

July 3, 1962

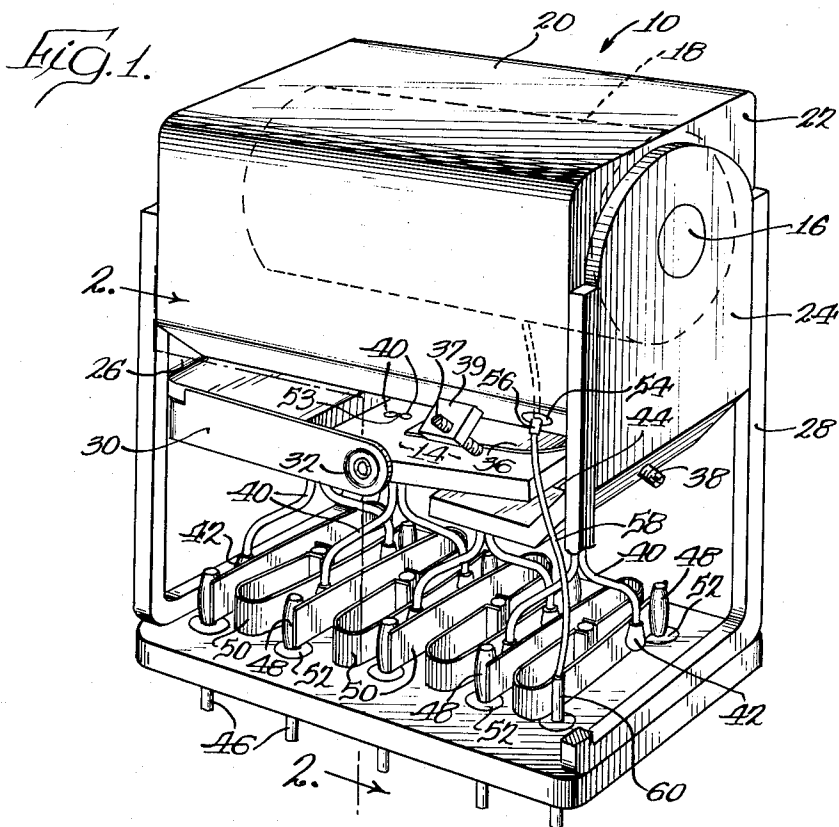
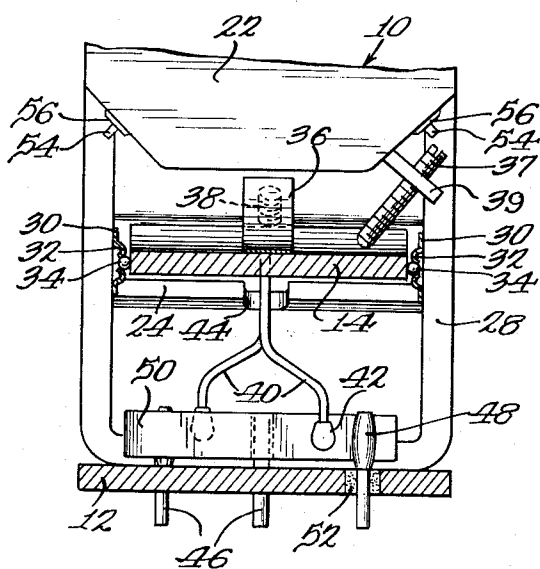
J. S. JORDAN

