March 4, 1947. E. DICKTEN, JR 2,416,681

ALTERNATING CURRENT RELAY

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FIG. 1A

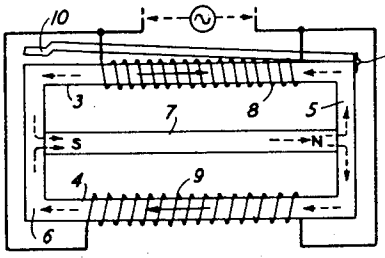
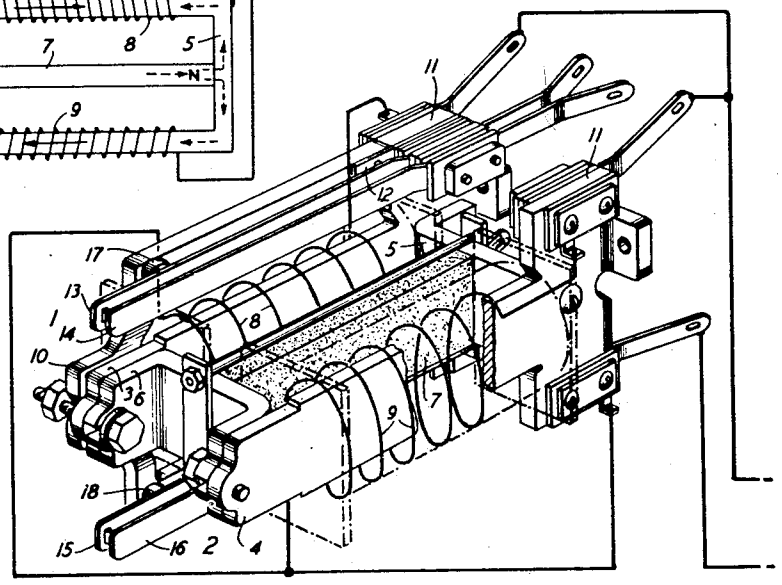


FIG. 1



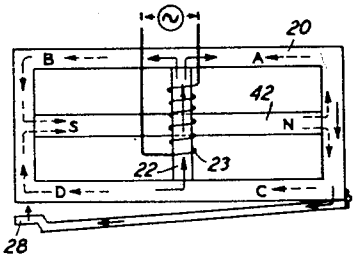
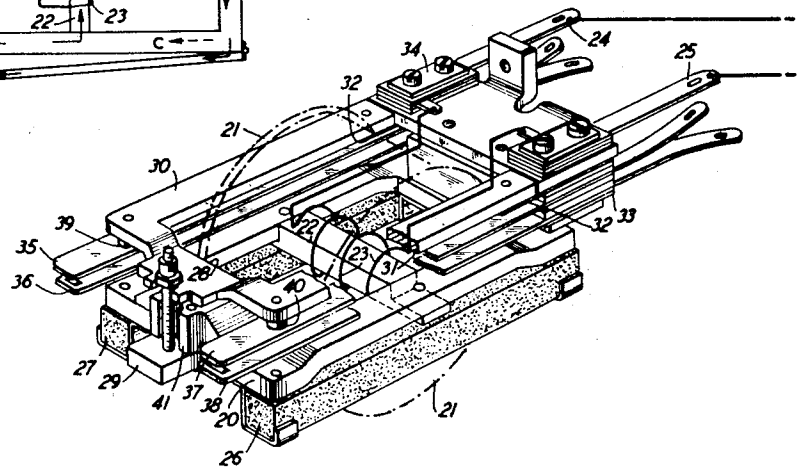


FIG. 2A

FIG. 2



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ALTERNATING CURRENT RELAY

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This invention relates to electromagnetic relays and more particularly to relays suitable for operation by alternating current.

An object of the invention is to provide an alternating current relay which operates efficiently, is devoid of so-called alternating current "hum" and develops a relatively large magnetic force on the armature with a comparatively small amount of iron in its magnetic circuit.

A feature of the invention resides in employing the non-linear saturating characteristic of iron, which permits or impedes the flow of flux therethrough according to its direction, and more particularly in establishing a permanent biasing flux in two sections of the magnetic structure of a relay which sections are subject to magnetization by an alternating operating current, whereby flux due to both the positive and negative half waves of the operating current is caused to flow in the same direction across the armature air gap.

