Sept. 1, 1964 | T. R. WELCH ETAL | 3,147,349

ELECTROMAGNETIC RELAY

Filed Oct. 26, 1960 | 3 Sheets-Sheet 1

Fig. 1

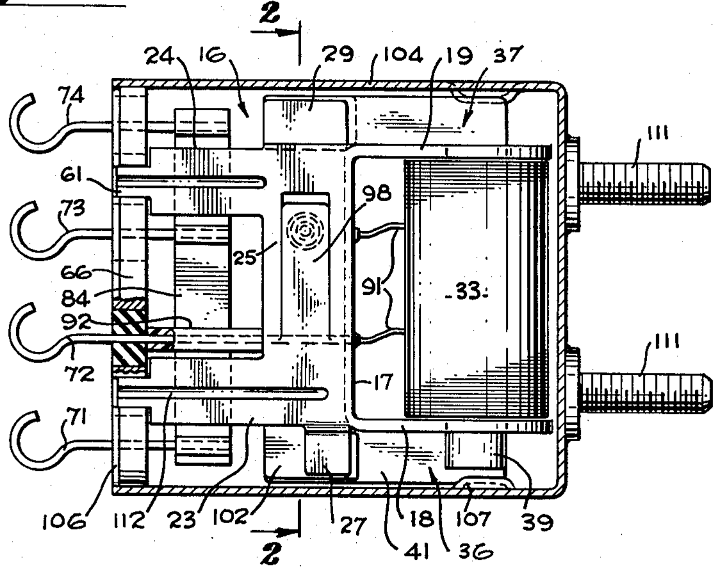
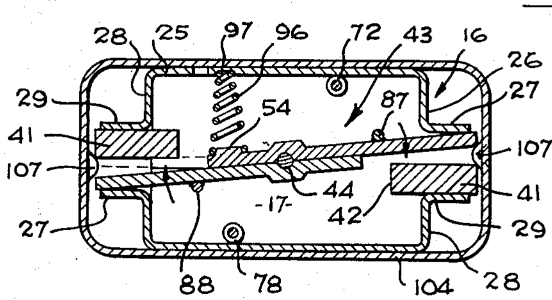