3,042,775

RELAY

Filed Sept. 9, 1959

2 Sheets-Sheet 1



July 3, 1962

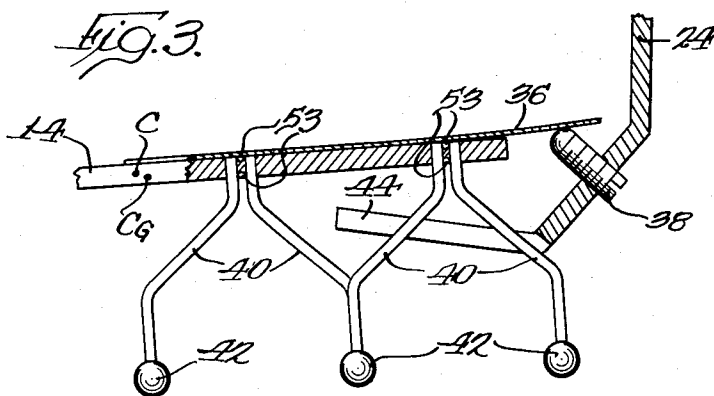
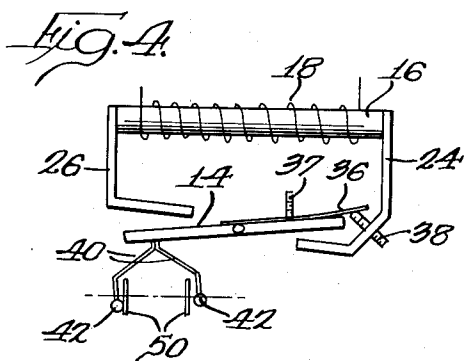
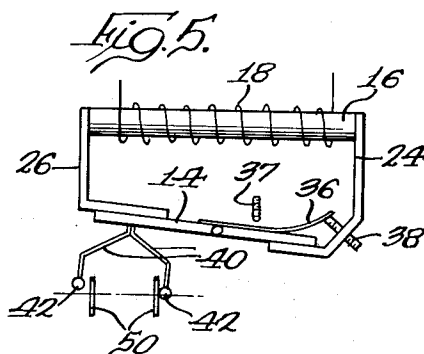
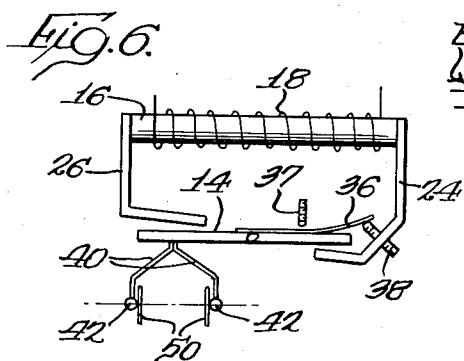
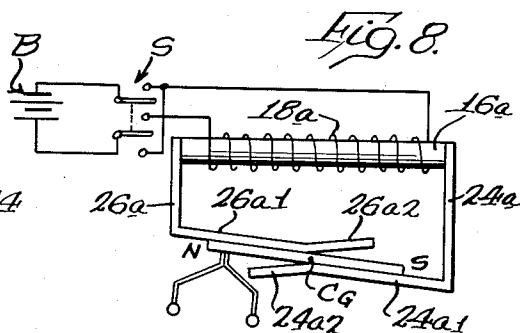
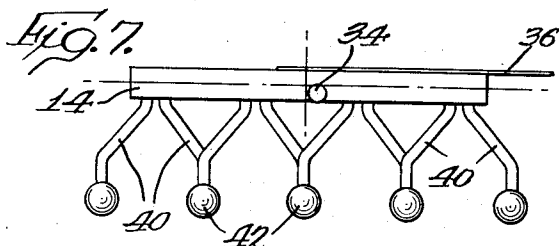
J. S. JORDAN

3,042,775

RELAY

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2 Sheets-Sheet 2



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1

3,042,775
RELAY

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Filed Sept. 9, 1959, Ser. No. 838,959
7 Claims. (Cl. 200—104)

The present invention relates to relays, and particularly, to improvements in the construction of relays of the character disclosed in, and especially adapted to serve the uses and satisfy the conditions described in, the co-pending application of Leonard J. Greshel, Serial No. 839,009, filed September 9, 1959, which application is assigned to the assignee of this application.