More specifically the foregoing object is attained in the preferred embodiment of the invention by assembling, side by side, two conventional neutral relays of the so-called flat type described in U. S. Patent 1,156,671 to E. B. Craft and interconnecting their respective cores, at each end, by brackets of magnetic material similar to that of the cores, interconnecting the two brackets by means of a permanently magnetized iron bar in such a manner that one bracket and the associated core ends become a north pole and the opposite bracket and core ends a south pole and connecting the two core windings in parallel to the operating circuit in such a manner that at any instant simultaneous fluxes in the two cores, due to the applied alternating current, flow in opposite directions therein.

The invention will be understood from the following description when read in connection with the accompanying drawings:

Fig. 1 of which shows a preferred embodiment of the invention comprising two electromagnets having the windings thereof connected in parallel with the operating voltage;

Fig. 1A is a schematic representation of the magnetic circuit of the relay of Fig. 1;

Fig. 2 shows a relay embodying the same operating principles as Fig. 1 but which employs a single operating winding; and

Fig. 2A is a schematic representation of the magnetic circuit of the relay of Fig. 2.

As hereinbefore stated, the preferred embodiment of the invention is an assembly of two neutral relay units of a well-known type but it will

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be understood that while a particular type of relay is disclosed, neutral relays of other types could also be employed or the structure could be designed de novo to incoporate the features of the invention.

Referring to Fig. 1 each relay unit 1 and 2, respectively, comprises core 3 and 4, respectively, the rear end or heel pieces 11 of which are joined by a U-shaped bracket 5 of magnetic material similar to that of the cores and the forward ends joined by a similar bracket 6 thereby forming a closed magnetic circuit. Interconnecting the two brackets 5 and 6 is a permanently magnetized bar 7 of magnetic iron so positioned that one bracket and the associated core ends become a north pole and the opposite bracket and core ends a south pole. A winding 8 is mounted on core 3 and a similar winding 9 is mounted on core 4 and both windings are connected in parallel in such a manner that when they are energized flux will flow in opposite directions in the two cores and consequently in opposite directions through the magnet bar 7 which is common to the magnetic circuit of both cores.

An armature 10 is positioned with an extension of its forward cross-reach opposing the forward portion of core 3 and its side arms extending on each side of the winding 8 with the ends hinged to the heel piece 11 by means of a leaf spring 12.

Mounted on and insulated from the heel piece 11 are two pairs of contact springs 13, 14 and 15, 16, the free ends of which are normally disengaged and extend forwardly beneath the upper side arm of the armature. The end of spring 13 bears against an insulating stud 17 and spring 15 against a similar stud 18 both of which studs are secured to the armature 10.

While only a single armature has been shown associated with relay unit 1, it will be understood that a second armature could be associated in a similar manner with the relay unit 2 in case it is desired to control other local circuits independent of springs 13, 14 and 15, 16.

Now referring to Fig. 1A which is a schematic of the magnetic circuit of the relay of Fig. 1, it will be assumed that the permanent magnet 7 is so proportioned that sufficiently large biasing fluxes are established in both cores so that the iron of the cores is operated at or near the non-linear portion of the saturation curve, which fluxes are pictured, by broken arrows, as leaving the N pole of the magnet 7, dividing and proceeding through the two cores, in the same direction, and entering the magnet at the S pole.

It will be noted that the armature path, as well

as the cores, is bridged by the permanent magnet 7 and hence, some of the permanent magnet flux will flow across the armature gap. With the armature in its retracted position, as shown in the drawing, the reluctance of this path is large compared with the reluctance of the core path and therefore the flux in the armature path is small and the steady force across the gap tending to attract the armature is insufficient to operate it.

In the attracted position of the armature, it is necessary that a non-magnetic stop, such for example as a thin strip of copper or other non-magnetic material of the order of .005 inch in thickness, be employed to prevent the armature from "freezing" to the core pole face.

