April 2, 1946. F. E. WOOD 2,397,635

ELECTROMAGNETIC RELAY

Filed Feb. 26, 1943

FIG. 3

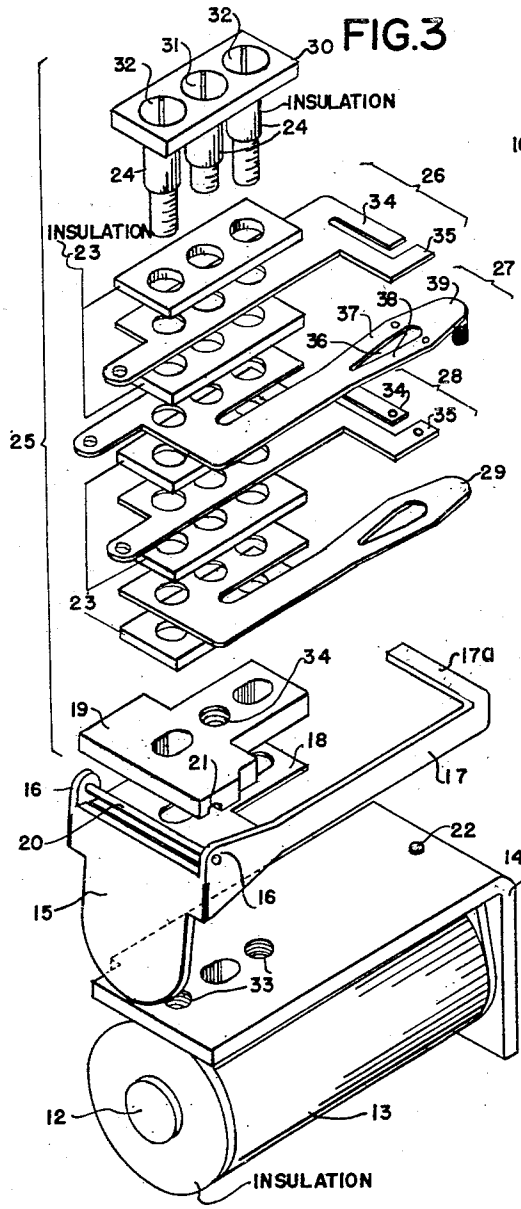


FIG. 1

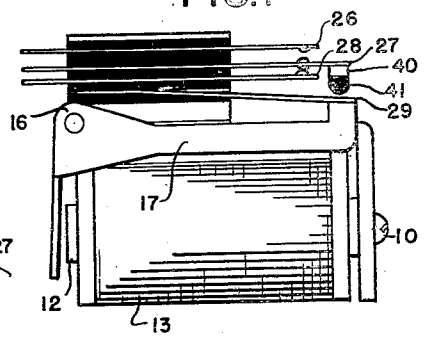


FIG. 2

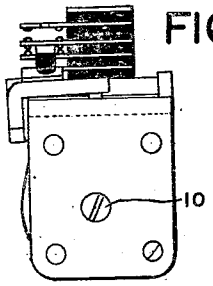
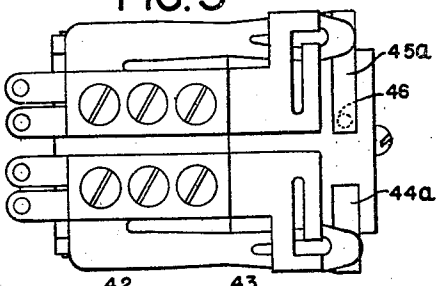


FIG. 5



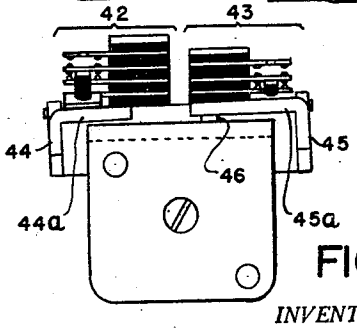
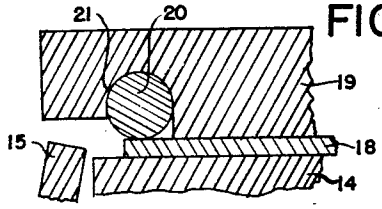


FIG. 6

FIG. 4



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2,397,635

ELECTROMAGNETIC RELAY

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Application February 26, 1943, Serial No. 477,230

6 Claims. (Cl. 200—104)

The present invention relates in general to electromagnetic devices and, more particularly, to electromagnetic devices of the relay type.