The object of the invention is to provide constructional improvements in relay structures of the type comprising a stacked arrangement of a single coil having an axial core, a terminal header disposed in spaced parallel relation to the core and an armature sandwiched between the header and the core; the structure includes pole pieces fixed to the opposite ends of the core and extending into the space between the header and the core, one extending between the armature and the core and the other between the armature and the header, a plurality of movable contacts mounted directly on the header at the side thereof adjacent the armature, and a plurality of actuators carried by the armature and extending respectively to the movable contacts.

It is specifically one object of the present invention to provide a relay structure as above described wherein the actuators are caused to move in an arc the mid-point of which is substantially coincident with the center line of the movable contact operated by the respective actuator, thereby to minimize twisting forces on the contacts.

Another object of the present invention is the provision of improved means for facilitating attainment of the above object and comprising an improved arrangement of the pole pieces and the armature for causing the armature to move in an arc at the mid-point of which the armature is parallel to the header.

More particularly, it is an object of the invention to provide an improved relay structure of the character described wherein the pole pieces are inclined relative to the axis of the coil core at an inclination equal approximately to one-half the arcuate movement of the armature about its pivot axis whereby the armature at the mid-point of its movement is parallel to the contact and terminal header.

An additional object of the invention is the embodiment in relay structures of the character described of improved armature pivot means for enhancing armature balance, the said means being characterized in that the pivot axis is offset from the transverse axis of the armature in the direction or directions of the instrumentalities carried by the armature for purposes of counter-balancing such instrumentalities, e.g., the contact actuators and the armature return spring.

A further object of the invention is the provision in relay structures of improved means for adjusting the characteristics of the armature, the said improved means comprising a screw engageable with the armature means at an angle significantly less than a right angle relative to the plane of said armature means for accommodating

2

vernier-like adjustment of the armature means even by a relatively coarsely threaded screw.

It is a particular object of the invention to provide the aforesaid adjusting means for the armature return spring and to embody the adjustment in a compact economical structure wherein the screw is threaded through an angularly disposed portion of one of the pole pieces.

A still further object of the invention is the provision of improved means for constituting the aforesaid coil core, pole pieces and header a compact rigid frame for the relay and for facilitating access to the relay adjusting means; the frame according to the present invention comprising a coil core, pole pieces fixed to the opposite ends of the core, a header disposed in spaced parallel relation to the core, and a pair of U-shaped straps or supports secured at their bights to the opposite ends of the header and at their legs to the respective pole pieces thereby to constitute the whole a rigid relay frame, the U-shape of the straps facilitating access to the space between the header and the core.

Yet another object of the invention is the provision of a relay structure of the character described including improved contact actuators and an improved mounting for said actuators on the relay armature.

In addition to the foregoing, it is an object of this invention to incorporate at least some of the aforesaid improvements not only in relays having a normally released spring biased armature, but in latching relays as well.

Other objects and advantages of the invention will become apparent in the following detailed description.

Now, in order to acquaint those skilled in the art with the manner of making and using my improved relay structure, I shall describe, in connection with the accompanying drawings, preferred embodiments of the structure and preferred manners of making and using the same.

In the drawings, wherein like reference numerals indicate like parts:

FIGURE 1 is a perspective view of a first embodiment of the relay structure of the invention, the view showing the relay with its outer hermetic sealing can removed;

FIGURE 2 is a fragmentary vertical section taken substantially on line 2—2 of FIGURE 1;

FIGURE 3 is a fragmentary longitudinal section showing, on an enlarged scale, one pole piece, the armature, the actuators, the armature return spring and the spring adjusting screw of my improved relay structure;

FIGURE 4 is a schematic elevational representation of the coil, pole pieces, armature, one actuator pair and one contact set of the relay structure of the invention, the view illustrating these components in their unoperated positions;

FIGURE 5 is a view similar to FIGURE 4, but showing the armature, the actuator pair and the contact set in operated position;

FIGURE 6 is a view similar to FIGURES 4 and 5, but showing the movable components at the mid-point of their travel;

FIGURE 7 is a detail view of the improved armature mounting provided according to the invention; and

FIGURE 8 is a view similar to FIGURES 4 to 6 illustrating the latching relay embodiment of this invention.

