SPLIT-PHASE RELAY

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FIG.3

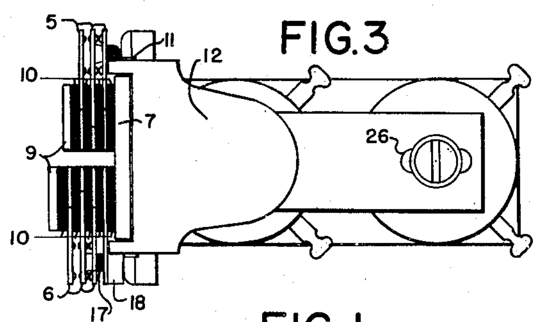


FIG.2

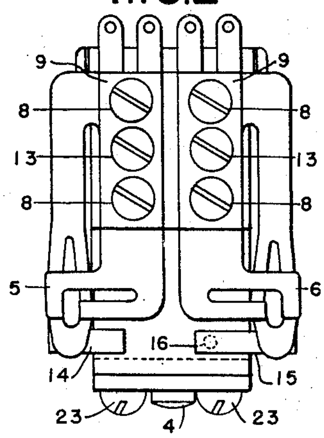


FIG.1

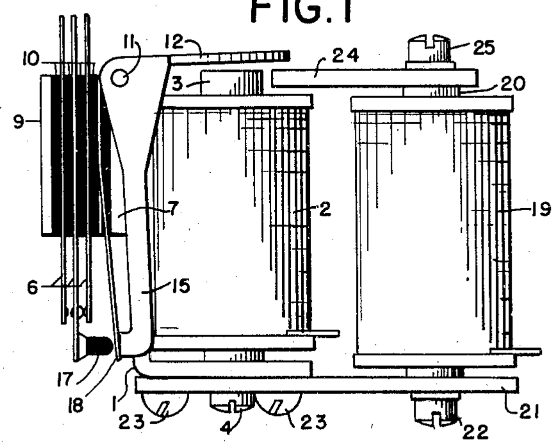
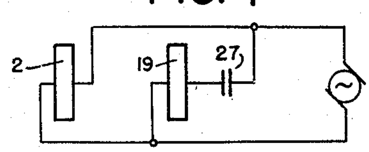


FIG.4



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SPLIT-PHASE RELAY

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The present invention pertains to electromagnetic relays employing more than one magnet, and more particularly to an improved alternating current relay of the split-phase type.

A split-phase alternating current relay conventionally comprises a field structure including two cores each provided with a winding, a movable armature carried by the field structure, one or more sets of contact springs operatively associated with the armature, and means for causing the magnetic fluxes created by the windings when energized to differ in phase.

The principal object of the present invention is to provide an improved electromagnetic relay of the type described which is light in weight, diminutive in size, economical in construction, quiet in operation, suitable for operation at audio frequencies, and yet reliable, long wearing, and positive in operation.

Another object of the invention is to provide a split-phase relay incorporating anti-vibration means which positively eliminates vibration of the armature mass from an external source, such as is encountered when the relay structure is mounted in an airplane, tank, automobile, train or other vibratory machinery either mobile or stationary, without subjecting the armature or its bearing to such stress or strain that the normal operating characteristics of the relay are thereby altered.

A further object of the invention is to provide a novel construction of the magnetic structure which will enable the use of an armature that is light in weight and has low inertia to further prevent the relay from being influenced by vibration from an external source.

Still another object of the invention is to provide a simple and economical means for converting a direct current relay into a split-phase alternating current relay so as to reduce the number of manufacturing tools required and to reduce the number of different parts which the manufacturer must stock.

A still further object is to provide a split-phase alternating current relay having means for adjusting the effective area of one of the pole faces so as to secure a constant resultant force acting on the relay armature to prevent chattering.

The above objects are in part realized by employing the improved mounting arrangement for the relay armature including an anti-vibration means which is descrbed and claimed in the copending application of Fredric E. Wood, filed February 26, 1943, Serial No. 477,230, which has matured into Patent No. 2,397,635, granted April 2, 1946.

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Other objects of the invention will appear in the following description taken in connection with the accompanying drawing in which:

Fig. 1 is a side view of the relay.

Fig. 2 is an end view of the relay as seen from the left of Fig. 1.

Fig. 3 is a top view of the relay as seen from the top of Fig. 1.

