April 14, 1959 H. SAUER 2,882,368

ELECTROMAGNETIC RELAY

Filed July 18, 1955 2 Sheets-Sheet 1

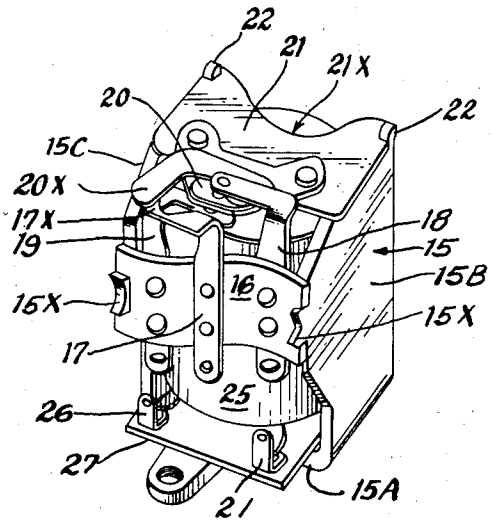


FIG. 1

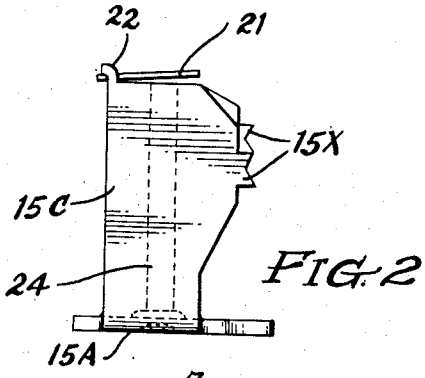


FIG. 2

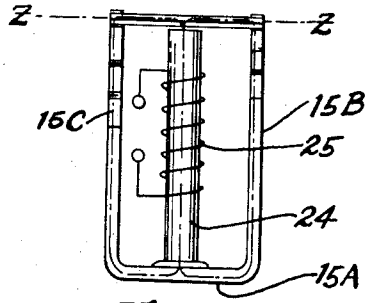


FIG. 3

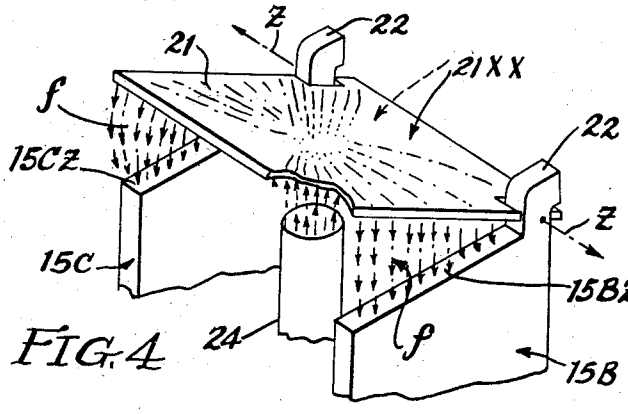


FIG. 4

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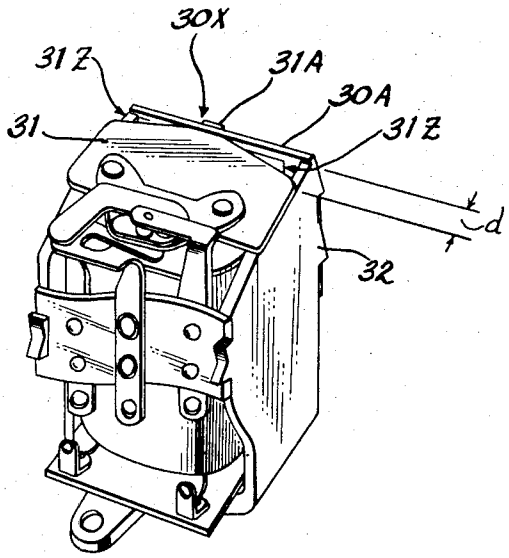