Referring now to the drawings, and particularly to FIGURES 1 and 2, the relay construction to which the present invention relates is comprised of a stacked ar-

range of a coil assembly 10, a terminal header 12 paralleling the axis of the coil assembly in spaced relation thereto, and an armature 14 sandwiched between the header and the coil assembly.

The coil assembly 10 includes a rigid axial core 16, a coil 18 wound on the core, and a coil enclosing can 20 through the ends 22 of which the core protrudes. The coil 18 is wound directly on the core for maximum utilization of winding space, or in other words, to maintain at a minimum the external dimensions of the coil. The components of the can 20 are hermetically sealed to one another and the core 16 thereby sealingly to enclose the coil 18.

To each of the protruding ends of the core 16 is fixedly secured a rigid pole piece 24 and 26, respectively. The pole pieces are preferably fixed to the ends of the core by peening protruding portions of the core into countersunk holes in the two pole pieces, each pole piece and the core having smooth mating faces and the assembly being held under pressure during peening, thereby to afford a structure that essentially is both the physical and magnetic equivalent of a one-piece structure. Preferably, the magnet material used is a nickel-iron alloy. The pole pieces 24 and 26 extend radially in the same direction from the core 16, and radially outward of the can 20 are extended toward one another in respective planes that are parallel to and spaced from one another to such extent that the distance between the lower surface of the pole piece 26 and the upper surface of the pole piece 24 is equal approximately to the thickness of the armature and residual if present.

The terminal header 12 is a rectangular planar member of a length equal substantially to the core 16 and of a width not significantly greater than the coil enclosing can 20. This member is preferably formed of metal having relatively low permeability, and it is rigidly joined to the pole pieces by means having negligible permeability. According to the present invention, the header is secured to the pole pieces 24 and 26 by U-shaped supports 28 which are preferably formed of stainless steel, the legs of each U being secured, as by welding, to the opposite sides of the respective pole piece 24, 26 and the bight portion thereof constituting the mounting surface for the header, to which the header is fixed as by welding, whereby the header is disposed in spaced parallel relation to the coil assembly at the same side thereof as the ends of the pole pieces. To conserve space and provide a compact assembly, the pole pieces 24, 26 are of a width less than the width of the can 20 and the U-shaped straps or supports 28 are of a width no greater than that of the can and the header 12. The legs of each strap are welded to the side surfaces of the respective pole piece and the bight of each strap is welded to the surface of the header adjacent the armature at the respective end of the header. Thus, the supports or straps 28 facilitate a compact assembly and constitute with the core, the pole pieces and the header a rigid frame, and facilitate access to the space between the header and the can 20.

As thus assembled, the core 16, the pole pieces 24 and 26, the header 12 and the supports 28 comprise a rigid box-like frame for the relay, which frame has the necessary mechanical strength to endure the high shock and vibration environment to be encountered by the relay, and the strains to be imposed thereon by virtue of the wide variation in temperature to which the relay is to be exposed. Consequently, this rigid frame is well adapted for definition of a fixed pivot axis for the armature 14. The armature is mounted on the said frame by means of a U-shaped bracket 30 which is rigidly secured to the frame, preferably by welding the side portions of the same to the left-hand pole piece 26 at the side of the pole piece. The legs of the bracket 30 extend inwardly to opposite sides of the pole piece 26, within the confines of the box-like frame, and at the inner ends thereof include bearing portions 32 defining a pivot axis for the armature. The

said axis extends in spaced parallel relation to the header 12 transversely of the axis of the coil and its core at a point intermediate the planes of the end portions of the pole pieces 24 and 26. The bearings 32 are preferably formed by a forward and reverse drawing operation whereby each includes an inwardly extending bulbous portion having a cylindrical center or core portion.