An electromagnetic device of the relay type conventionally comprises a field structure including a core provided with a winding, a movable armature carried by the field structure, and one or more sets of switch springs operatively associated with the armature.

It is the object of the present invention to provide an improved electromagnetic relay of the type described which is light in weight, diminutive in size, economical in construction, and yet reliable, long wearing, and positive in operation.

Another object of the invention is to provide in an electromagnetic relay an improved multicontact switch spring arrangement which positively insures electrical contact between each pair of associated contacts carried by the switch springs and which accommodates equalization of the contact pressure between associated contacts.

A further object of the invention is to provide in an electromagnetic relay an improved mounting arrangement for the relay armature including an 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, and 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 altered thereby.

The objects set forth above are in part realized in accordance with one feature of the present invention by providing an electromagnetic relay which comprises one or more sets of switch springs, each set comprising one or more so called armature springs, which are movable under control of the relay armature, and one or more so called make or break springs, engageable with or disengageable from said movable armature springs under control of said armature, wherein each of the armature springs comprises a relatively long flexible portion and is provided with two spaced-apart and independently flexible portions and a plurality of contacts carried by the flexible portions, and wherein each of the make or break springs comprises a relatively short stiff portion and is provided with two spaced-apart and independently flexible portions and a plurality of contacts carried by the flexible portions, the contacts carried by the flexible portion of the armature spring cooperating with the contacts carried by the flexible portions of the make or break springs. More particularly, each of the break or make springs is formed of flat metallic stock and is provided with a base end and a free end comprising a relatively short stiff portion to facilitate maximum ease of adjusting the relative position thereof, and a pair of very flexible branches which, although of unequal cross section and unlike shape, equalize the contact pressure between cooperating contacts of armature springs.

Each of the armature springs is formed of flat metallic stock and is provided with a base end and a free end comprising a relatively long flexing portion to facilitate maximum ease of adjusting the pressure of the spring against the armature or cooperating spring, and minimum operating power from the relay to move the armature, thereby to effect a change in the relative positions of the contacts on the armature springs with respect to the cooperating contacts of the make or break springs.

The two independently flexible portions provided in the armature spring are formed by an elongated slot provided adjacent the free end thereof and the two flexible portions provided in the make or break spring are formed by an elongated L-shaped slot provided at the free end thereof. Also, the contacts respectively carried by the flexible portion of the spring are carried thereby at points along the lengths of the flexible portions whereat the flexible portions have a maximum movement with respect to the base portion of the springs, thereby to insure self equalization of contact pressure between the respective engaging contacts when the contacts carried by the flexible portion of the armature springs are respectively forced into engagement with the contacts respectively carried by the flexible portions of the associated make or break springs.

Furthermore, the means for moving the armature springs comprises an operating member carried by each armature spring adjacent the free end and intermediate the two flexible portions thereof and an arm including the relay armature operating to engage the operating member.

According to another feature of the invention, one or more spring sets are assembled, independently of the relay, to a non-magnetic clamping plate provided with a comparatively long armature bearing surface whereby the armature and its associated pivot pin is rotatably secured to the field structure by the mere act of securing the spring set or sets to the field structure. The clamping plate is also of greater width than the free end of the heel piece so that there is sufficient space between the arm or arms of the arma-

ture and the sides of the heel piece to insure minimum loss of power as a result of magnetic leakage therebetween. A non-magnetic bearing is also provided between the spring set clamping plate and the field structure to provide a bearing surface for the armature pivot pin.

Relays having armatures of the pivot pin type have been extensively used in telephone systems and have proved very satisfactory. However, it has been found that relays of this type when subjected to constant vibration from an external source are subject to stresses not present in the normal use of these relays. Tests have shown that the vibration caused excessive wear on either the bearing surface for the pivot pin or upon the pivot pin itself, thereby, interfering with the normal operating characteristics of the relay. The analysis of this excessive wear shows that it results from at least two different types of motion.