Fig. 2



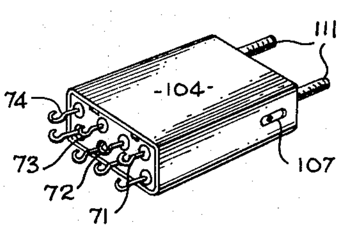


Fig. 3

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Fig. 4

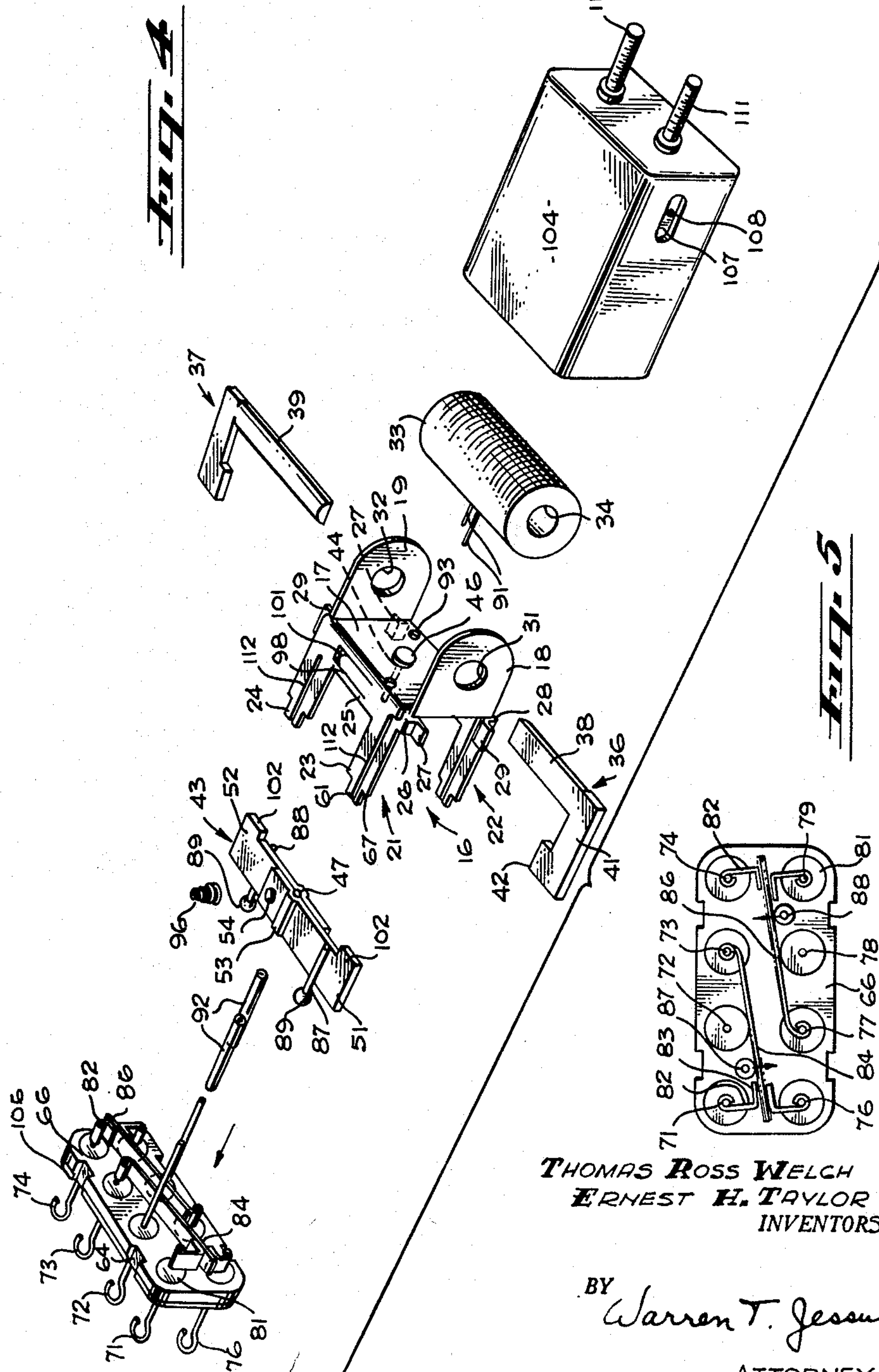

Fig. 5

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Fig. 6

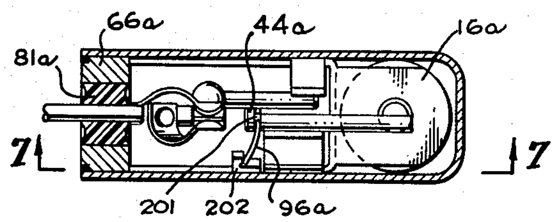


Fig. 7

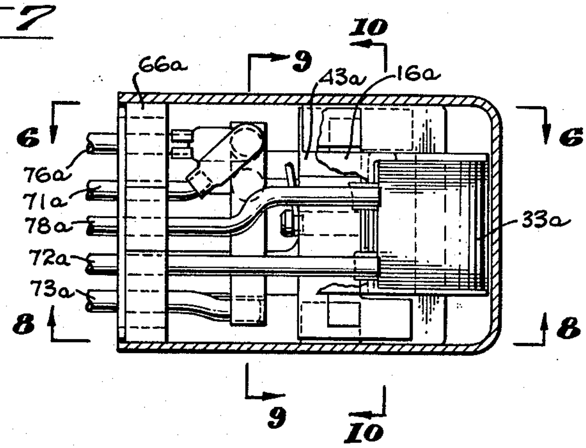


Fig. 8

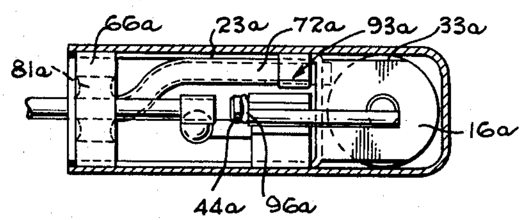


Fig. 9

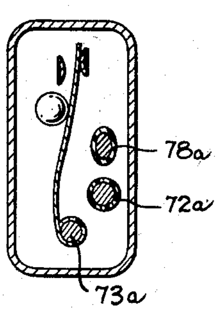
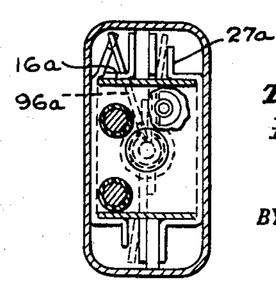


Fig. 10



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ELECTROMAGNETIC RELAY

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3 Claims. (Cl. 200—87)

This invention relates to an electro magnetic relay structure and processes for fabricating the same, and particularly to a very tiny relay in the dimensional field which has come to be known as micro-miniature.

It is an object of this invention to provide a relay structure capable of being mass produced with economy and which is designed to withstand shock and vibration without faulty operation and without damage.

It is another object of this invention to provide a miniature relay which may be made from a minimum of parts, thereby simplifying the fabricating process.

It is another object of this invention to provide a relay design which by its very nature may be assembled and fabricated easily and simply and with relatively unskilled labor.

It is another object of this invention to provide a relay structure wherein maximum efficiency and conversion of electrical energy into a magnetic field and hence into operating pull is achieved.

It is another object of this invention to provide a relay design which is readily susceptible to variations and adjustments without major modification.

In accordance with these and other objects which will become apparent hereinafter, preferred forms of the present invention will now be described with reference to the accompanying drawings, wherein:

FIG. 1 is a cross sectional view of a relay constructed in accordance with the present invention;

FIG. 2 is a cross section taken on line 2—2 in FIG. 1;