The armature 14 comprises a substantially rectangular planar member pivotally mounted on the bracket 30 on a transverse pivot axis disposed generally centrally thereof and having its longitudinal axis extending in the same direction as the core 16 and the header 12. At the opposite sides thereof, and coincident with the said transverse pivot axis, the armature carries a pair of balls 34 comprising the bearings thereof. Preferably, the balls are formed of stainless steel to close tolerance and are welded to the armature.

The bearing balls 34 of the armature are journaled in the cylindrical core portions of the journal bearings 32 to have substantially a circular line of bearing contact therewith. Bearing play is held to extremely close limits of from about .00005 inch to about .00010 inch to mitigate armature vibration and maintain relay adjustments under all conditions. Also, the reverse draw of the journal bearings 32 affords a curved smooth surface to minimize frictional resistance to movement when the side edges of the armature engage the armature mounting bracket.

The armature 14 is formed of metal having high permeability. The armature mounting bracket 30 is preferably formed of beryllium copper because of the formability, hardenability and non-magnetic properties of this metal. After formation, the bracket is age-hardened for minimum wear and maximum vibration resistance. This journal, in combination with the stainless steel ball bearings, affords an exceedingly accurate pivot for the armature, and one that will have exceptionally long service life.

The armature thus extends generally in the same direction as the header 12 and core 16 and is sandwiched between the two with its left end extending below the end portion of the pole piece 26 and its right end extending above the end portion of the pole piece 24, whereby the armature is adapted to be attracted by the pole pieces upon energization of the coil 18. Generally speaking, the armature is movable in a predetermined arc about its pivot axis, and it is one object of this invention to so mount the armature that it is parallel to the header 12 when it is at the mid-point of its arcuate path of movement. To this end, the portions of the pole pieces 24, 26 opposed to the armature are inclined relative to the header at an inclination equal approximately to one-half the arcuate movement of the armature. Specifically, the pole piece 24 is extended radially from the core 16 and outwardly of the armature it is inclined away from the header toward the armature at the selected angle; the pole piece 26 is extended radially from the core and outwardly of the can it is inclined away from the core and toward the armature at the said selected angle; and the inclined portions of the two pole pieces are disposed in spaced parallel relation with the distance between the planes of the adjacent surfaces of the pole pieces equal approximately to the thickness of the armature and the residual if present. In its operated position, the armature is disposed at substantially the same inclination as the pole pieces and substantially engages the same. Residuals (not shown) may comprise non-magnetic plates or platings on the opposed surfaces of the armature and/or the pole pieces, or may comprise adjustable residual screws. To return the armature from its operated position, a return spring 35 is fixed to one end of the armature, and to limit movement of the armature away from the pole pieces under the urge of the spring a back stop 37 is provided which acts to retain the armature in a normal position inclined oppositely from the inclined operated

5

position thereof. Thus, the armature is movable in an arc at the midpoint of which the armature is parallel to the header, whereby the relay structure affords particular advantages to be described in detail hereinafter.

With respect to the armature return spring 36 and its back stop 37, it is an object of this invention to provide improved means for effecting accurate adjustment of the armature characteristics. Specifically, I provide means whereby the armature is adjusted by screws which extend at an angle significantly less than a right angle relative to the plane of the armature means thereby to afford a vernier-like adjustment even while employing a relatively coarsely threaded screw. To this end, the return spring 36 comprises a flat strip of beryllium copper or the like fixed to the upper surface of the right-hand portion of the armature and reacting against an abutment screw 38 which extends at an angle in the order of about 45 degrees to the plane of the spring. To facilitate mounting of the screw at such angle, the right-hand pole piece 24 includes an angular portion intermediate the portions thereof extending radially of the core and generally in the direction of the core, the angle of which intermediate portion is in the order of about 45 degrees relative to the said radial portion. The screw 38, which is preferably formed of stainless steel, is threaded directly through said intermediate portion thereby to engage the spring at the aforesaid angle. Also, this construction leaves the end of the screw freely accessible between the legs of the U-shaped support 28 whereby the spring is readily adjusted to exacting specifications. In similar manner the back stop 37 comprises an adjustable screw extending at an angle in the order of about 45 degrees to the plane of the armature. In this case, the screw is threaded through a nut 39 which is welded to the can 20 adjacent the right-hand end thereof whereby the screw 37 is engageable with the upper surface of the right-hand end portion of the armature to limit the return movement thereof. Again to conserve space and facilitate the construction, the lower corner portions of the can are comprised of portions inclined at about 45 degrees to the planes of the sides and bottom of the can 20, whereby the nut 39 is conveniently disposed at the appropriate angle relative to the plane of the armature and the adjusting screw 37 is accommodated entirely within the confines of the box-like frame defined by the can, the supports and the header (see FIGURE 2).

