June 25, 1957 J. H. HORMAN 2,797,371

SENSITIVE RELAY

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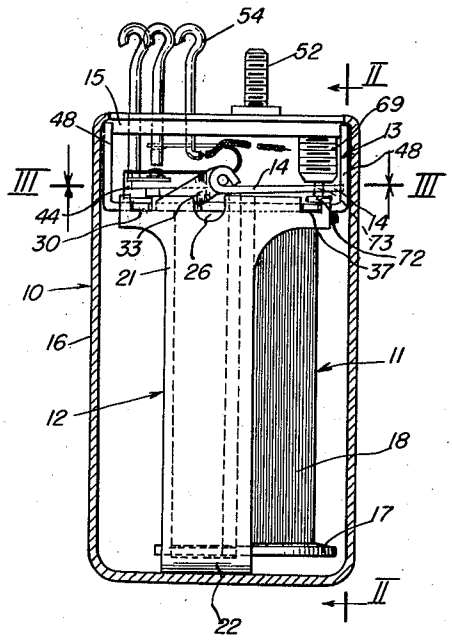


FIG. 1

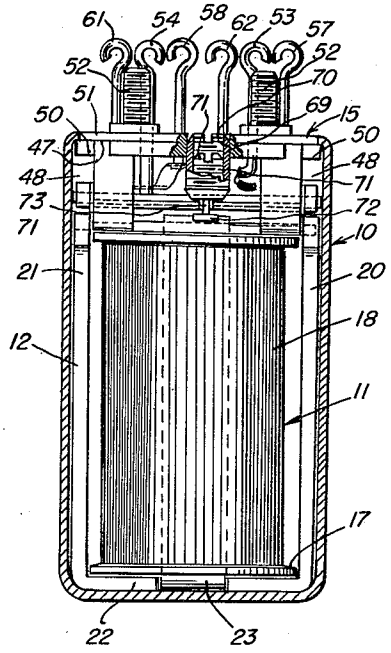


FIG. 2

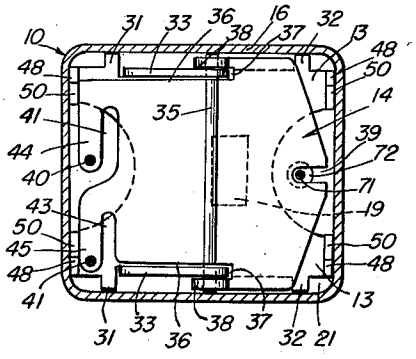


FIG. 4

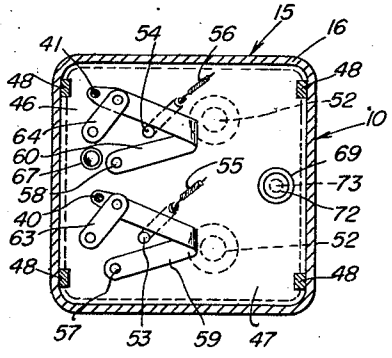


FIG. 3

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FIG. 5

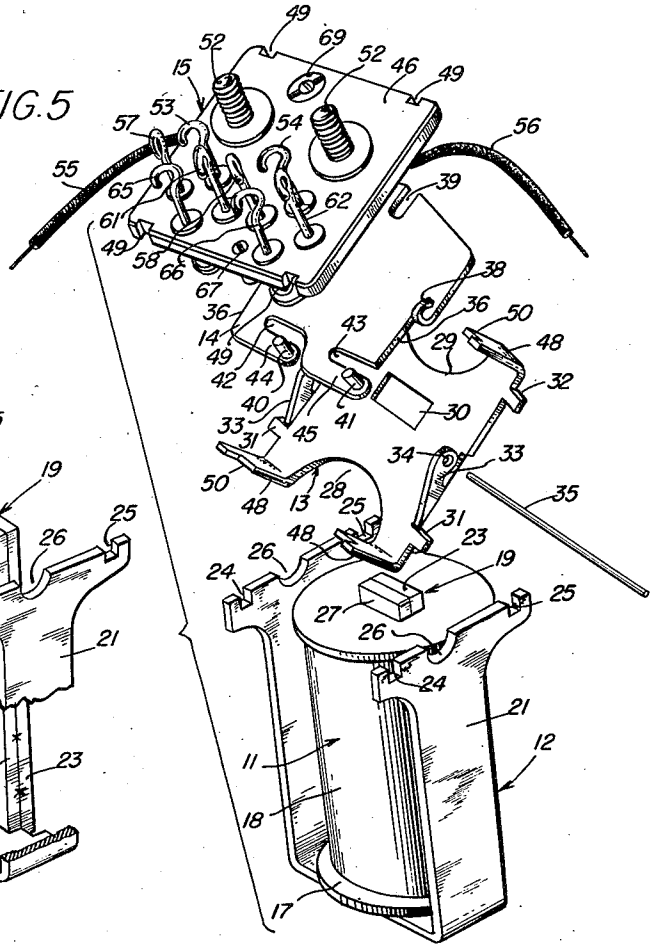


FIG. 6

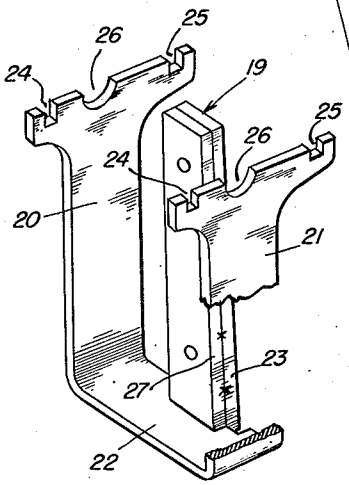


FIG. 7

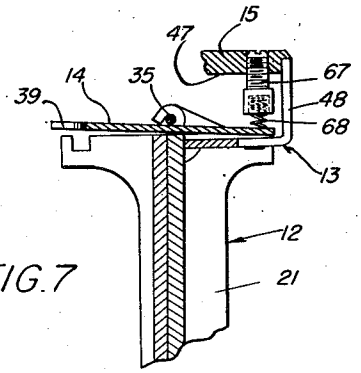
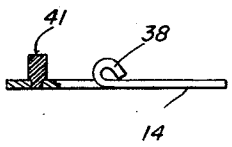


FIG. 8



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SENSITIVE RELAY

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Application January 4, 1954, Serial No. 401,864

8 Claims. (Cl. 317—176)

This invention relates to a sensitive relay, and more particularly a sensitive relay having a low operating power requirement. The invention is especially useful in its application to relays of small size, to which use, however, it is not restricted.

The principal objects of the invention are to provide a relay which:

(*a*) Is highly sensitive, that is, capable of being operated on power of the order of only a few milliwatts and which requires only a single magnet coil;

(*b*) Has a balanced armature to help prevent false operation when subjected to shock or vibration;

(*c*) Has a mechanical adjusting system whereby its pull-in voltage and drop-out voltage may be externally and easily and also precisely adjusted, thus permitting final or touch-up adjustments to be made after an enclosing can is soldered in place;

(*d*) Is capable of being made in small sizes requiring little space and of being hermetically sealed;

(*e*) Is easily factory assembled and adjusted and may therefore be economically manufactured;

(*f*) Has contact circuits requiring no internal wiring which therefore have very low resistance, inductance and capacity.

According to the invention, a sensitive relay is constructed, requiring a minimum operating power which is exerted through a single electromagnet and two connected frame members of magnetic material, which provide return paths for the magnetic flux induced in the core of the electromagnet on opposite sides thereof. High flux concentration per unit of electrical input is thereby realized. A balanced armature is provided for attraction by the electromagnet to close the magnetic flux gap between the end of its core and adjacent ends of the connected frame members. The armature is preferably centrally pivoted. Although small mass is desirable in the armature, its balanced condition minimizes false operation due to shock or vibration, and ample mass may be given it to provide an optimum path for the magnetic flux. Furthermore, the armature is positioned closely adjacent to the ends of the electromagnet core and the ends of the connected frame members to reduce to a minimum the air gap between these ends and the armature, and to provide for minimum required movement of the armature toward the flux gap closing position, upon actuation of the relay.