The armature exerts a turning movement proportional to its mass and the rate and the direction of the vibrations. This tends to produce oscillations of the armature transverse to the axis of the pivot pin at a rate corresponding to the vibration rate.

If the vibrations are in a plane which includes the pivot pin and the center of mass of the armature, a force is exerted which tends to make the pivot pin chatter in the bearing at a rate proportional to the vibration rate.

It is a feature of the present invention to eliminate the above mentioned motions of the armature produced by external vibration of the relay by exerting a twisting action upon the armature and its associated pivot pin by means of a flexible spring, included in the spring set, which spring applies a relatively light pressure to the armature at a point between the armature backstop and the bearing surface. This light pressure maintains the pivot pin in constant engagement with the bearing surface and eliminates the possibility of the above mentioned objectionable vibratory motion between the pivot pin and the pivot pin bearing. Such a pressure is sufficient to prevent both the transverse motion and the chatter motion referred to above without adversely affecting the operating and releasing characteristics of the relay when the same is energized and deenergized.

Other object and features of the present invention will be apparent by reference to the following specification taken in connection with the accompanying drawing, in which:

Fig. 1 is a side view of an electromagnetic relay constructed and arranged in accordance with the present invention;

Fig. 2 is a right end view of the relay illustrated in Fig. 1;

Fig. 3 is an exploded perspective view of the electromagnetic relay illustrated in Fig. 1;

Fig. 4 is an enlarged sectional view showing the arrangement for pivotally supporting the relay armature;

Fig. 5 is a plan view of an electromagnetic relay constructed and arranged in accordance with the present invention but modified to accommodate two separate switch spring sets;

Fig. 6 is a right end view of the modified relay illustrated in Fig. 5.

Referring now more particularly to Figs. 1 to 4, inclusive, of the drawing, the electromagnetic relay there shown comprises a field structure including a longitudinally extending core element 12 provided with a winding 13, a substantially L-shape magnetic heel piece 14, secured to the core element 12, by means of a screw 19, and a movable magnetic armature 15 pivotally mounted upon the outer end of the heel piece 14 and cooperating with the core element 12.

As best shown in Figs. 1 and 3, the armature 15 carries a pair of spaced-apart upwardly extending ears 16 provided with aligned holes therein and an operating arm 17. A pivot pin 20 is inserted into the aligned holes and the outer ends of the pivot pin 20 are flanged over in order to rigidly secure the pivot pin 20 to the armature 15. The operating arm 17 extends along the side of the heel piece and parallel thereto, and is provided at the end thereof with an inwardly extending operating projection 17a which overlaps the upper surface of the heel piece 14 and normally rests upon a non-magnetic rivet 22, secured to and extending upwardly from the upper surface of the heel piece 14.

In order to provide a bearing surface for the pivotal armature, a non-magnetic bearing plate 18, formed of bronze or the like, is carried upon the upper surface of the heel piece 14 adjacent to the outer end thereof, and the pivot pin 20 is rotatably held against the upper surface of the bearing plate 18 in a transverse pivot pin receiving slot 21 formed in the bottom surface of the clamping plate 19. The arrangement for securing the armature 15 in pivotal relationship with the heel piece 14 and the core 12 will be described in detail hereinafter.

To facilitate assembly of the electromagnetic relay, the switch spring set 25 is assembled independently of the relay structure itself, and, after assembly, is secured to the heel piece 14 together with the bearing plate 18 and the armature 15. With this arrangement different combinations of switch spring sets may be carried in stock by a relay manufacturer in order to meet the customers' requirements for different numbers of springs as well as different combinations of make and break switch springs.