Secured to and projecting downwardly from the armature, i.e., toward the header 12, are a plurality of actuators 40 which will serve to actuate the movable ones of contact means carried by the header. In the illustrated construction, there are four contact sets each having a pair of movable contact means. Consequently, the armature carries four pairs of actuators each comprising a stainless steel wire having a glass bead 42 at its lower end for engagement with the respective movable contact. As will be appreciated, the armature may carry more or less actuators as may be required for any particular contact assembly, the assemblies contemplated, however, requiring an even number of actuators. For any such assembly, the actuators are of even numbers to opposite sides of the armature pivot axis and corresponding actuators to opposite sides of said axis are spaced equal distances from that axis to accommodate a balanced assembly. To accommodate the actuators at the right end of the armature, the end portion of the right-hand pole piece 24 is slotted longitudinally thereof, as is indicated at 44.

The terminal header 12 is provided with a plurality of terminals projecting therethrough which terminals, at the side of the header 12 adjacent the armature, directly carry and/or constitute the contact means of the contact assembly embodied in the relay, whereby the movable contacts are disposed to be conveniently actuated by the armature, the relay assembly is decreased in size and no leads are required between the terminals and the contacts. In FIGURES 1 and 2, I have indicated the contact mounting terminals at 46, the stationary contacts at

6

48 and the movable contacts at 50. The specific arrangement of the disclosed assembly is described in detail in the aforesaid co-pending application of Leonard J. Greshel. For the present, suffice it to say that there are three parallel rows of terminals 46, the center row of which carries the movable contacts 50 and the outboard rows of which carry the stationary contacts 48, the several contacts being mounted on the terminals to the side of the header adjacent the armature.

As previously stated, the header plate 12 is preferably formed of metal. This plate is provided with holes therethrough for reception of the terminals 46, which are in the form of rigid pins extended perpendicularly through the plate and insulatedly sealed thereto by glass compression seals 52. Each stationary contact 48 comprises a barrel-shaped member formed of precious metal and telescoped onto and soldered or otherwise secured to the respective pin 46. The movable contacts 50 are each fabricated of a pair of generally U-shaped springs secured at the ends of respective legs thereof to the opposite sides of a respective pin 46 in the center row, whereby each contact 50 is of S-shape and has its terminal pin disposed centrally thereof. By virtue of this construction, each end of each spring 50 is disposed to be moved in the direction of the longitudinal axis of the header and to engage a respective stationary contact 48. The S-shaped springs 50 are each pre-stressed so that the ends thereof are normally biased toward pressure engagement with their respective stationary contacts 48 thereby to afford a permissive-make contact arrangement.