Fig. 4 is a schematic diagram showing one method of securing two phases for energizing the two coils from a single phase source.

Essentially, the invention comprises an L-shaped heelpiece having two cores secured thereto, each provided with a winding, to form an E-shaped magnetic structure, an armature pivotally secured to the heelpiece and extending to a point between the two cores, an adjustable bridging member extending from the outer core to a point between the end of the armature and the inner core, and a plurality of contact spring sets secured to the heelpiece in operative relationship with the armature.

It is recognized that split-phase magnets have been disclosed in the prior art having an E-shaped magnetic structure with windings on the center and on one of the outer legs and with an armature pivotally secured to the remaining leg and extending over all three legs. However, this type of constructure has been found to be unsatisfactory when the relay is exposed to external vibration due to the relatively high inertia of the armature. That a very substantial reduction in the inertia of the armature may be obtained by the use of the novel magnetic structure herein disclosed will be apparent when it is recalled that the moment of inertia of a thin rectangular body when rotated about one side of the body is proportional to the mass of the body times the square of the length of the side perpendicular to the axis of rotation. Thus for a given cross sectional area of the armature the mass will be reduced approximately one-half and the length of the armature, which is the side perpendicular to the axis of rotation, will also be reduced by one-half when the armature extends only half way across the E-shaped magnetic structure as in the present invention. The moment of inertia of the armature is thus reduced by a factor of one-eighth compared with the previously known construction. Actually a greater reduction is secured as the armature extends considerably less than half way across the field structure.

The construction of the relay will now be described in detail with reference to the accompanying drawings.

The construction of the lefthand portion of the relay in Figs. 1 and 3 is identical to the relay shown in Figs. 5 and 6 of the copending application of Fredric E. Wood previously referred to. This portion comprises an L-shaped heelpiece **1** with a magnet **2** provided with a magnetic core **3** secured thereto by a screw **4** passing through a clearance hole in the heelpiece **1** into a threaded hole in the core **3**. Two contact spring sets **5** and **6** are secured to a non-magnetic bearing plate **7** by four flathead screws **8** passing through clearance holes in clamping plates **9**, insulators **10**, contact spring sets **5** and **6**, into threaded holes in the bearing plate **7**. The bearing plate **7** has a transverse U-shaped slot in it to receive the bearing pin **11** of the armature **12**. The assembly of contact springs and bearing plate **7** is secured to the heelpiece **1** with the bearing pin **11** in the slot in the bearing plate so as to rotatably secure the armature **12** to the heelpiece **1** by means of flathead screws **13** passing through clearance holes in the assembly of contact springs and bearing plate into threaded holes in the heelpiece **1**. Tubular bushings are inserted in each of the clearance holes through the insulators **10** and the contact springs **5** and **6** to insulate the contact springs from the screws **8** and **13**. Two arms **14** and **15** projecting at right angles from the armature **12** and extending on either side of the heelpiece **1** have their ends formed parallel to the heelpiece. One of these arms **15** has its end normally resting on a non-magnetic rivet **16** in the heelpiece to prevent the armature from sticking due to magnetic leakage at this point. Each of the arms **15** and **16** engages an insulating buffer such as **17** secured to the tip of the armature spring of each contact spring set. An auxiliary spring **18** is tensioned against the arm **15** so as to silghtly twist the armature **12** to maintain the bearing pin **11** in constant engagement with its bearing surface and at the same time tends to rotate the armature **12** in a counterclockwise direction (Fig. 1) to appose any torque produced by external vibration which might tend to rotate the armature in a clockwise direction.

The portion of the split-phase relay just described is a complete relay in itself suitable for use on direct current. In order to adapt this relay for use on alternating current an additional magnet **19** having a core **20** is secured to heelpiece **1** by means of a magnetic yoke **21** by screw **22** passing through a clearance hole in the yoke **21** into a threaded hole in the core **20**. The yoke **22** is secured to heelpiece **1** by four screws such as **23** passing through clearance holes in the yoke **21** into threaded holes in the heelpiece **1**. A clearance hole is provided in the yoke **21** to clear the head of screw **4**. A bridging member **24** is secured to the opposite end of core **20** by screw **25** passing through an elongated hole **26** in the bridging member **24** into a threaded hole in the core **20**. The bridging member **24** is substantially flush with the top of core **3** and may be adjusted so as to vary the area over which it contacts armature **12** when the armature is operated.

