which the rotor current can co-act. Inasmuch as current can be supplied to the rotor by induction only, it follows that the relay is inoperative on direct current.

Furthermore it is apparent that the relay

can operate only when the current in the rotor and the magnetic flux in the motor poles of the stator are in synchronism, and so it follows that the relay will not operate if currents of two different frequencies are supplied to the two windings.

Considering now the torque characteristics measured at the rotor shaft, it is to be noted that the torque available to do work is not constant throughout the travel of the rotor from the biased position to an operated position, and that the torque curve can be varied to suit a particular requirement. In the relay illustrated in the present application it will be noted that while one arm of the rotor is at all times within the filed of, or actually in the air gap of, one of the motor pole pieces, the maximum area of rotor material is presented to motor pole piece flux when the rotor is in the operated position, and consequently the torque on the rotor is maximum at this time. Inasmuch as this condition is gradually approached, as the rotor approaches the full operated position, it is obvious that the torque curve rises as the rotor approaches its operated position so that as the contact load of the relay increases the torque exerted on the rotor also increases, thus enabling the rotor to satisfactorily meet the load imposed upon it at the contacts.

I have found by experiment that by changing the relation between the motor pole pieces of the stator and the shape and disposition of the limbs and arms of the rotor, various forms of torque characteristics may be obtained. This will be apparent when it is noted that the rotor torque is proportional to the product of the component of the rotor current in time phase with the stator field flux, the stator field flux, some geometrical function of the angle which the direction of rotor makes with the radius of rotation of the point of the rotor considered and its distance from the center of rotation.

To sum up the foregoing, a relay embodying my invention is characterized by the fact that when either winding alone is supplied with alternating current an electro-magnetic force is exerted on the rotor tending to bring the latter to its neutral position, this being true whether the de-energized winding is on short circuit or open circuit, and this electro-magnetic biasing force is augmented by an over voltage in either of the windings.

One important feature of the relay is that the energy supplied to the stator winding can be increased to the limit imposed by the heat radiating capacity of the windings without interfering with quick movement of the rotor from an operated position to the neutral position.

Another important characteristic is that

the torque available to do work increases as the rotor approaches the operated position.

Another important characteristic is that the relay is inoperative on direct current.

5 Relays embodying my invention are particularly well adapted for use in railway signaling systems. When so used the stator winding 22 may be constantly supplied with alternating current from a suitable source
10 such as a transmission line, while the exciting winding 18 may be supplied with current from a track circuit, the track circuit being in turn supplied from the same transmission line through a pole changer. It will
15 be apparent, therefore, that when the track circuit is unoccupied the rotor will swing to one operated position or the other depending upon the position of the pole changer, and will assume its neutral or intermediate position when the track circuit
20 becomes occupied by a car or train, in which event the supply of current to the exciting winding is of course discontinued or reduced to a comparatively low value.

25 By providing the relay with coil 18 adapted to be connected to line circuit as distinguished from track circuit, this device may be controlled from line circuits with pole changers as a 3-position line relay, the
30 rotor R taking a position to the right or the left in accordance with the relative polarity of the current in the exciting winding 18 and stator winding 22 or assuming an intermediate position when either the stator
35 winding 22 or the exciter winding 18 or both may be de-energized.

The foregoing disclosure covers the operation of the device through 3-positions of operation, one on either side of the de-energized biased position. It will be obvious
40 that in the event that 3-position control of the rotor R is not required, the device might be biased to assume its intermediate position as shown in Fig. 4 against a fixed stop
45 which would prevent the rotor from moving toward the dotted position of Fig. 7. With this construction, the rotor would have an operated position corresponding to Fig. 6 and a de-energized position corresponding
50 to Fig. 4. This construction would impose the condition that the rotor would not assume an operated position unless the winding 18 was energized with currents of predetermined polarity, with relation to the
55 currents in windings 22; currents in winding 18 of the opposite polarity merely tending to hold the rotor R against the fixed stop in addition to the counterweight. With
60 this construction, the device is adapted for 2-position operation on track or line control as distinguished from the 3-position control as mentioned above.

65 Although I have herein shown and described only one form of relay embodying my invention, it is understood that various

changes and modifications may be made therein within the scope of the appended claims without departing from the spirit and scope of my invention.

Having thus described my invention, what I claim is:

1. An alternating current relay comprising an apertured disk-like rotor of electro-conductive material, means for inducing an alternating current in said rotor, means for
75 creating an alternating magnetic flux for co-operation with said current to move the rotor, and a contact controlled by said rotor.

2. An alternating current relay comprising a rotor constituting a closed circuit of electro-conductive material, means for inducing an alternating current in said rotor, other and independent means for creating an alternating magnetic flux for co-operation with said current to move the rotor,
85 and a contact controlled by said rotor.

3. An alternating current relay comprising a rotor constituting a closed circuit of electro-conductive material, a magnetizable core passing through said rotor and provided with a winding whereby alternating current in said winding will induce alternating current in said rotor, other and independent means for creating an alternating magnetic flux to co-operate with the current in said rotor to move the rotor, and a contact controlled by said rotor.
90

4. An alternating current relay comprising a rotor constituting a closed electrical circuit, an exciting winding in inductive relation to said rotor for creating alternating current in the rotor, other and independent means for creating an alternating magnetic flux to co-operate with the current in said rotor to move the rotor, and a contact controlled by said rotor.
100

5. An alternating current relay comprising a rotor constituting a closed electrical circuit, an exciting winding in inductive relation to said rotor for inducing alternating current in the rotor, thereby producing an alternating magnetic flux at right angles to the plane of the rotor, other and independent means for creating a second alternating magnetic flux to co-operate with said rotor flux to move the rotor, and a contact controlled by said rotor.
105