More particularly, the switch spring set 25 comprises a plurality of individual switch springs 26, 27, and 28, and an armature restoring and restraining spring 29 arranged in super-imposed relationship. Each of the switch springs comprise a base end and a free end and is provided with a cantilever mounting at its base end. Also, the springs are insulated from each other and from the clamping plate 19 at their base ends. The arrangement for assembling and insulating the base ends of the spring set 25 comprises a clamping plate 19, the plurality of insulators 23, tubular insulators 24, an end plate 30, the individual springs 26, 27, 28, the restoring spring 29, and a retaining screw 31. More particularly, the retaining screw 31 is inserted through the center tubular insulator 24 and threaded into the tapped hole 34' in the clamping plate 19 to securely clamp the springs and insulators between the clamping plate 19 and the end plate 30 in assembled relationship, until it is desired to fasten the spring set, by means of mounting screws 32, upon the heel piece 14.

In order to assemble the spring set 25 upon the heel piece 14, the bearing plate 18 is placed thereon with the three clearance holes therein in alignment with the three holes provided in the heel piece 14. The armature 15 is then held in place with the pivot pin 20, in engagement with the pivot pin receiving slot 21 provided in the bottom surface of the clamping plate 19, as is clearly shown in the enlarged view Fig. 4, and the holes in plate 19 placed in alignment with the holes provided in the heel piece 14 and the bear-

ing plate 18. Screws 32 are then inserted through the two outside holes in the end plate 30 and threaded into the tapped holes 33 in the heel piece 14 to securely fasten the spring assembly 25, the pivot pin bearing plate 18, the armature 15, and the heel piece 14 together into a unitary structure. In order to permit adjustments of the air gap between the armature 15 and the relay core 12, slotted holes are provided in the clamping plate 19 and the bearing plate 18, and the two outside tubular insulators 24 are provided with clearance holes therein which are slightly greater in diameter than the diameter of the mounting screws 32.

The switch springs 26, 27, and 28 as disclosed, comprise a so-called break-make spring combination in which the armature spring 27 is adapted to be moved out of engagement with the cooperating break spring 28 into engagement with the cooperating make spring 26. In order to facilitate maximum ease of adjustment of the relative position of springs 26 and 28 with respect to the armature spring 27, these springs are provided with a relatively short stiff portion extending from the base end thereof, and a pair of very flexible branches 34 and 35. The flexible portions 34 and 35 of springs 26 and 28 carry adjacent the free end thereof a pair of metallic contacts.

Although the pair of flexible branch portions of springs 26 and 28 are of unequal cross-section and of unlike shape, they provide, in combination with the associated relatively long, but flexible, armature spring 27, an arrangement which equalizes the contact pressure between cooperating contacts of associated cooperating springs. Since the branch portions 34 and 35 are very flexible, the position to which the stiff portions of these springs are adjusted with respect to the cooperating armature spring 27 may be approximate rather than accurate.

The armature spring 27 is provided with a relatively long, flexible portion, as compared with the relatively short, stiff portion of the cooperating make and break springs 26 and 28, to facilitate maximum ease of adjusting the pressure of this spring against the break spring 28, or, if no break spring such as 28 is provided, against the operating projection 17a, whereby minimum operating power is required of the relay to overcome the tension of this spring in order to disengage the armature spring 27 from the cooperating break spring 28 and to move it into engagement with the cooperating make spring 26. In the event no break spring 28 is required, the armature restoring spring 29 may be omitted in which case the bushing 41 on the spring 27 may directly engage the operating projection 17a. More particularly, the armature spring 27 is provided with an elongated longitudinally extending slot 36 formed therein adjacent the free end thereof, which slot provides the armature spring with two spaced apart and independently flexible branches 37 and 38 connected together at the free end thereof by a curved operating portion 39.

The flexible portions 37 and 38 of the armature spring 27 each carry a metallic contact. One pair is provided on the bottom side of the spring to cooperate respectively with the pair of contacts provided on the top side of the break spring 28; and the other pair is provided on the top side of the spring to cooperate respectively with the pair of contacts provided on the bottom side of the make spring 26. Each of the spring contacts is welded to its associated flexible portion of the springs at a point along the length of the flexible portion of the associated spring, whereat the flexible portion has a maximum movement with respect to the base end or relatively stiff body portion of its associated spring, thereby to insure self-equalization of the contact pressure between the respective engaging contacts, either when the contacts of the armature spring 27 and the contacts of the break spring 28 are in engagement, or when the contacts of the armature spring 27 and the contacts of the make spring 26 are in engagement.