The movable contact springs 50 are actuated by the actuators 40, the glass beads 42 of which afford insulated engagement between the actuators and the contacts. Each spring 50 requires two actuators, and the actuators are thus provided in pairs, one pair for each spring. The actuators of each pair are disposed respectively adjacent the free ends of the spring to the side of the respective end facing toward the respective stationary contact 48, whereby the actuator is adapted to move the contact 50 away from one contact 48 and to permit the contact 50 to move into engagement with the other associated contact 48 upon appropriate movement of the armature 14. The actuators of each pair, due to the disposition of the respective spring 50, define a plane perpendicular to the plane of the armature and inclined relative to the axes of the armature, and each pair of actuators may suitably be secured to the armature as a unit at this approximate inclination in assembly of the armature and actuators. In particular, the armature is preferably provided along its longitudinal axis with a plurality of pairs of holes. Each actuator of the respective pair of actuators is inserted in one hole of the respective pair and the two actuators of the pair are commonly secured to the armature by a single staking operation whereby the material of the armature and the two actuators is commonly upset, as indicated at 53. The actuators may be staked to the armature both at the upper and lower surfaces of the armature as indicated, or a single stake may be effected at the lower surface of the armature. After assembly, the stainless steel wires forming the actuators may readily be bent to effect adjustment of the contacts and the operating characteristics of the relay.

In particular, the actuator wires may be so adjusted as to provide either a make-before-break or a break-before-make characteristic as desired. In either case, however, the respective glass beads 42 are separated from the closed contacts in the end positions of armature movement, thereby to insure a permissive-make contact arrangement as previously described. In particular, each actuator wire 40 is so adjusted as to provide between the glass bead and its associated movable contact, in the contact closed position, a gap of from .002 inch to .004 inch. Each spring is thus closed under its own tension, and the arrangement allows for some armature bounce on operation and release and for some armature motion during shock and vibration without affecting the closed contacts. This mini-

mizes contact bounce and chatter during vibration, and also minimizes variation in contact pressure thereby to increase contact life.

Contact life is further increased by complete elimination of organic materials from the vicinity of the contacts. In particular, the relay is so constructed as to facilitate enclosure of the contacts in a contaminant-free atmosphere. As the first step in this direction, the coil 18 is enclosed in its own hermetically sealed can 20. To supply current to the coil, the coil ends are secured to terminal pins 54 which extend through the inclined lower corner walls of the can 20 in insulatedly sealed relation thereto, the pins preferably being glass-sealed, as at 56, in the same manner as the terminals 46. The terminal pins 54 extend from diagonally opposite lower corner portions of the can 20 and are connected, by means of non-contaminant leads 58, to respective adjacent ones of a pair of current supply terminals 60 which are mounted in diagonally opposite corner portions of the header 12. The terminals 60 are mounted in the same manner as the pins 46, and are each preferably aligned with the pins 46 in the respective outboard row of pins thereby to afford a compact, unitary terminal assembly for the relay. The leads 58 may be insulated by a coating of glass, or may be left uninsulated, so long as there is no organic or contaminant material involved. As the final step, the entire relay assembly is hermetically sealed within a second can (not shown) which fits down over the can 20, the pole pieces 24 and 26, the supports 28 and the edge of the header 12, and is hermetically sealed about the edge of the header. In the resultant structure, the space between the coil assembly 10 and the header 12 is closed and hermetically sealed. The only materials within this space are metal and glass, which are non-contaminants. The only relatively moving parts are stainless steel on hardened beryllium copper and glass on the hardened alloy of the contact springs. Thus, there is nothing within the sealed space that could contaminate the contacts, interfere with their operation, or hasten their wear. Moreover, the armature bearings are thus also sealed within a contaminant-free atmosphere thereby to insure long service life for the bearings and the contacts.

In view of the foregoing, it is to be appreciated that the described structure provides a strong, rigid relay that is exceptionally compact, that facilitates manufacture of relays in small sizes and to exacting specifications, that facilitates accurate production of small relays by mass production methods and that assures long, efficient service life for the relay due not only to the constructional features involved but the enclosure of all operational components in a contaminant-free atmosphere.

As a specific example of the physical capabilities of the relay structure, the same has been embodied within an exterior enclosure can $1\frac{1}{4}$ inches high, $1\frac{1}{8}$ inches long, and $\frac{5}{8}$ of an inch wide. The weight of the relay is only .13 pound. The relay withstands vibration in the order of 15-20 gravities at 10 to 2000 cycles per second and shock in the order of 50-75 gravities of 11 millisecond duration. It operates over a temperature range of minus 65 degrees C. to plus 125 degrees C.