The operating principle of the relay will now be described by assuming an operating current to be applied to the two-core winding whereby due to the conection of winding 9 a current wave of one polarity therein causes flux to flow, as indicated by the solid arrow, in core 4 in the same direction as the biasing flux produced by the permanent magnet 7 as indicated by the broken arrows. Since this core is already near saturation due to the permanent magnet, the increase in flux therein is very slight and a correspondingly negligible operating flux is set up in the armature path.

The same current wave, due to the reversed direction of winding 8 with respect to winding 9, causes flux to flow in core 3 in opposition to the permanent biasing flux and therefore the total flux in this core is decreased and a substantial pulse of operating flux readily flows across the armature gap.

As the alternating wave changes its polarity, current in winding 8 now produces flux in its core 3 in the same direction as the permanent biasing flux and since this core is also near saturation, the increase in flux is small and the flux which reaches the armature gap is also small. The current wave in winding 9, however, produces a flux in core 4 which is in opposition to the biasing flux and a second pulse of operating flux flows across the armature gap which tends to maintain the armature attracted to its pole face.

It will therefore be observed that both plus and minus waves of the alternating current cause a unidirectional flux to flow across the armature gap and cause the armature to be steadily operated.

It is important that the parallel windings of the two cores be connected in opposite directions to the operating voltage as otherwise if the two windings were connected in such a manner that the flux in both cores was in the same direction at any instant then the armature flux would be at a maximum for one-half wave and practically zero for the other half-wave.

The effect of connecting the windings in parallel and in the reverse direction with respect to each other may be considered briefly as follows:

Again assuming a current wave applied to the windings which causes a flux to oppose the biasing flux in core 3 and aid the biasing flux in core 4 then the total flux in core 3 is therefore decreased and the iron of this core becomes more permeable. At the same time the current wave in winding 9 tends to aid the flux in core 4 and since this core is already near saturation the iron becomes even less permeable. There is, therefore, a greater flux change in core 3 than in core 4

and hence the self-induction of winding 8 is greater than the self-induction of winding 9.

As the current wave changes in polarity the same reasoning applies in a reverse direction, i. e., the winding 9 now has greater self-induction than winding 8.

There is, therefore, dissymmetry in the electrical circuit composed of the two windings which causes dissymmetry of the current waves in the parallel winding branches because in each winding and for each wave of the alternating current supply the self-induction of the windings is alternately increased and decreased.

Because of the parallel connection of the windings and the dissymmetry in the electrical circuit the respective current waves in the winding branches do not pass through zero at the same instant and the current wave in one winding is of longer time duration than that of the corresponding wave in the other winding.

As each winding has, alternately, a wave of long duration and one of short duration, the ones of long duration produce pulses of operating flux but the ones of short duration do not contribute to the operation of the armature but only tend to increase the flux in the core that is already near saturation.

Since the operating current waves and the pulses of operating flux produced by them are of longer time duration than the current waves of opposite polarity which do not contribute to the operation of the armature the pulses of operating flux as they reach the armature gap are additive and overlapping. It is these overlapping pulses of operating flux which produce an almost uniform force on the armature and cause the relay to give quiet operation with an alternating current supply.

It will be understood that the arrangement of Fig. 1 can be modified to the extent of connecting the two windings 8 and 9 in series instead of parallel provided the instantaneous current therethrough is such as to cause flux of opposite direction to flow in the respective cores. Such a series connection of the windings, however, will cause the armature flux to approach zero as the alternating current changes polarity which causes the relay to buzz even for small armature loads. To prevent such a buzzing action due to series connection of the windings a copper sleeve or a number of short-circuited turns of wire may be located on the side arms of the armature near the gap thereby obtaining satisfactory operation.

Single winding relay

The embodiment of the invention shown in Figs. 2 and 2A represents a relay operating on the same principle as the relays of Figs. 1 and 1A before described but employ a single winding which necessitates a somewhat different over-all structure.