FIG. 3 is a perspective view of the relay with the cover on and shown somewhat larger than actual size;

FIG. 4 is an exploded perspective view of the principal relay parts;

FIG. 5 is a plan view looking down on the wall or header of the relay which carries the electrical contacts;

FIG. 6 is a cross section of another form of relay constructed in accordance with the present invention and taken on line 6—6 in FIG. 7;

FIG. 7 is a sectional view taken on line 7—7 in FIG. 6;

FIG. 8 is a sectional view taken on line 8—8 in FIG. 7;

FIG. 9 is a cross section taken on line 9—9 in FIG. 7; and

FIG. 10 is a cross section taken on line 10—10 in FIG. 7.

Referring to the drawings, **16** designates a frame struck from a single piece of sheet metal such as brass, or an alloy thereof. The frame **16** comprises a central base portion **17** which has a pair of coil mounting tabs **18** and **19** upturned at each end of the base portion **17**. Also integrally formed with the base portion **17** are a pair of leg portions **21** and **22** downturned at each side of the base **17**. Each leg portion, for example, the leg portion **21**, includes a pair of legs **23** and **24** and a skirt **25** extending between the legs **23** and **24**. At the upper extremity of the leg **21**, where it joins the base **17**, is a tab, which is bent from the end of the skirt **25**, first at right angles, to parallel the walls **18**, as shown at **26**, and again at right angles to parallel the leg **23**, as shown at **27**. The tab **27** constitutes an armature stop as will be explained hereinafter. At the opposite end of the skirt portion **25**, a wider tab is bent from the skirt, first at right angles and paralleling the walls **18** and **19**, as shown at **28**, and again at right angles to parallel the legs **23** and **24**, as shown at **29**. Wide tabs **29** are duplicated at diagonal corners, as shown in FIG. 5, and small tabs **27** are also duplicated at the other diagonal corners. The wide tabs **29** constitute mounting tabs to which the pole pieces of the relay are spot welded, as will be explained hereinafter.