FIG. 5

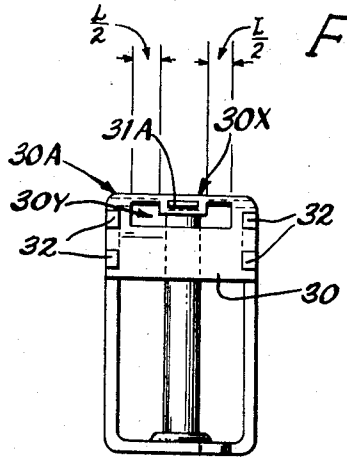


FIG. 6

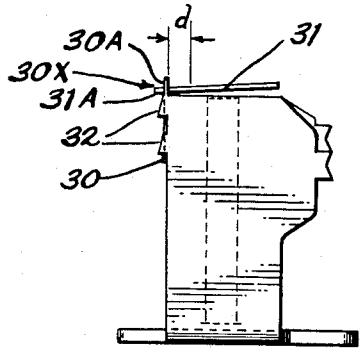


FIG. 7

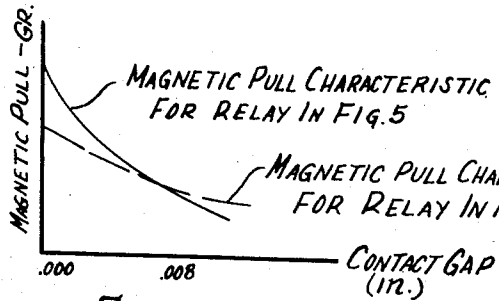


FIG. 8

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United States Patent Office 2,882,368 Patented Apr. 14, 1959

2,882,368

ELECTROMAGNETIC RELAY

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Application July 18, 1955, Serial No. 522,480

10 Claims. (Cl. 200—87)

This invention pertains to electromagnetic relays and has as one of its broader objects the provision of a highly sensitive relay having a remarkably increased efficiency owing to a construction of the ferromagnetic frame, on the one hand, and the pivotal mounting of the armature on the other, together with the form and arrangement of the contact means, all of which make possible a substantial increase in magnetic pull without any increase in the overall proportions of the device, while at the same time achieving these objects and advantages with a very substantial reduction in the power rating required as compared with the old type of relay available for similar applications and work loads.

Some of the more detailed objects of the invention relate to the provision of a very sensitive relay having a lightweight armature; improved armature bearings and contact means having minimized interference with the magnetic flux; a generally improved flux distribution owing to a double magnetic circuit acting almost wholly on optimum, useful areas of the armature with reduced flux leakages and losses; and a generally reduced overall reluctance without increase in the ferromagnetic mass.

Additional objects, advantages, and aspects of utility and novelty inherent in the new relay structure will become apparent as the following description proceeds in view of the annexed drawing in which:

Fig. 1 is a front perspective view of one form of the new relay;

Fig. 2 is a side elevation of the frame and armature assembly for the relay of Fig. 1;

Fig. 3 is a front elevational schematic view of the frame and core illustrating the double magnetic circuit for the relay structure of Figs. 1 and 2;

Fig. 4 is a purely schematic portrayal of the major flux distribution for both forms of the relay;

Fig. 5 is a front elevational view of a modified form of the relay;

Fig. 6 is a rear elevation of the magnetic frame and armature bearing for the device of Fig. 5;

Fig. 7 is a side elevation of the structure of Fig. 6;

Fig. 8 is a comparative graph for the pull characteristic of both forms of the new relay.

According to the construction of Fig. 1, the relay consists of a U-shaped field frame **15** including a base part **15A**, and opposite, upstanding legs **15B**, **15C**, said legs having forwardly-projected tapered portions terminating respectively in staking ears **15X** with which is supportably engaged an insulating contact strip **16** of somewhat sinuous shape and held firmly in position by appropriate staking of said ears.

The sinuous shape of strip **16** affords access for adjustment to contacts **17**, **18**, and **19** riveted thereto, each of the latter having a laterally offset finger with a suitable contact point affixed thereto for engagement with a movable fourth contact member **20** riveted on a thin armature plate **21**.

The movable contact **20** has a recurved spring finger portion **20X** positioned and spring-biased at all times to bear upon the offset finger **17X** of the lower fixed contact for the dual purpose of establishing electrical connection with the movable contact, via fixed or stationary contact **17**, and also springing the armature to its normally raised position, as illustrated in Fig. 2.