Referring to Fig. 2 of the drawing, 20 represents a rectangular-shaped member of magnetic material providing a closed flux path. Centrally located within the member 20 is an operating coil assembly 21 having a core 22 of magnetic material attached to the sides of member 20 in any suitable manner. The winding 23 of coil 21 is connected to line terminals 24 and 25. Attached to and parallel with the two sides of member 20 are permanent magnet bars 26 and 27 whereby one end of the member 20 becomes a north pole and the other end a south pole. An armature is positioned with its cross-reach 28 opposing a

forward extension 29 of the magnetic member 20 and its side arms 30 and 31 extending parallel to the side arms of member 20 and with their rear ends hinged by leaf springs such as 32 to the spring pile-up blocks 33 and 34. Contact springs 35, 36 and 37, 38 are insulatedly mounted on the spring pile-up blocks 33 and 34, respectively, and their free forward ends are extended beneath the side arms 30 and 31 of the armatures. The forward end of spring 35 bears against an insulating stud 39 mounted on the side arm 30 and spring 37 against a similar stud 40 mounted on the side arm 31.

For convenience in manufacture the forward extension 29 is built up to form a pole face for the cross reach 28 of the armature by means of a block of magnetic material 41.

The permanent magnets 26 and 27 provide high biasing fluxes in the two sides of the closed magnetic path of member 20 which operates the material of this member at or near the non-linear portion of the saturation curve.

Now referring specifically to Fig. 2A the N pole of the relay is shown at the right of the figure and the permanent or biasing flux is pictured as leaving the N pole of the magnet 42, which is equivalent to the two magnets 26 and 27 of Fig. 2, dividing and proceeding in opposite directions through the two end sections of the member 20 thence from right to left in the upper and lower sections of the member 20 and joining the magnet 42 at the left or S pole. These paths are indicated by broken arrows.

If we assume an alternating current half wave applied to the winding 23, such that flux is caused to flow in an upward direction in the winding core 22 as indicated by the solid line arrow and this flux opposes the bias flux in the right-hand half of the upper section A of the magnetic member and aids the bias flux in the upper left half B of the same section. In the upper left half B the increase in flux is very small but in the right half A the flux therein is decreased and a pulse of operating flux readily flows through the armature 28, across the gap and to the lower end (S pole) of the core 22. It will be further noted that the pulse of operating flux also tends to aid the bias flux in the lower right-hand portion C whereas it opposes the bias flux in the lower left portion D.

As the current wave changes in polarity the flux now produced aids the bias flux in the lower left portion B and the upper right portion A of the member 20 and opposes the bias flux in portions C and D and a pulse of operating flux flows in the armature path in the same direction as before thereby causing the armature to be attracted and held by both half waves of the operating current.

The alternate waves of operating flux as they reach the armature gap are overlapping and no other means to produce steady operation is required.

What is claimed is:

1. In an alternating current relay a pair of magnetic cores, a magnetic bridge member interconnecting one end of each core, a second magnetic member interconnecting the other ends of said cores thus constituting a closed magnetic circuit, an armature pivotally supported from one bridge member and attractable to the other bridge member, a permanent magnet interconnecting said bridge members, and means including a winding on each of said cores for subjecting said cores and bridge members to successive half waves of alternating current whereby a unidirectional magnetic flux is caused to flow in said armature.

2. In an alternating current relay, a U-shaped core of magnetic material, a yoke of similar magnetic material bridging the two free ends of said core to form a closed magnetic circuit, an armature hinged at one end to the bottom of the core and opposing said bridging yoke at the other end and attractable thereto, a permanent magnet connected between said bridging yoke and the bottom of said core to establish a unidirectional flux in both arms of the core at or near saturation, and means including a winding on each arm of the core connected in parallel relation for subjecting both arms of said core and said bridging yokes to successive half waves of alternating current whereby a substantial unidirectional attractive force is exerted between said armatures and the opposing bridging yoke.

3. In an alternating current relay, a pair of electromagnets adjacent and parallel to each other, each electromagnet comprising a core having a winding thereon, one of said electromagnets having an armature, a U-shaped yoke of magnetic material at each end of the relay and joining the respective ends of said cores, and a straight bar permanent magnet clamped between the two yokes, said core windings being connected in parallel relation and constituting means for subjecting said cores and U-shaped yokes to successive half waves of alternating current whereby an alternating flux is caused to flow in said cores for each half wave of alternating current and a unidirectional flux is caused to flow through said armature.