Special means are also provided, according to the invention, for adjusting the relationship between the armature and the electromagnet, the armature and the switches of the controlled circuits, and the strength of the resilient force urging the armature away from magnetic gap-closing position.

Finally, the invention provides for easy association of the elements of the relay into sub-assemblies, which may be quickly and simply brought together to form the complete apparatus.

The invention will best be understood from the following detailed description of the present preferred embodiment of the invention, illustrated in the accompanying drawings, in which:

Fig. 1 is an elevation of a relay constructed and arranged according to the invention, a side of the housing of the relay being cut away to show the construction;

Fig. 2 is a similar view taken on the line II—II of Fig. 1, viewed in the direction of the arrows;

Fig. 3 is a horizontal cross-section taken on the line III—III of Fig. 1, viewed upwardly in the direction of the lower pair of arrows;

Fig. 4 is a horizontal cross-section also taken on the line III—III of Fig. 1, viewed downwardly in the direction of the upper pair of arrows;

Fig. 5 is an exploded perspective view of the relay shown in Figs. 1 to 4, without the cover;

Fig. 6 is a broken perspective view of the magnetic core and frame of the relay;

Fig. 7 is a fragmental elevation, partly in section, of parts of the magnetic core, the frame, the armature, the armature retainer, and the header sub-assembly; and

Fig. 8 is an elevation of the armature, shown partly in section.

In the drawings, there is shown a relay **10**, comprising a single electromagnet **11** including a frame **12**, an armature retainer **13** formed for close fitting with the frame **12**, an armature **14** formed to be pivoted to the armature retainer, and a header sub-assembly **15** formed for close fitting with the armature retainer **13**. A housing **16** is provided for enclosing the assembled relay except for the face of the header sub-assembly from which the external connecting members of the relay project. The electromagnet and frame, armature retainer, armature, and header sub-assembly are easily and simply fixed together and firmly fitted within the housing to form the completed relay, as will be explained.

The single electromagnet **11** is of generally conventional form, comprising a bobbin **17**, of insulating material and suitable shape, wound with the usual coil of insulated wire, the entire coil being covered, preferably, with a protective insulating wrap **18**, all according to well-known practice. The core **19** (Fig. 6) of the electromagnet extends centrally through the bobbin **17** and is preferably made unitary with the frame **12** of magnetic metal such as nickel iron.

As shown, frame **12** is formed with two like frame members or arms **20** and **21** extending in the same direction at right angles from opposite ends of a central portion **22** of the frame, with which they are unitary. The length of the central portion **22** is slightly greater than the greatest width of bobbin **17**. An integral third arm **23** extends at right angles from one edge of the central portion **22** of the frame half way between the arms **20** and **21**, and in the same direction as these arms, but at right angles to their major planes. The third arm **23** and the arms **20** and **21** extend in parallel directions for equal distances from the central portion **22** of the frame.

The arms **20** and **21** are mirrored reflections of each other and terminate in unsymmetrical bracket ends to provide a substantial equality of metal on either side of the end of the third arm **23**. Spaced notches **24** and **25** are formed in the bracket end of each arm, and between these notches there is provided an adjustment indentation **26**, all for purposes which will be subsequently explained.

The third arm **23** forms a part of the electromagnet core **19**. In order to provide a sufficient cross-section of the core **19**, a strip of magnetic metal **27** is fixed coextensively with the third arm **23**. As here shown, the strip **27** is welded against the inner face of the third arm

23 with one of its ends in contact with the central portion 22 of the frame.

The bobbin 17, with the winding thereon, is positioned to surround the core 19, and when in place rests against the central portion 22 of the frame. See Figs. 1, 2 and 5. The lengths of the bobbin 17, the arms 20 and 21, and the core 19 are such that, when the bobbin surrounds the core in the position just described, the core projects beyond the end of the bobbin and the arms 20 and 21 project the same distance on opposite sides of the bobbin. See Fig. 5. Thus, when the electromagnet 11 is energized, the core 19 and the frame 12 provide paths for the magnetic flux from the core 19, across opposite air gaps to the ends of the arms 20 and 21, through the arms to the central portion 22, and back through the core 19.