The upturned tabs **18** and **19** are provided with aligned holes **31** and **32**, and placed between the tabs **18** and **19** is a cylindrical relay coil **33** having an axial hole or bore **34** aligned with the holes **31** and **32**.

A pair of angular pole pieces **36** and **37** are inserted into the coil **33** from opposite ends thereof. Each of the pole pieces **36** and **37** has a semi-cylindrical coil portion **38** and **39**, respectively, the flat faces of which mate within the hole or bore **34** to form the core for the relay coil **33**. Extending integrally at right angles from each semi-cylindrical core **38** for example, is a pole piece **41** having an inturned extension **42**. The pole portion is spot welded on the tab **29** to secure the pole piece in position to the frame. Securement of the pole pieces **36** and **37** by such spot welding also serves to secure the coil **33** to the frame **16** between the tabs **18** and **19**.

To the underside of the base **17** is pivotally mounted an armature **43**. The armature is mounted on a pivot pin **44** having at its upper end a shoulder and an enlarged head. The enlarged head is inserted through a central hole in the base **17** and the upper portion thereof is peened as shown at **46** by a spinning operation, to secure the pin **44** firmly to and beneath the base **17**. The armature **43** is pivotally mounted over the pivot pin **44** by a journal bore **47** and is secured thereto by a U-shaped securement snapped into a groove on the end of the pivot pin **44**.

The armature **43**, like the pole pieces **36** and **37**, is made of paramagnetic material, so that when magnetic flux is induced in the pole pieces by the coil **33**, the armature **43** is caused to pivot slightly and come into firm magnetic engagement with the pole pieces **42**. In so doing the armature actuates electric contacts in a manner to be described hereinafter.

The armature **43** is preferably formed of two pieces, **51** and **52**, welded together in overlapping relation. The pieces **51** and **52** are identical and stamped from the same die. They are formed with transverse ridges or bosses **53** and with smaller circular bosses **54** before being bonded together. The formation of the boss **53** leaves on the opposite side a small groove, and the grooves are placed face to face as shown in FIG. 2 before the pieces **51** and **52** are bonded together. There is thus formed a coarse guide hole extending transversely from edge to edge through the armature **43**. This guide hole is used to guide unerringly and with utmost accuracy a small drill which forms the finished bore **47**, by means of which the armature is mounted over the pivot pin **44**. By this formation of a guide hole, it is possible to accurately drill the bore **47** edgewise through the armature **43**, a most difficult task were it not for the preformed guide.

The lower or free extremities of the legs **23** and **24** are ensmalled, as shown at **61**, for example, in order to provide mounting tabs which engage in notches **64** formed in a terminal wall or header **66** to which the frame **16** is mounted. In fabrication, the frame is mounted on the header **56**, with the tabs **61** mating in the notches **64**, and with the shoulders **67** resting flush against the inner or upper surface of the header **66**. The tab **61** is of length slightly less than the thickness of the header **66**, thereby leaving a small external well at the edge of each notch **64** into which solder may gather for a firm bond when securing the frame **16** to the header **66**.

Eight terminals **71, 72, 73, 74, 76, 77, 78** and **79** (FIG. 5) pass through the header **66** and are insulated therefrom by insulating grommets **81**. To the inner ends of terminals **71, 74, 76** and **79** are secured leaf like stationary contacts **82**, which are bent at right angles as shown at **83** to parallel the two switch blades **84** and **86**. The switch blades or arms **84** and **86** are curled around and bonded to the inner ends of the terminals **73** and **77** and bend back and forth by the resiliency of the metal of which they are made, to constitute the switch operation. As seen in FIG. 5, there are thus constituted two independent double throw switches each having two positions. In one position (de-energized), for example, the switch blade **84** makes circuit between the terminal **73** and the terminal **71**, while in the other (energized) position the switch blade **84** makes contact between the terminal **73** and the terminal **76**. In similar manner the switch blade **86** makes selective contact from terminal **77** to terminal **74** or **79**.