At the rearmost upper corners of each of the two frame legs **15B**, **15C** are two armature-retaining lugs **22**, of somewhat inverted L shape and dimensioned to interfit in cut-outs or notches on the armature plate, the latter being turned down onto the lugs in assembly and prevented from escaping by the subsequently assembled contact springs **18** and **20**, the inwardly facing corners of the lugs **22** being rounded to facilitate such assembly.

Staked centrally of the base part **15A** of the field frame structure is a core piece **24** (Figs. 2 and 3) about which the wire spool or winding **25** is disposed, the terminals thereof being led to lugs **26** on an insulating member **27**.

One of the features of this relay structure is the fact that (unlike prior types of relay employing U-shaped field frames) the two legs **15B**, **15C** are at the sides, rather than at the front and rear edges of the armature. In other words, the two upright legs of the frame have been displaced respectively by 90° from the conventional position, so that in the new relay, as illustrated in the exaggerated view of Fig. 4, the pivotal axis Z—Z for the armature **21** is through the two ears **22** at the uppermost rear corners of the legs and across the space between said legs.

As a result of the foregoing angular displacement of the frame legs, the working pole faces **15BZ** and **15CZ** thereof are in effect enlarged in the sense that the working flux F has a greater cross-sectional area in which to do useful work with respect to the legs of the field frame and the armature plate **21**. Little, if any, useful work can be done by the flux in the immediate region of the axis Z—Z. Therefore, in the old style of construction (with the U-shaped or yoke-shaped frame legs at front and rear) only one of the pole faces or heel pieces did effective work in moving the armature; whereas, the present construction in effect nearly doubles the efficiency of the magnetic circuit without any change in the relative ferromagnetic mass, because both pole faces work equally.

Moreover, as brought out in Figs. 3 and 4, there are two complete magnetic circuits, one through each leg **15B** or **15C**, and the core piece **24**, as indicated by dash-dot line in Fig. 3.

Close along the pivotal axis Z—Z (Fig. 4) the useful working flux acts in some respects negligibly and in some respects negatively, that is to say, against the desired efficiency in this region; and in Fig. 4 it has been attempted schematically to depict the approximate pattern of flux distribution and concentration in the armature plate, it being noted especially that in the region designated **21XX** there is an area of lesser flux density with a tendency toward concentration again in the region of the pivot posts or ears **22**.

Accordingly, I have gained efficiency by cutting away a somewhat arcuate area at **21X** on the armature plate **21** (Fig. 1) and by so doing have lightened the mass of the armature without in the least impairing the magnetic circuit.

The modified form of this relay shown in Figs. 5 to 7 includes all of the inherent advantages of the first-described form, but involves some structural differences which still further increase the sensitivity of the device, the essential difference residing in the bearing structure.

Whereas the device of Fig. 3 is wholly open at the rear with only the insulated contact panel **16** extending across the front thereof, the modified construction, as seen in Fig. 6, especially, is provided with a bearing plate **30** made of nonmagnetic spring material such as phos-

phor bronze and staked onto ears 32, there being an upward extension 30A into which is punched a short horizontally-extensive slot 30X to receive and seat a tongue 31A projecting from the rear edge of the armature plate 31, which is the sole bearing means for the same.

The bearing plate 30 is cut away in the region 30Y about the small remnant portion in which the bearing slot 30X is punched, in consequence of which this area and the appertaining portions of the bearing plate to which it is attached, act as a torque spring for the tongue 31A, said spring having an effective length

$$L=\frac{L}{2}+\frac{L}{2} \qquad \text{(Fig. 6).}$$

Having in mind the pattern of approximate flux distribution in the armature plate, as shown in Fig. 4, and observing that the distribution will be quite similar for the modified construction of Fig. 5, it should now become clear that the pivotal tail 31A is disposed, first in a region of minimum flux density, and second on a combination non-magnetic fulcrum-piece and spring; and that moreover there is here no negatively-acting flux at all adjacent the rearward two corners of the frame piece, because in this modified construction the two rearward corner regions of the armature plate have been eliminated, as at 31Z, leaving a substantial corner gap or spacing *d* (Figs. 5 and 7), wherein there is no downward attraction or force acting on the armature plate.