According to a fundamental principle of magnetism, when the electromagnet 11 is energized, any body of magnetic metal adjacent the end of the core 19 and the ends of the arms 20 and 21 is attracted to close the gaps between the core and the arm ends by a force which is inversely proportional to the square of its distance from those ends. Moreover, because of the concentrated flux paths provided by the core and the arms, such body of magnetic metal is attracted both by the core and by the arms. Hence, a greater pull per unit of energizing force is realized by the disclosed electromagnet and frame than could be exerted by the core alone. The armature 14 of the sensitive relay is designed and mounted to take advantage of this principle and this construction of electromagnet and frame.

The armature 14 is operatively mounted in the relay by means of the armature retainer 13, which is designed for attachment to the frame 12. The armature retainer 13 is formed from a thin-gauge stiff sheet of non-magnetic material, preferably brass, cut away as at 28 and 29 and provided with a central opening 30 which conforms to the shape of the end of the electromagnet core 19. The width of the armature retainer is equal to the distance between the arms 20 and 21. Thus, the retainer may be closely fitted over the end of the core 19 and between the ends of the arms 20 and 21 to lie against the insulated end of the bobbin 17. Furthermore, the construction of the core and frame, and the thickness of the material of which the armature retainer is made, are so related that the core 19 and the arms 20 and 21 extend slightly beyond the outer surface of the armature retainer when the latter is in contact with the end of the bobbin 17. Projections 31, 31 and 32, 32 in the major plane of the armature retainer 13, extend outwardly thereof to fit snugly into the notches 24, 24 and 25, 25 of the arms 20 and 21 and support the armature retainer firmly on the frame. Although these projections are made to fit closely in the respective notches, a drop of solder may be applied in one or more notches, if desired, to hold the projections in place.

In order that the armature 14 may be pivotally carried by the armature retainer 13, a pair of integral arms 33, 33 are stamped out of the retainer symmetrically on opposite sides thereof adjacent the projections 31, 31. The arms 33, 33 are bent parallel to one another in planes at right angles to the major plane of the retainer, and are so formed that they extend at an acute angle to said major plane. Oppositely positioned holes 34 are formed in the arms 33 for reception of a pivot pin 35 for the armature.

The armature 14 is formed from a sheet of magnetic metal, of small thickness in order to insure small mass, yet of sufficient thickness to provide an optimum path for the magnetic flux across the gaps between the core 19 and the arms 20 and 21. The area of the armature is generally the same as that between the bracket ends of the arms 20 and 21. However, a part of the armature, on one side of its pivot, is of sufficient width to extend over such ends, and the part on the opposite side of the pivot is narrower and fits with suitable clearance between the integral arms 33, 33 of the armature retainer. The parallel edges 36, 36 of the armature between the arms 33, 33 extend toward the wider part of the armature as slots 37 (Fig. 4) forming metal strips which are formed into loops 38, 38. The pivot pin 35, projecting through such loops and the holes 34 in the integral arms 33 of the armature retainer, thus pivots the armature 14 closely adjacent the core 19 and the bracket ends of the arms 20 and 21. So pivoted, one part of the armature is movable between the bracket ends, and the other part toward and away from magnetic gap closing position.

The armature 14 being pivoted closely adjacent one side of the end of the core 19, a minimum air gap exists between the armature and the core, which acts through a minimum lever arm when the electromagnet is energized. See Figs. 1 and 4. Also, by so designing the armature 14 that substantially equal masses thereof lie on each side of the pivot pin 35, the armature is substantially centrally pivoted and a balanced armature is provided which resists movement by shock or vibration forces. The structure requires a minimum magnetic force to move the armature toward closure of the magnetic flux gap and a minimum counter force suffices to return the armature to its "open" position when the magnet is de-energized. As a result of the light weight and balanced condition of the armature, its close positioning to the electromagnet, and the small angle of its movement, a relay constructed and arranged according to the invention may be operated with a minimum application of energy.