The switch blades **84** and **86** are actuated simultaneously by the oscillation of the armature **43** through the intermediacy of a respective pair of depending operating rods **87** and **88**, to the ends of which are secured non-conducting contact spheres **89**. The inner ends of the remaining two terminals, **72** and **78**, pass upwardly on opposite sides on the armature **43** and are electrically connected to depending lead wires **91** of the coil **33**. These terminals are prevented from short circuiting to other parts of the relay by a pair of insulating sleeves **92** that extend from the insulating grommet **81** in the base **61**, to and through the passage holes **93** in the base **17**, through which the leads **72** and **78** extend to join the leads **91** at the upper surface of the base **17**.

The armature **43** is biased in a given direction (counterclockwise in FIG. 2) by means of a somewhat conical shaped compression spring **96**, the smaller, outer end of which rests in a dimple **97** formed in a bendable tab **98** lanced out of the skirt **25**. The inner, larger end of the spring **96** mates over the boss **54** formed on the armature **43**. The lancing of the tab **98** from the skirt **25** provides a means for adjusting the stress in the spring **96** and hence adjusting the return bias of the armature **43**. This is aided by cutting away a slot **101** in the skirt **25** at the end of the tab **98** when the tab **98** is lanced out. The slot **101** provides access for the blade of a narrow screw driver, in order to lift the tab if desired. To increase the compression of the spring **96** the fabricator need merely depress the tab **98** slightly with the point of the screw driver.

The final adjustment of the armature return spring **96** is quite critical. It has been found that when this adjustment is achieved by a set screw applied to either end of the spring **96**, the advancing or retracting of the spring must, of course, be accompanied by a turning of the screw. This in turn alters the torsion on the spring **96**, which results in a change in its compression. This torsion is not uniform, because, as a rule, the torsional frictional engagement between the set screw and the end of the spring is quite variable and the spring may or may not slip with respect to the screw. Furthermore, when using an adjusting screw, there is danger of its turning under vibration and thus altering the spring adjustment. By the tab structure **98** there is no torsional moment whatever placed on the spring during adjustment and surety of final adjustment is thus attained.

The magnetic pull of the armature toward and against the core or pole piece **37** may be readily regulated by designing the size of the pole tab **47** and also the size of the upturned portion **102** formed transversely on the end of the armature **43**. The area of these engaging faces is an important factor in determining the force on the armature resulting from the magnetic flux induced by the coil **33**; by adjusting these areas the magnetic force on the armature may be regulated and the magnetic impedance matched to the internal magnetic impedance within the coil **33**.

Maximum efficiency in converting the magnetic field generated by the coil **33** into armature actuating flux is attained by matching the internal magnetic impedance inside the coil **33** to the external magnetic impedance outside the coil, i.e. the pole pieces **41** and the armature **43**. Such magnetic impedance matching is aided greatly by the structure of the pole member **37**, wherein the mating faces of the semi-cylindrical core pieces **38** and **39** are substantially parallel to the direction of the flux and a long cross sectional area of mating faces is thus achieved. Thus, a low magnetic reluctance within the coil **33** itself is achieved with maximum conversion of electric energy in the coil **33** into physical force on the armature **43**.

The entire assembly is covered by a can or casing **104**, having only one open face, which face is closed by the terminal wall or header **66**, to complete the assembly as shown in FIG. 3. A small bevel or groove **106** (shown exaggerated in FIG. 4) is formed around the outer edge of the header **66**. When the can **104** is placed over the relay and the header **66**, this groove **106** cooperates with the adjacent edge of the can **104** to form a channel into which bonding solder may flow to complete a physical securement and hermetic seal completely around the relay. At the same time, the solder also fills the four tiny wells formed in the notches **64** at the extreme ends of the leg tabs **61**.