The preferred method of manufacturing the relay is to first complete the lefthand portion of Figs. 1 and 3 including all adjustments such as the length of the armature stroke, tension in the contact springs, and the point in the armature stroke where the break contacts break and the make contacts make. The armature stroke is adjusted by bending arm **15** and is measured by inserting feeler gauges between the core **3** and the armature **12**. The point in the stroke where the break contacts break or the make contacts make is conveniently adjusted by inserting the proper size of feeler gauge between the core **3** and armature **12**, energizing the magnet **3** on direct current, and bending the break or make springs until the contacts barely break or barely make. Finally the contact pressure is set within the desired limits by tensioning the armature springs until the relay will operate on a predetermined value of current but will not operate on a smaller predetermined value of current. This last adjustment is called margining the relay. The advantage of performing these adjustments prior to the addition of the second magnet **19** is that the number of variables is reduced. These additional variables include the magnetic properties of the core **20**, bridging member **24**, and yoke **21**, the number of turns in the coil winding of magnet **19**, and the adjustment of bridging member **24**. A more accurate adjustment of spring tension and resulting contact pressure can be obtained when these variables are absent. After these adjustments are completed the additional magnetic circuit including magnet **19** is added and bridging member **24** is adjusted to secure quiet operation when the relay is energized with alternating current of the frequency for which it is intended to be used.

When used on alternating current the magnets **2** and **19** are energized with currents of different phases, preferably ninety degrees apart. Different phases of a polyphase source may be used or a single phase source may be used by inserting a condenser **27** in series with one of the magnets as shown in Fig. 4. Other known methods for obtaining currents of different phases in the two magnets may be used; such as, using a short circuited winding on one magnet, or making one winding highly inductive and the other highly resistive, although the arrangement shown in Fig. 4 is preferred. The magnetic fluxes produced by magnets **2** and **19** in the air gaps between core **3** and armature **12** and between bridging member **24** and armature **12** are also out of phase and thus there is always a resultant torque acting on the armature because the individual torques pass through zero at different times. By properly proportioning the strengths of the magnets and the effective area of the corresponding pole faces to the distances between the armature pivot point **11** and the centers of magnetic forces acting on the armature at the two air gaps the resultant torque acting on the armature can be made constant as follows:

Let

$\theta_1 \sin wt$ be the flux produced by magnet 2 in the air gap between core **3** and armature **12**,

$\theta_2 \cos wt$ be the flux produced by magnet **19** in the air gap between bridging member **24** and armature **12**,

A_1 be the effective area of the pole face of core 3,
A_2 be the effective area of the pole face of bridging member 24,
D_1 be the distance from the pivot point 11 to the center of A_1, and
D_2 be the distance from the pivot point 11 to the center of A_2.

Then the torque T_1 acting on the armature 12 due to the flux produced by magnet 2 is:

$$T_1=A_1D_1\left(\frac{\phi_1 \sin wt}{A_1}\right)^2=\frac{D_1\phi_1^2}{A_1}\sin^2 wt$$

and the torque T_2 acting on the armature 12 due to the flux produced by magnet 19 is,

$$T_2=A_2D_2\left(\frac{\phi_2 \cos wt}{A_2}\right)=\frac{D_2\phi_2^2}{A_2}\operatorname{Cos}^2 wt$$

The net torque T acting on the armature is T_1+T_2 or

$$T=\frac{D_1\phi_1^2}{A_1}\sin^2 wt+\frac{D_2\phi_2^2}{A_2}\cos^2 wt$$

Since $\sin^2 wt+\cos^2 wt=1$ the net torque T will be constant when

$$\frac{D_1\phi_1^2}{A_1}=\frac{D_2\phi_2^2}{A_2}$$

or

$$A_2D_1\phi_1^2=A_1D_2\phi_2^2$$

The above calculations have ignored the torque acting on the armature produced by the flux at the air gap between the armature 12 and the top of the heelpiece 1 because the distance between the pivot point 11 and the heelpiece is so short as to make this torque negligible in comparison to the torques T_1 and T_2 considered. If the armature is pivoted on the heelpiece this torque would actually be zero.

It is thus apparent that for given areas A_1 and A_2 the number of turns on the magnets 2 and 19 and the magnitude of the currents through them can be varied so as to produce a constant torque on the armature so as to prevent chattering. Variation of area A_2 affords an alternative method of securing the above relation and may be used to compensate for manufacturing variations in the relay components or may be used to cause the resulting torque acting on the armature to be constant for different values of current in the relay windings.