In order to adjust the distance of the armature 14 from the core 19, the arms 33 may be bent toward or away from the electromagnet. The housing being removed, it is merely necessary to press the arms in the desired direction by means of an inserted tool, the adjustment indentations 26 in the bracket ends of the arms 20 and 21 affording room for this insertion beneath the arms 33.

A further feature of the armature construction is an adjustment slot 39 formed in the end of the wider portion of the armature. Adjustable stops, including a stem passing through the slot 39, may thus contact opposite faces of the armature at this point to limit movement thereof about its pivot, as hereinafter described.

Knobs or plugs 40 and 41 of non-conductive material are fixed at the narrower end of the armature for operating the contacts or switches of the controlled relay circuits. In order that the positions of the knobs may be adjusted with respect to such contacts, slots 42 and 43 are formed in the armature to provide tongues 44 and 45 at the outer ends of which the respective knobs 40 and 41 are fixed. By bending the tongues out of the plane of the armature, the positions of the knobs may be adjusted as desired.

The header sub-assembly 15 is built up on a plate 46, preferably of cold rolled steel, hot tin dipped, having an inner face 47 which, when the relay is assembled, is disposed toward the armature 14. The header assembly is positioned and fixed by means of prongs 48 of the armature retainer 13 which extend past the armature 14 and engage notches 49 in the rim of the plate 46. The prongs 48 are formed with shoulders 50 thereon against which the inner face 47 of the header sub-assembly rests to establish its position with respect to the other units of the relay. A drop of solder may hold the plate to each prong 48. As here shown, the plate 46 is chamfered entirely around its outer face 51 in order that the rim of the housing 16 may be turned inwardly thereabout to hold the assembled relay therein. See Figs. 1, 2 and 3.

Fixed to the plate 46 and extending at right angles outwardly therefrom are two threaded studs 52, whereby the entire relay may be held upon a support (not shown). The plate 46 is perforated, as here shown, in eight places,

and a metallic conventional hook terminal of the relay extends through each perforation, being fixed therein and insulated from the plate by a body of insulating material, such as glass. In the embodiment illustrated, two of the hook terminals **53** and **54** are provided for connecting the relay control circuit to the relay. To this end, the inner ends of the hook terminals **53** and **54** are connected by conductors **55** and **56**, respectively to the coil of the electromagnet **11**.

A second pair of hook terminals **57** and **58** have spring metal contact arms **59** and **60**, respectively, fixed to their inner ends, and spaced from the inner face **47** of the header plate **46**. The spring contact arms **59** and **60** are each reversely bent at an angle, as best seen in Fig. 3, and have the usual contact buttons near their free ends. The latter are positioned between the inner ends of the hook terminals **61** and **62**, respectively, and leaf contacts **63** and **64** extending parallel to the inner face **47** from the inner ends of hook terminals **65** and **66**, respectively. The inner ends of the hook terminals **61** and **62** are nearer to the inner surface **47** than are the leaf contacts **63** and **64**, and the resiliency of the spring metal contact arms **59** and **60** holds them in electrical contact with the leaf contacts **63** and **64**, respectively, beyond which the free ends of the spring metal contact arms extend. Thus, two single-pole double-throw switches are formed for the controlled circuits. Any other suitable contact arrangement may be employed.

When the relay **10** has all of its parts fixed together as described, with the armature **14** pivoted to the armature retainer **13**, and the header sub-assembly **15** in place thereon, the knobs **40** and **41** press against the free ends of the spring metal contact arms **59** and **60**, respectively, as best shown in Fig. 3. When the electromagnet **11** draws the armature toward flux gap-closing position, the knobs **40** and **41** thereon move the contact arms **59** and **60**, against their resiliency, out of contact with the leaf contacts **63** and **64** and into contact with the inner ends of the hook terminals **61** and **62**.