In order to facilitate movement of the armature spring 27, with respect to the associated break and make springs, a substantially cup-shaped metallic fixture 40 is securely fastened by welding or the like to the lower surface of the curved operating portion 39 of the armature spring 27. A substantially cylindrical insulating operating element, or bushing 41, is arranged within the fixture 40 and frictionally secured in place by the side wall thereof. Preferably, one end of the bushing 41 is provided with an inverted frusto-conical section which is inserted into the cup-shaped fixture 40, and then the side wall of the fixture is spun or pressed down into firm engagement with the conical side wall of the received section of the bushing 41. The specific construction and arrangement described above is disclosed in the copending application of Fredric E. Wood, Serial No. 459,121, filed September 21, 1942.

The bushing 41 cooperates directly with the armature restoring and restraining spring 29, and contacts on the armature spring 27 are adapted to be urged thereby out of engagement with the cooperating contacts on the break spring 28 into engagement with the cooperating contacts on the make spring 26. More particularly, when the winding 13 is energized, the armature 15 is rotated about the pivot pin 20 in a counterclockwise direction as viewed in Fig. 1, thereby to cause the armature 15 to be moved from its normal position to its operated position. When this occurs, the pivot pin 20 rotates in the transverse pivot pin receiving slot 21 formed in the bottom side of the clamping plate 19, the adjacent upper surface of the bearing plate 18 serving also as a bearing surface therefor. Also, at this time the operating projection 17a, carried by the arm 17 of the armature 15, acts upon the armature restoring spring 29 and the bushing 41, and consequently, upon the armature spring 27. Accordingly, the armature spring 27 is flexed, whereby the normally engaged contacts of the associated break spring 28 are disengaged, and the normally disengaged contacts of the associated make spring 26 are engaged by the associated cooperating contacts of the armature spring 27.

It is to be noted that the non-magnetic rivet 22 underlying the operating projection 17a prevents the projection mentioned from sticking to the adjacent surface of the heel piece 14, due to leakage of magnetic flux therebetween.

In order to prevent objectionable play between the pivot pin 20 and the bearing surfaces, comprising the transverse pivot pin receiving slot 21 and the bearing plate 18, when the entire relay structure is vibrated from an external source, the relatively long flexible restoring spring 29 is lightly tensioned against the upper surface of the operating projection arm 17a between the point where the bottom surface thereof rests upon the rivet 22 and the point where the arm 17

joins the projection 17a. The rivet 22 acts as a fulcrum, so that pressure applied to the upper surface of the operating projection 17a at a point removed from the fulcrum tends to twist the armature 15, as is clearly shown in a slightly exaggerated form in Fig. 2. Consequently, if there is any play between the pivot pin 20 and the bearing surfaces indicated above, the armature restoring spring automatically takes up the play therebetween and thereby prevents vibration of the armature from an external source, either transverse to the axis of the pivot pin or parallel to the axis of the pivot pin.

In view of the fact that the armature restoring spring 29 applies its pressure to the operating projection 17a at a point remote from the pivot pin 20 and also at a point remote from fulcrum 22, considerably less pressure is required to overcome any tendency of the armature 15 to vibrate from an external source than would be required if the pressure was applied directly to the pivot pin itself. By actual test, it has been found that a very small percentage of the pressure required at the pivot pin to prevent vibration of the armature, is required when the pressure is applied to the operating projection 17a at the remote end of the armature 15 in the manner shown.

It may be well to mention at this time that in the event that the break spring 28 is omitted from the combination of switch spring set 25, the necessity of providing a separate armature restoring spring, such as spring 29, is eliminated, because the function of restoring the armature and applying the necessary pressure to the operating projection 17a may then be performed by the armature spring 27.