4. In an alternating current relay, a pair of electromagnets adjacent and parallel to each other, each electromagnet comprising a core having a winding thereon and the windings being connected in parallel relation, one of said electromagnets having an armature, a U-shaped yoke of magnetic material at each end of the relay and joining the respective ends of said cores, a permanent bar magnet clamped between the two yokes in such a manner that a biasing flux flows in the same direction in each core, and means including said parallelly connected windings for subjecting said relay to a half wave of alternating current whereby magnetic flux is caused to flow in said cores in opposite directions and in said armature in but one direction.

5. In an alternating current relay, a rectangular shaped core of magnetic material, a cross bar of similar material bridged between two opposite sides of said core and substantially midway between the ends thereof, a winding on said cross bar, means for causing a steady flux at or near saturation to flow in the same direction in each of the two opposite sides of the core and an armature parallel to said opposite sides of the core hinged at one end of the core and attractable at the other.

6. In an alternating current relay, a rectangular shaped core of magnetic material, a cross bar of similar magnetic material bridged between two opposite sides of said core and substantially midway between the ends thereof, a winding on said cross bar and means comprising a permanent magnet individual to and coextensive with each of said opposite sides and having their like polar ends in engagement with corresponding ends of the respective opposite sides to cause a steady biasing flux to flow in the same direction in each of the two opposite sides of the core, and an

armature parallel to and bridging said opposite core sides.

7. In an alternating current relay structure, a pair of oppositely disposed legs of magnetic material, a magnetic yoke interconnecting corresponding ends of said oppositely disposed legs of magnetic material, said legs and yokes thereby constituting a closed magnetic circuit, an armature mounted on said structure and having one end thereof spaced from a part of said magnetic circuit by an air gap, permanent magnet means paralleling said legs and interconnecting said yokes for producing a unidirectional biasing flux in said magnetic circuit such that said legs of magnetic material are normally maintained in a condition of substantial magnetic saturation, and alternating current responsive winding means disposed on said structure for generating magnetic flux in said magnetic circuit which opposes the biasing flux in one of said legs and aids the biasing flux in the other of said legs, whereby a resultant flux is caused to traverse said armature and air gap in but one direction incident to the response of said alternating current winding means.

8. In an alternating current relay, a magnetic structure including a pair of oppositely disposed parallel magnetic legs joined at their ends by yokes of magnetic material, said legs and yokes constituting a closed magnetic circuit, an armature displaced from said magnetic circuit by an air gap, means normally saturating each of the legs of said magnetic circuit with a steady biasing magnetic flux comprising permanent magnet means parallelly disposed relative to said legs and interconnecting said yokes, and means for directionally opposing the biasing flux of said permanent magnet means in each of said legs alternately comprising alternating current responsive winding means disposed upon said structure, whereby a pulse of operating flux flows in the same direction through said armature and air gap for successive half wave responses of said alternating current responsive winding means.

9. In an alternating current relay, a first core, a winding carried by said first core, a second

core, a winding carried by said second core, a yoke of magnetic material interconnecting the forward ends of said cores, a yoke of magnetic material interconnecting the rear ends of said cores, an armature hinged at the rear end of said first core and bridging the forward end thereof and spaced therefrom by an air gap, means connecting said windings in parallel relation whereby, when said windings are subjected to alternating current, the resulting magnetic flux generated by each winding traverses said cores in different directions relative to the interconnecting yokes and in opposite directions in a shunt path which includes said armature and air gap, and means for producing a unidirectional biasing flux in the said shunt path comprising a permanent magnet paralleling said cores and interconnecting said yokes substantially at their mid-points.

10. In an alternating current relay, a rectangular core of magnetic material, a winding on each of two oppositely disposed legs of said rectangular core, permanent magnet means parallelly disposed to said two oppositely disposed legs and interconnecting the other two oppositely disposed legs of said core for causing a steady flux at substantial saturation to flow in the same direction in each of the first said two oppositely disposed legs of said core, and an armature hinged at one end to one of said first two oppositely disposed legs and spaced at its other end from the same one of said legs by an air gap, whereby said armature operates in the direction of the said one of said legs upon energization of said windings.

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