The importance of this resides in the fact that there is substantially no useful clearance between the armature plate and the pole faces in the immediate vicinity of the pivotal axis (as along a line like Z—Z, Fig. 4), in consequence of which there exists no useful magnetic moment at the area *d* or close to said rearward corners of the armature plate and frame piece; and the moment or force that is exerted in this vicinity is negative in that it is more deleterious than useful; hence the cut-away areas 31Z at *d* actually achieve a measurable increase in efficiency, with differences sought to be made apparent by the comparative curves of Fig. 8.

As in the case of the embodiment of Fig. 1, the relay of Fig. 5 gains further in efficiency not only through a more efficacious utilization of the available flux, i.e., by angular re-locating of the pole faces, and improved flux distribution across the armature plate, but there is again a reduction of mass in the armature plate without impairment of magnetic efficiency; and in the case of the device of Fig. 5, there is even a further gain in magnetic efficiency by the construction 31A, 30X, and 31Z.

While dual and divided magnetic paths have been utilized heretofore, for instance in the so-called E-shaped cores for transformers, chokes, and other electromagnetic devices, the construction disclosed is novel especially in respect of the central core or pole piece 24 (Fig. 2) flanked by a pair of heel pieces or field pieces 15B, 15C, respectively displaced by 90° from the conventional yoke structure long used in this style of relay.

As a result of the new construction, the flux in both embodiments works as well between the core and the armature as between the armature and the two heel pieces or field pole faces 15BZ, 15CZ (Fig. 4).

The increase in pull is very marked when the air gap is kept small; and in the constructions illustrated, the air gap can actually be held smaller than the contact gap, under which circumstances the increase in pull can amount to nearly 50%.

Minimization of flux concentration in the region of the bearings owing both to the angular displacement of the pole faces 15BZ, 15CZ, and the shape and location of the bearing members for both embodiments, also accounts for a measurable difference in the performance of the device; and it may be observed from the comparative graph of Fig. 8 that the difference in performance of the two forms of the relay is mainly caused by the differences in their bearing means.

The performance curve for the relay of Fig. 1 is based, for example, upon a contact pressure of about 20 gm. with a gap of .008 in. max. at 8 milliwatts expended in a coil of 127 ohms, under which circumstances the measured pull is about 40 gm., achieving a fast pull-in time of about 17 milliseconds, with the result that the new construction outperforms other relays of this class, size for size, by a significant margin with respect to power rating, pull-in time, contact gap and pressure, and overall weight and size, with added features of ease of adjustment and access to the contact assembly.

I claim:

1. In a relay, a U-shaped field frame of wide, flat, low-reluctance metal, a core mounted medially on the bight between the opposite arms thereof; a thin armature plate pivotally supported at the respectively rearmost corner portions of said arms for movement about an axis extending between said arms at said corners so that each said arm presents a long pole face extending beneath one of the side margins of the armature, spring means acting on the armature to raise the same, and an energizing coil on said core, said armature being cut away a substantial amount from said rearmost corner portions inwardly toward and close to said core to remove portions thereof not substantially traversed by the flux path from said corners to said core whereby to lighten the armature without impairing the relative magnetic efficiency thereof.

2. In a relay, a field frame of wide, flat ferromagnetic metal stock bent into U-shape to provide wide, flat opposite legs joined by a bight portion; each leg providing a long pole face extending in a direction parallel to the pole face of the other and both faces being contained in a common plane, said frame being open at front and rear sides at the corresponding opposite front and rear ends of said pole faces; an electromagnet mounted between said legs on said bight beneath said armature plate with a pole face substantially in said common plane; a thin armature plate spanning the space between said legs to the outer side margins of said pole faces, at least, and spanning the distance from the outermost margins of said front and rear sides, at least; means providing bearing support for said armature plate to rock upon an axis extending along a line connecting the rearmost ends of said pole faces; the front margins of said legs each having a forward projection; a contact panel carried by said forward leg projections; and cooperative spring contact means carried by said panel and said armature plate.