Referring now to Figs. 5 and 6 of the drawing, there is shown therein an electromagnetic relay, constructed and arranged in accordance with the relay constructure disclosed in Figs. 1 to 4, inclusive, but modified to accommodate two separate switch spring sets. More particularly, the left-hand switch spring set 42 of Fig. 6 is identical to the switch spring set 25, except that the clamping plate 30 and the bearing plate 18 are increased in width to accommodate both the left-hand switch spring set 42 and the right-hand switch spring set 43. Furthermore, the armature of the modified relay is provided with left and right hand armature arms 44 and 45 and associated operating projections 44a and 45a, instead of a single armature arm 17 and a single operating projection 17a as is provided in the relay disclosed in Figs. 1 to 4 inclusive. A non-magnetic rivet 46 is provided, underlying the operating projection 45a, to prevent the armature operating projections 44a and 45a from sticking to the adjacent heel piece and to provide a fulcrum about which the armature tends to twist and take up objectionable play in the same manner as has been previously described.

It is to be noted, however, that the switch spring set 43 does not include an armature restoring and restraining spring such as spring 29. A spring of this type is included, however, in the switch spring set 42 and provides the necessary pressure to the armature in order to automatically take up any play which might occur between the armature pivot pin and its bearing surfaces, and thereby prevents vibration of the armature from an external source.

Having described the construction and assembly of the relay, the utility and purpose of the invention will be set forth to enable the same to be more fully understood and appreciated.

It is well known that in mass production of a large number of parts which are to be assembled together, manufacturing tolerances within certain limits are resorted to in order to speed up production and to reduce the costs of manufacturing such parts. For example, since relay parts are manufactured in large numbers, manufacturing tolerances are allowed on both the pivot pin 20 and the pivot pin receiving slot 21 of the relay shown in the drawing. It has been found that in manufacturing the pivot pin 20, it may be oversize or undersize from the desired diameter, and that the pivot pin receiving slot 21 may also be oversize or undersize from the desired diameter. In view of the above, it can be seen that a minimum diameter pivot pin may be assembled in a maximum diameter pivot pin receiving slot. Consequently, there may be considerable play between the pivot pin and the pivot pin receiving slot. In the event that a relay is assembled with a pivot pin of minimum diameter mounted in a pivot pin receiving slot having a maximum diameter, and the relay is mounted on an object subject to vibration, such as may be encountered in an airplane, tank, automobile, train and other vibratory machinery, either mobile or stationary, the vibrations of the armature will cause a gradual wearing of the pivot pin and the pivot pin receiving slot, and thereby gradually increases the play between these parts to such an extent that the operating characteristics of the relay will be materially affected.

According to the present invention, the light pressure applied to the operating projection 17a of the armature 15 causes the pivot pin to be twisted in the pivot pin receiving slot to constantly maintain the parts in engagement with each other and thereby take up any play which may occur as a result of manufacturing tolerances.

It is to be noted that the armature spring 27 swings about a pivot point which is located approximately adjacent the point where the spring protrudes from the side of the securely clamped base end of the spring. When the armature spring 27 is actuated responsive to the movement of the armature arm 17 the contacts thereon swing through a rather large arc and consequently wipe across the contacts on the cooperating make or break springs 26 and 28 in a line longitudinal to the length of the armature spring. Furthermore, since the portion of the make and break springs 26 and 28 extending from the end of the securely clamped base ends of the springs is relatively short and stiff as compared with the armature spring 27, and, also, since the relatively flexible branch portion 34 thereof extends at right angles to the short-stiff portion, the branch portion 34 swings through a rather short arc, when engaged or disengaged by the associated armature spring 27, and consequently wipes across the associated contact thereof at right angles to the wiping action caused by the movement of the armature spring 27. In addition, the L-shape branch portion 35 of the make and break springs 26 and 28, extending at right angles to the relative short-stiff portion, swings through a first rather short arc with the base of the L forming the pivot point therefor together with a second rather short arc, with the junction of the short-stiff portion and one leg of the L forming the pivot

point therefor. Consequently, the contact on the L-shape portion of spring 26 or 28 wipes across the associated contact on the armature spring 27 at an angle intermediate the wiping action caused by movement of the contacts on the armature spring 27 and the wiping action caused by movement of the contact on the flexible branch portion 34. From the foregoing it will be noted that the wiping action which occurs between the contact on the branch portion 34 and the associated contact on the armature spring 27 are at right angles to one another, thereby insuring positive contact engagement therebetween and also maximum movement therebetween for the purpose of dislodging any dust particles. Furthermore, it will be noted that the wiping action which occurs between the contact on the branch portion 35 and the associated contact on the armature spring 27 are at an angle from one another, which angle is intermediate the wiping motion occurring between the contact on the branch portion 34 and the associated contact on the armature spring 27. The wiping action therebetween also insures positive contact engagement between the contact on branch portion 35 and the associated contact on the armature spring 27 and also considerable movement therebetween for the purpose of dislodging dust particles.