As the assembly is inserted into the cam **104** it is guided securely into proper position by means of two indentations **107** formed in opposite end walls in the can **104**, which rest against the upper corners of the pole pieces **41**, guiding them into position and holding the assembly in firm predetermined relation within the can **104**. Mounting studs **111** are secured to the end wall of the can **104**.

One of the indentations **107** also forms an elegant means for evacuating the assembly once it is completely sealed, and, if desired, inserting an inert gas. This is done by simply forming a small hole in the can **104** at the bottom of the indentation **107**, either by drilling, or punching at the same time that the indentation **107** is formed. After the evacuation process, the hole is sealed by a tiny drop of solder **108**. Since the solder **108** resides completely within the indentation **107**, there is no added projection from the smooth can **104**. This can be very important in micro-miniature equipment, where relays such as this are inserted into minute spaces with virtually no clearance.

The arrangement of parts described hereinbefore makes possible an assembly technique that virtually obviates the necessity for adjustments after fabrication. Such adjustments are often required in order to insure that, when the relay is actuated, the armature **43** comes firmly and flush against the pole faces **41** and **42**. In accordance with the present invention this is absolutely assured by the following observation and technique.

It has been discovered, in accordance with the present invention, that when soldering the ends of the leg portions **21** and **22** to the header **66**, just sufficient stress and strain may be applied to the frame **16** to bring about an excellent magnetic contact between the opposite faces of the armature **43** and their respective pole pieces **41** and **42**. This is effected in production by temporarily clamping, by means of a jig, the armature faces **51, 52** tightly against their respective pole faces **41, 42**, before the legs of the frame are bonded into the notches **64** of the header **66**. After the solder bonding has been effected between the frame **16** and the header **66**, the assembly is removed from the jig thus unclamping the armature from the pole faces. Any small stresses and strains which may have been placed in the frame **16** by the clamping of the armature thereto are retained by the bonding of the legs to the header **66**. Thus, when the armature is unclamped, it is ready to oscillate back and forth and always return with flush engagement to the pole faces **41, 42**.

By virtue of the structure thus described above, a relay of micro-miniature proportions having great structural strength against vibration and shock may be simply fabricated. The symmetrical, pivoted nature of the armature inherently counter balances accelerative or shock forces, which tend to cause faulty or spurious operation. By making the frame **16** from a single integral sheet of brass, not only is great strength obtained, but simplicity of assembly is also made possible.

The legs **23, 24** are given added strength against bending, by inwardly indented channels **112** which extend from the free ends of the legs up almost to the bend, where the legs join the base portions **17**. Thus, the bending strength is continued throughout virtually the entire length of the leg, and particularly into the skirt area **25**.

The relatively simple structure described hereinbefore makes it possible to easily assemble the parts while they are held in predetermined position in assembly jigs, thus assuring that uniformity of assembly is attained.

The relay described occupies, with its can or container, less than 0.128 cubic inch, and, as noted hereinbefore, provides two simultaneously operated, electrically independent double throw switches.

In FIGS. 6–10 there is illustrated a second form of the present invention which is even smaller than the first form heretofore described. The drawings shown are about five times the actual size of the fabricated item. The basic structure of this relay is the same as the relay heretofore described, and only those points of difference will now be set forth.

This second form of relay has only one switch, i.e. is a single pole, double throw switch, as shown in FIG. 9.

The frame **16*a*** is basically similar to the frame **16** of the first form hereinbefore described, and has four legs **23*a*** which extend downward and are bonded to the terminal wall or header **66*a***. Five terminals **73*a*, 72*a*, 78*a*, 71*a***, and **76*a*** extend through the header **66*a***, the central portion of which is made of insulating material as shown at **81*a***. The terminals **72*a*** and **78*a*** extend upward through channels or recesses **93*a*** indented into the frame **16*a***, and connects to the leads of the coil **33*a***.