6. An alternating current relay comprising a rotor constituting a closed electric circuit, a closed magnetizable core passing through said rotor, a winding on said core whereby alternating current in said winding will induce alternating current in said rotor, other and independent means for creating an alternating magnetic flux to co-operate with the current in said rotor to move the rotor, and a contact controlled by said rotor.
110

7. An alternating current relay comprising a stator core having three parallel pairs
120

- of confronting pole-pieces magnetically connected at their outer ends, a stator winding for said core, a closed electrical conductor mounted to move between said pole-pieces and biased to such position that it is symmetrically disposed with respect to the pole-pieces, means for inducing alternating current in said conductor, and a contact controlled by said conductor.
8. An alternating current relay comprising a stator core having three parallel pairs of confronting pole-pieces magnetically connected at their outer ends, a stator winding for said core, a closed electrical conductor mounted to move between said pole-pieces and biased to such position that the middle pole-piece substantially registers with the opening in said conductor and two opposite limbs of the conductor lie between the middle pole-piece and the two outer pole-pieces respectively, means for inducing alternating current in said conductor, and a contact controlled by said conductor.
9. An alternating current relay comprising a rotor in the form of a closed ring of electro-conductive material biased to an intermediate position and movable in opposite direction therefrom, means for inducing alternating current in said rotor, a stator core having three parallel pole-pieces each perpendicular to the plane of the rotor and each provided with an air gap to accommodate the rotor, said pole-pieces being so disposed that when the rotor is in its intermediate position the middle pole-piece substantially registers with the opening in the rotor and two opposite limbs of the rotor register substantially with the spaces between the middle pole-pieces and the two outside pole-pieces respectively, an energizing winding for said stator, and a contact controlled by said rotor.
10. An alternating current relay comprising a ring-like rotor of electro-conductive material formed by two electrically connected diverging limbs and two electrically connected diverging arms all in substantially the same plane and the free ends of the arms being electrically connected respectively with the free ends of the two limbs, said rotor having a neutral position and movable in opposite directions therefrom to two operated positions, a stator core having three parallel pairs of confronting pole-pieces between which said stator is free to move each pair being perpendicular to the plane of the rotor, the relations of the parts being such that when the rotor occupies the neutral position the middle pole-pieces register substantially with the spaces between the arms and limbs of the rotor whereas the two rotor limbs lie between the middle pole-piece and the two outer pole-pieces respectively, and that when the rotor is in either operated position one arm registers with one outer pole-piece or the other arm registers with the other outer pole-piece, a winding for said stator core, and contacts controlled by said rotor.
11. A relay rotor comprising two electrically connected diverging limbs and two electrically connected diverging arms all in substantially the same plane, the free ends of the two arms being electrically connected respectively with the free ends of the two limbs.
12. A relay comprising a movable member mounted to oscillate, an eccentric fixed to said member, a contact support mounted to oscillate, and an operating arm fixed to said support and provided with two followers co-operating with said eccentric.
13. A relay comprising a stator having two pole-pieces each provided with an air gap, a winding for said stator, a rotor mounted to move in said air gaps, and means including a core passing through the rotor for causing alternating current to flow in said rotor.
14. A relay comprising a stator having two pairs of confronting poles; a member carrying a conductor which is normally midway between said pairs of poles but which is movable away from the field of one pair of poles and into the field of the other pair, and means including a core passing through the conductor for creating alternating current in said conductor.
15. A relay comprising means for creating an alternating magnetic field, an electrical conductor mounted to move in said field, means for creating an alternating current in said conductor comprising a core passing through the conductor, and a contact controlled by said conductor.
16. A relay comprising means for creating an alternating magnetic field, an electrical conductor mounted to move in said field, a closed magnetic core passing through said conductor, a winding on said core and therefore in inductive relation to said conductor, and a contact controlled by said conductor.
17. A relay comprising a movable member in the form of a closed conductor biased to one position, and electromagnetic means including two windings for exerting a force on said member in opposition to the biasing force when both windings are supplied with alternating currents of the same phase and for exerting a force on said member in the direction of said biasing force when either of said windings is supplied with alternating current and the other is not.
18. A relay comprising a movable member in the form of a closed conductor biased to one position, and electromagnetic means including two magnetic circuits and a winding for each circuit for exerting a force on said member in opposition to the biasing force when both windings are supplied with al-

ternating currents of the same phase and for exerting a force on said member in the direction of said biasing force when either of said windings is supplied with alternating current and the other is not.

19. A relay comprising a magnetic core having two parallel legs each provided with an air gap, a winding for said core, a movable member having a closed ring-like conductor biased to a normal position wherein it substantially encircles one leg and movable in said air gaps to a position wherein one limb of the conductor approaches the geometrical center of the other leg, and means for creating current in said conductor; whereby when said conductor and said winding are both energized the conductor will be moved toward its second position by inductive reaction, when the conductor is de-energized and the winding is energized the conductor will be urged toward its normal position due to reaction between the said conductor limb and the second leg, and when the conductor is energized and the winding is de-energized the conductor will be urged

towards its normal position because in such position the reluctance of the magnetic path through the conductor is minimum.

20. A relay comprising a magnetic core having two parallel legs each provided with and air gap, a winding for said core, a movable member having a closed ring-like conductor biased to a normal position wherein it substantially encircles one leg and movable in said air gaps to a position wherein one limb of the conductor approaches the geometrical center of the other leg, and means for creating current in said conductor; whereby when said conductor and said winding are both energized the conductor will be moved toward its second position by inductive reaction and when either the conductor or the winding is energized and the other is not the conductor will be urged to its biased position and positively held there by electromagnetic action.

WILLIAM D. HAILES.

Witnesses:

WADE H. REICHARD,
EUGENE SEITZ.