3. A construction according to claim 2 further characterized in that said panel is of sinuous configuration in the direction between said projections to facilitate access to said contact means.

4. A construction according to claim 2 further characterized in that said bearing means includes a medial tongue at the rearmost edge of the armature plate and interfitting with a slot in a cross plate extending between and supported on the rearward edges of said legs.

5. In a relay, a magnetic frame formed from flat plate stock bent into U-shape; a magnetizing core located centrally between the opposite legs of the frame; an armature plate having opposite longitudinal edge portions each overlying and coextensive with a free horizontal edge on one of said legs; means pivotally supporting said armature plate to rock along an axis extending along a third edge portion of said plate between said opposite edge portions thereof; said plate having substantial portions thereof adjoining said axis cut away in a region of low flux concentration between said legs, said core and said axis.

6. The construction of claim 5 in which said supporting means comprises a thin bearing plate of springy

metal extending between said frame legs in alignment with the pivotal edge of the armature plate, and the latter has a narrow tongue projecting through a slot in said bearing plate, the latter having symmetrical portions cut out therefrom on both sides of the slot toward said legs to leave the portion containing the slot connected to the remnant by two narrow strips of said springy metal respectively constituting a torque spring acting on the armature.

7. In a sensitive relay a thin armature plate, a pair of opposite, elongated pole pieces each having a long pole face underlying a marginal region of said plate, means mounting said armature plate to rock toward and away from said pole faces, a magnetic core piece situated medially between said poles with a pole face substantially in the same plane as the pole faces of said pole pieces, a magnetizing winding for said core, said pole pieces and core being connected in good magnetic circuit at their sides remote from their respective pole faces, said armature plate being cut away in areas of lesser flux density lying between said core and said pole pieces and bounded inwardly toward the core by regions of relatively high flux density, whereby to substantially reduce the weight of the armature with no appreciable loss in magnetic efficiency therein.

8. In a sensitive relay, a U-shaped pole each leg of which provides a long pole face parallel to the other; a core mounted centrally of said legs and having a pole face substantially in the plane containing the pole faces of the legs; a winding for said core, an armature plate and means mounting the same to rock toward and away from said pole faces about a lateral axis between said legs and located near corresponding ends of said leg pole faces; spring means for biasing the armature away from the pole faces; said armature plate having substantially relieved areas with no metal in a region lying close to said axis and outside of a boundary extending from close to said corresponding ends of the leg pole faces close to, but outwardly of, said core, said boundary corresponding to that general line which divides a region of higher flux density from a region of relatively low flux density in the armature linking each pole face of the legs and the pole face of the core.

9. In a sensitive relay, a U-shaped magnetic frame having a central core and winding therefor, the opposite legs of the frame each providing a long pole face extending parallel to the pole face of the other and lying respectively in a plane which is close to the plane of the pole face of the core, said frame being substantially open at front and rear sides between the legs thereof; bearing

means including a cross member of non-magnetic metal secured to the open back side of said frame near the top of the legs thereof terminating at said leg pole faces, said cross member having a narrow horizontally-extensive slot close to the top margin thereof and substantially medially between said legs, an armature plate having a median, narrow, flat bearing tongue projecting through said slot and supporting the armature for rocking movement relative to said pole faces along an axis which extends laterally between said legs and corresponding rearmost ends of the pole faces on the latter near said bearing cross member, said armature having opposite side portions each of which overlies one of the leg pole faces from a forward margin of the plate a substantial distance rearwardly toward, but ending short of, said rearward ends of the leg pole faces and the line of said axis, whereby the armature is substantially relieved in areas lying between the core pole face, said bearing means, and said rear ends of the leg pole faces.

10. A construction according to claim 9 further characterized in that said bearing member is of a non-magnetic metal which is also springy and which is substantially thinner than the armature tongue, and said member is cut away in areas close to the said slot therein whereby to render the slot portions a spring with close fit between the tongue and spring which spring mounts the armature in normally biased relation away from the pole faces.

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