Having fully described the invention, what is considered to be new and desired to have protected by Letters Patent is specifically pointed out in the following claims.

What is claimed is:

1. In a relay including a magnet and a heel piece secured thereto, an armature therefor including a pivot pin, means for supporting said pivot pin on said heel piece whereby said armature is rotatably supported on said heel piece, said armature including an operating arm extending transversely across said heel piece, a fulcrum on said heel piece cooperating with said operating arm, and means for applying pressure to said operating arm at a point removed from said fulcrum and said armature pivot pin whereby any play existing between said pivot pin and said supporting means is eliminated.

2. In a switching device, an armature, a pivot pin secured to said armature, a heel piece, a pivot pin bearing plate, means securing said bearing plate to said heel piece, means in said bearing plate rotatably securing said pivot pin on said heel piece providing a bearing surface for said pivot pin, said armature including an operating arm, a fulcrum for said operating arm providing an air gap between said operating arm and said heel piece to prevent magnetic leakage therebetween, and means for applying a light pressure to said operating arm at a point removed from said fulcrum whereby said pivot pin is twisted in said bearing to take up any play existing between said pivot pin and said bearing surface.

3. In a relay including a magnet and a heel piece secured thereto, an armature therefor including a pivot pin, a switch spring set, means for rotatably mounting said pivot pin between said switch spring set and said heel piece whereby said armature is rotatably supported on said heel piece, said armature including an operating arm for operating said switch spring set, a fulcrum for said operating arm, and means including said switch spring set for applying pressure to said operating arm at a point removed from said fulcrum and said armature pivot pin to create a torque whereby any play existing between said pivot pin and said rotatable mounting means is eliminated.

4. In a switching device, a spring set including a plurality of spring contacts, an armature, a pivot pin secured to said armature, a heel piece, a pivot pin bearing plate, means securing said spring set to said bearing plate, means securing said spring set and said bearing plate to said heel piece, means in said bearing plate rotatably securing said pivot pin on said heel piece providing a bearing surface for said pivot pin, said armature including a spring set operating arm, a fulcrum for said operating arm providing an air gap between said operating arm and said heel piece to prevent magnetic leakage therebetween, and means including said spring set for applying a light pressure to said operating arm at a point removed from said fulcrum whereby said pivot pin is twisted in said bearing to take up any play existing between said pivot pin and said bearing surface.

5. In a relay including a maget and a heel piece secured thereto, a unitary structure comprising an armature and a pivot pin, a spring set comprising a plurality of springs and a clamping plate secured together, a pivot pin bearing surface in said clamping plate, means for securing said spring set to said heel piece thereby to secure said unitary structure to said heel piece with said pivot pin in rotatable relationship with said bearing surface, and means including one of said plurality of springs for applying pressure to said armature at a point removed from said pivot pin, to thereby tilt said pivot pin in said bearing to maintain said pivot pin in constant engagement with said bearing surface and to prevent movement of said armature except when said magnet is being energized and deenergized.

6. In a relay including a magnet core and a heelpiece secured thereto, an L-shaped armature, means including a pivot pin and a bearing for rotatably supporting said armature on said heelpiece, an operating arm on said armature, extending in a plane parallel with said pivot pin and transversely across said heelpiece, a nonmagnetic member on said heelpiece cooperating with the free end of said operating arm to provide an air gap between said operating arm and heelpiece and for limiting the air gap between said armature and core, and a restoring spring on said heelpiece for applying pressure to said operating arm at a point intermediate said member and bearing whereby said member acts as a fulcrum to twist said pivot pin in said bearing to eliminate any existing play between said pivot pin and bearing.

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