While the invention has been described as applied to a split-phase alternating current relay it is not intended that it shall in any way be so limited except as pointed out in the appended claims. The method of varying the effective area of a magnet pole face, for example, may equally well be applied to a direct current relay as a means for adjusting the value of the force acting on the armature due to the magnetic attraction between the armature and the magnet pole face.

Having described and illustrated the invention, what is considered new and desired to secure by Letters Patent is distinctly pointed out in the appended claims.

What is claimed is:

1. In a relay having a substantially E-shaped core, a first winding on the center leg of the core, a second winding on one of the outer legs of the core, an armature pivotally secured to the other outer leg of the core extending to a point between said one outer leg and the center leg, and a bridging member extending from said one outer leg to a point between said center leg and the free end of said armature.

2. In a relay having a substantially E-shaped core, a first winding on the center leg of the core, a second winding on one of the outer legs of the core, an armature pivotally secured to the other outer leg of the core extending to a point between said one outer leg and the center leg, and an adjustable bridging member extending from said one outer leg to a point between said center leg and the free end of said armature.

3. In an alternating current relay including a field structure and an armature pivotally secured thereto, a first magnet secured to said field structure presenting a pole face to said armature at a distance D_1 from said pivot point and having an effective area A_1, a second magnet secured to said field structure presenting a pole face to said armature at a distance D_2 from said pivot point and having an effective area A_2, and means for energizing said two magnets with alternating currents in time quadrature so as to produce corresponding magnetic fluxes having amplitudes ϕ_1 and ϕ_2, respectively, in said pole faces in proportions which satisfy the following relation:

$$A_2D_1\phi_1^2=A_1D_2\phi_2^2$$

4. In an alternating current relay including a field structure and an armature pivotally secured thereto, a first magnet secured to said field structure presenting a pole face to said armature at a distance D_1 from said pivot point and having an effective area A_1, a second magnet secured to said field structure presenting a pole face to said armature at a distance D_2 from said pivot point and having an effective area A_2, means for energizing said two magnets with alternating currents substantially ninety degrees out of phase so as to produce corresponding magnetic fluxes having amplitudes ϕ_1 and ϕ_2, respectively, in said pole faces, and means for varying the effective area of one of said pole faces so as to satisfy the relation:

$$A_2D_1\phi_1^2=A_1D_2\phi_2^2$$

5. In an alternating current relay comprising an armature, a cooperating magnetic member presenting at least two pole faces to said armature, winding means on said member adapted to establish alternating fluxes in time quadrature in said pole faces when energized by alternating current, and means for adjusting the effective area of one of said pole faces so that the resultant torque acting on the armature due to the attractions between said pole faces and the armature is substantially constant when said armature is in a predetermined position and as long as the effective value of said current is substantially constant.

6. In a relay, a heelpiece, a magnet secured thereto, an armature pivotally secured to said heelpiece in operative relationship with said magnet, a device for converting said relay into a multi-magnet relay comprising a second magnet, a yoke secured to one end thereof and adapted to be secured to said heelpiece, and a bridging member secured to the other end of said second magnet so as to be positioned in operative relationship with said armature when said yoke is secured to said heelpiece.

7. In a relay having a field structure and an armature pivotally secured thereto, a first magnet secured to said field structure presenting a pole face to said armature, a second magnet secured to said field structure, and an adjustable extension member secured to the pole face of said second magnet positioned so as to influence the operation of said armature.

8. In a relay, a field structure including a heel-

piece and a pair of magnets secured thereto, an armature pivotally secured to said heelpiece so as to permit movement of the armature into abutment with the pole face of only one of said magnets, and an extension member secured to the pole face of the other of said magnets positioned so as to permit movement of the armature into abutment with said extension member.

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REFERENCES CITED

The following references are of record in the file of this patent:

UNITED STATES PATENTS

Number	Name	Date
991,829	Clement	May 9, 1911
1,752,023	Packard	Mar. 25, 1930
1,906,027	Wahl	Apr. 25, 1933
2,013,229	Andis	Sept. 3, 1935
2,318,359	Bellows	May 4, 1943
281,249	D'Infreville	July 17, 1883

FOREIGN PATENTS

Number	Country	Date
561,904	France	Aug. 20, 1923