Thus, the electromagnet not being energized, a controlled circuit is closed through the hook terminal **57**, the spring metal contact arm **59**, the leaf contact **63** and the hook terminal **65**; and a second controlled circuit is closed through the hook terminal **58**, the spring metal contact arm **60**, the leaf contact **64** and the hook terminal **66**. When the electromagnet is energized, the knobs **40** and **41** bear upon the contact arms **59** and **60** to break the controlled circuits just described and close two other controlled circuits through the relay. One of these closed circuits includes the hook terminal **57**, the spring metal contact arm **59** and the hook terminal **61**. The other of these closed circuits includes the hook terminal **58**, the spring metal contact arm **60** and the hook terminal **62**.

The header sub-assembly **15** also carries adjustable means for resiliently holding the armature **14** away from magnetic gap-closing position, and means for limiting the angular movement of the armature about its pivot.

The first means comprises (see Fig. 7) an externally threaded cup member **67**, having a slot in its threaded end, screwed into a threaded bore extending through the plate **46** between the hook terminals **65** and **66** in proximity to the edge of the pivoted armature. The cup **67** is screwed into the plate, with its open end on the inside and its slotted end accessible from the outside, and a light coil spring **68** has one end positioned in the cup **67** and its other end bearing against the end of the armature between the knobs **40** and **41**. Thus, the armature is resiliently held away from magnetic gap-closing position by this spring in addition to the force exerted by contact springs **59** and **60**. The strength of the resilient force so holding the armature may be adjusted by turning the cup **67** in the bore through the plate into which it is threaded.

The angular movement limiting means carried by the header sub-assembly comprises an externally and internally threaded bushing **69** having a screw-driver slot. See Figs. 1 and 2. A threaded bore **70** is provided to extend through the plate **46** in line with the central adjustment slot **39** in the armature **14** when the latter is pivoted in place; and the bushing **69** is screwed in the bore **70** to cause its inner end to bear upon the face of the armature nearest the plate **46**. A stop is thus provided to limit movement of the armature away from magnetic gap-closing position. By turning bushing **69** in bore **70**, the position of such stop may be adjusted. This adjusts the pull-in voltage.

Threaded into bushing **69** is a stem **71** having a terminal head **72** carried by a neck **73** which is of smaller diameter than the width of the slot **39** in the armature, and the terminal head **72** is of greater diameter than that width. When the relay **10** is assembled, the neck **73** is positioned in slot **39** with the head **72** on the side of the armature distant from the inner face **47** of the plate **46**. Thus, the head **72** acts as an adjustable stop to limit movement of the armature **14** toward magnetic gap-closing position. This adjusts the drop-out voltage.

By so arranging the adjustments provided for by the cup **67**, the bushing **69** and the stem **71** that they may be made from the outside, on the face of header plate **46**, final adjustments can be made after the relay has been enclosed in the housing **16**. The latter is soldered to header plate **67** and the heat of this soldering operation is liable to upset adjustments previously made. When the housed relay has cooled, the adjustments can be touched up and, if desired, the container can be pumped out, the air flowing out around the screws **67** and **69**, which are then hermetically sealed with solder which also makes the adjustments permanent.

From the foregoing, it will be evident that the invention provides a sensitive, mechanically balanced relay which requires a minimum of operating power, which affords a maximum flux concentration through the armature, which is easily adjusted according to the requirements of its operation, which lends itself readily to hermetic sealing and which is easily and inexpensively assembled. It will also be appreciated that a relay according to the invention may be constructed in small sizes because of the simplicity of its individual and sub-assembled parts and the simplicity of their inter-fitting and inter-connection.

The form of the invention here disclosed is presented merely to illustrate the invention. Other forms and embodiments, coming within the scope of the appended claims, will readily suggest themselves to those skilled in the art.