In the form shown in FIG. 6, the armature **43*a*** is biased upward (axially), and also pivotally, by a single spring **96*a***, which thus serves as a return spring and also as a resilient stop, keeping the armature **43*a*** pressed upwardly to a predetermined position against the underside of the frame **16*a***. The inner end of the spring **96*a*** encircles the pivot pin **44*a*** in a groove **201** and is then hooked over the edge of the armature **43*a*** to provide a turning moment about the pivot pin. The other end of the spring **96*a*** is mounted to the frame at **202**. Groove **201** is made sufficiently wide that the spring **96*a*** may press upwardly (to the right in FIG. 6) against the armature **43*a*** thus holding it in position axially and at the same time biasing it to a predetermined position against the stop tab **27*a***.

Like its larger counterpart previously described, the smaller relay shown in FIGS. 6–10 has the elegant advantages of strength and ease of assembly with extremely tiny, micro-miniature size. It provides a double pole, single throw switch in a volume of less than 0.0455 cubic inch, including the can or container.

While the instant invention has been shown and described herein in what is conceived to be the most practical and preferred embodiments, it is recognized that departures may be made therefrom within the scope of the invention which is therefore not to be limited to the details disclosed herein but is to be afforded the full scope of the claims.

What is claimed is:

1. In a relay, a frame structure comprising a floor portion, a pair of arms and a pair of legs projecting in respectively opposite directions from each of the two opposite sides thereof, said pairs being angularly displaced 90° about an axis normal to said floor;
   - said pair of legs constituting base-mounting and spacing legs;
   - a base-member having supporting engagement with said mounting legs;
   - contact means on said base-member;
   - a coil disposed in alignment with and disposed in a position between said pair of arms;
   - pole pieces projecting through said arms into the coil and having offset pole-face parts extending to a level beyond said floor toward said mounting legs;
   - an armature bearing carried on said floor at least on the side thereof toward said mounting legs;
   - an armature pivotally mounted on said bearing for cooperative movement relative to said pole-face parts; and
   - said pair of legs having four tab portions offset toward one another within the planes established by said legs and in quadrant relationship, said pole pieces being secured for support to two diagonally positioned tab portions, and the remainder two positioned to act as stop members limiting the pivotal movement of said armature.

2. In a relay, a frame structure comprising a floor portion, a pair of arms and a pair of legs projecting in respectively opposite directions from each of the two opposite sides thereof, said pairs being angularly displaced 90° about an axis normal to said floor;
   - said pair of legs constituting base-mounting and spacing legs;
   - a base-member having supporting engagement with said mounting legs;
   - contact means on said base-member;
   - a coil disposed in alignment with and disposed in a position between said pair of arms;
   - pole pieces projecting through said arms into the coil and having offset pole-face parts extending to a level beyond said floor toward said mounting legs;
   - an armature bearing carried on said floor at least on the side thereof toward said mounting legs;
   - an armature pivotally mounted on said bearing for cooperative movement relative to said pole-face parts; and
   - a cantilever beam carried by said frame and projecting to a position laterally of said armature, a resilient compression member mounted between said beam and said armature, said resilient compression member contacting said armature on one side of the pivot established by said bearing and thereby providing a bias pressure upon said armature, the bias pressure being adjustable by bending said cantilever beam toward or away from said armature.

3. In a relay, a frame structure comprising a floor portion, a pair of arms and a pair of legs projecting in respectively opposite directions from each of the two opposite sides thereof, said pairs being angularly displaced 90° about an axis normal to said floor;
   - said pair of legs constituting base-mounting and spacing legs;
   - a base-member having supporting engagement with said mounting legs;
   - a coil disposed in alignment with and disposed in a position between said pair of arms;
   - pole pieces projecting through said arms into the coil

and having offset pole-face parts extending along the frame structure to a level beyond said floor toward said mounting legs;

a housing fitting over said relay and hermetically sealed to said base member, said relay and housing having a path of telescoping movement upon assembly;

a pair of projection surfaces on opposite sides of said housing positioned to interfere with the free movement of said pole pieces along said path and thereby cause a twisting movement of said relay in said housing resulting in a wedge fit of the relay in said housing.

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