What is claimed is:

1. A sensitive relay having minimum operating power requirement, said relay comprising: a single electromagnet; a core for said electromagnet; a frame for said relay comprising two members of magnetic metal connected to one end of said core extending on opposite sides of said electromagnet to provide return paths for the magnetic flux induced in said core, the unconnected ends of such frame members being positioned adjacent the unconnected end of said core; an armature retainer of non-magnetic metal fixed to the unconnected ends of such frame members; and a sheet metal armature pivoted substantially centrally of its mass to said armature retainer closely adjacent one side of the unconnected end of said core to provide a minimum gap between said armature and said core when said magnet is not energized and a minimum angular movement of said armature toward said core when said magnet is energized.

2. A relay comprising a single electromagnet; a central core of magnetic metal for said electromagnet; two frame members of magnetic metal connected to one end of said core extending on opposite sides of said electromagnet to provide return paths for the magnetic flux induced in said core, said frame members having their unconnected ends displaced from the unconnected end of

said core to provide flux gaps between such unconnected ends and the unconnected end of said core; and an armature retainer of non-magnetic metal fixed to the unconnected ends of said frame members, said armature retainer having integral pivot-supporting arms extending away from the ends of said frame members, and also having integrally formed thereon shouldered prongs extending away from the ends of said frame members; in combination with a balanced armature pivoted substantially centrally of its mass to the pivot-supporting arms of said armature retainer and positioned thereby closely adjacent the unconnected ends of said core and said frame members for movement about its pivot toward a position to close the flux gaps between the unconnected ends of said core and said frame members upon energization of said electromagnet; a header sub-assembly fixed to the shouldered prongs on said armature retainer; circuit terminals fixed to said header sub-assembly; and movable contacts carried by said header sub-assembly and positioned for actuation by said armature.

3. A relay comprising a single electromagnet; a central core of magnetic metal for said electromagnet; a frame member of magnetic metal connected to one end of said core and having legs extending on opposite sides of said electromagnet to provide return paths for the magnetic flux induced in said core, said frame member having its unconnected ends displaced from the unconnected end of said core to provide flux gaps between such unconnected ends and the unconnected end of said core; and an armature retainer of non-magnetic material fixed to the unconnected ends of said frame members; in combination with a balanced armature pivoted substantially centrally of its mass to said armature retainer and positioned thereby closely adjacent the unconnected ends of said core and said frame members for movement about its pivot toward a position to close the flux gaps between the unconnected ends of said core and said frame members; a header sub-assembly fixed to said armature retainer; switches carried by said header sub-assembly and positioned thereby for actuation by said armature; resilient means for holding said armature away from said core adjustably carried by said header sub-assembly; and adjustable stop means for limiting movement of said armature about its pivot in both directions also carried by said header sub-assembly.

4. In a relay, in combination, a magnet coil, a frame having a central member disposed axially in said coil as a core and extending from the end thereof and a pair of side members extending outside said coil parallel to said core and terminating in elongated edges, said edges and the end of said core lying substantially in the same plane, a flat armature adapted to cooperate with said frame to bridge the gaps between the end of the core and said edges, means for pivotally supporting said armature for rotation about an axis parallel to said plane and disposed centrally of said armature, that portion of the mass of said armature on one side of said axis having a width less than the space between the side members and that portion on the other side of said axis being wider than said space, said axis also lying adjacent said core end, whereby flux gaps are formed extending away from said axis between the edges of the wider portion of said armature and said elongated edges of the side members.

5. A relay comprising a single coil electromagnet, a core for said electromagnet, an armature of magnetic material substantially balanced about an axis closely adjacent the longitudinal axis of said core with its central portion closely adjacent the end of said core, a U-shaped frame attached to one end of the core and having arms spaced from said core and extending outside of said coil, the ends of said arms underlying said armature only on one side of its axis, said armature moving about its axis on energizing of the electromagnet to close flux return paths between the ends of the arms of the frame and said core.

6. A relay according to claim 5 having a contact-carrying header assembly supported adjacent said armature, said armature having means for actuating said contacts when moved by said electromagnet.

7. A relay according to claim 6 wherein said header carries means for resiliently urging said armature away from said core and means accessible from outside the header for adjusting said means.

8. A relay according to claim 6 wherein said header carries a pair of screws threaded through the header for adjustably limiting the movement of said armature about its axis in opposite directions.

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