The rigid frame structure provided by my U-shaped supports accommodates the described high resistance to shock and vibration; the screw adjustment facilitates accurate setting of the armature and the return force thereon and permits finite adjustment of the operate and release characteristics of the relay; and the particular mounting of the contact actuators facilitates not only the construction of the relay but the subsequent adjustment of the actuators relative to their respective contacts. The disposition of the pole pieces at the described inclination imparts symmetry to the arcuate movement of the armature relative to the other components of the relay, and this in turn affords notable advantages with respect to contact actuation.

In particular, as depicted schematically in FIGURES

4 to 6, the armature 14 is movable from a normally inclined released position (FIG. 4) to an equally but oppositely inclined operated position (FIG. 5), whereby the armature at the midpoint of its travel is parallel to the coil core 16 (FIG. 6) and thus to the header 12. The actuators 40 in effect project substantially perpendicularly downward from the armature 14, so that at the midpoint of armature travel each actuator is in effect substantially perpendicular to the header 12 and thus parallel to its respective movable contact 50 (see FIG. 6). According to the present invention, each actuator is of a length to engage with substantially the centerline of its respective movable contact when the armature is at the midpoint of its travel, as is depicted schematically in FIGURE 6. Consequently, the actuator, in moving with the armature from released to operated position or vice versa, is moved through an arc the midpoint of which is coincident with the centerline of the contact so that the maximum excursion of the actuator away from said centerline is no more than one-half the total arc of movement of the actuator. Considering, for example, the left hand actuator illustrated in FIGURES 4 to 6, it is moved from a position wherein its glass bead is a certain distance below the centerline of the contact (FIG. 4) to a position wherein the bead is an equal distance above the centerline of the contact (FIG. 5). Because of this, exertion of unbalanced forces on the contacts is minimized thereby to mitigate twisting or warping of the movable contact springs and exertion of forces thereon that would tend to hasten spring fatigue. In the exemplary relay above described, armature movement could suitably be about 4° , in which case the pole pieces 24 and 26 are inclined at about 2° relative to the plane of the header and the axis of the core. With this movement of the armature, horizontal displacement of all of actuator beads is equal, in the specific example about .015 inch. Vertical displacement of the end beads is about .028 inch, of the next inwardly beads about .014 inch, and of the middle beads about 0.002 inch. In each case, bead vertical displacement from the centerline of the respective contact is no more than approximately one-half the figure given.

In addition to the above, it is a further object of this invention to increase the resistance of the armature to shock, vibration and acceleration. As above noted, the actuators are disposed in counterbalancing relation to one another relative to the pivot axis of the armature, and the movable contacts are arranged in a similarly compensating manner. However, the actuators all project from one side of the armature and thereby produce an unbalanced effect. To an extent, the actuators are counterbalanced by the return spring 36 which is mounted on the surface of the armature opposite that from which the actuators protrude. Further to compensate for the weight of the actuators, I offset the pivot axis of the armature laterally of the armature in the direction of the actuators, and to compensate for the return spring, I offset the pivot axis longitudinally of the armature in the direction of the return spring, whereby the pivot axis of the armature, and thus the ball 34, is offset from the central transverse axis of the armature in the manner depicted in FIGURE 7. The degree of offsetting the armature pivot axis and pivot ball as shown in FIGS. 3 and 7 is exaggerated for purposes of illustration. In other words, I have located the pivot axis of the armature to pass substantially through the center of gravity of the assembly comprised of the armature, the return spring, and the actuators and their beads, thereby to provide a balanced assembly.

In view of the foregoing, it is to be appreciated that the structural improvements provided according to the present invention result in a compact, rigid relay that is constructed to exacting specifications in a convenient and facile manner, that assures long contact life and accurate actuation of the contacts, that facilitates sealing

of the movable components of the relay in a contaminant-free atmosphere, that provides good resistance to shock, vibration and acceleration, and that is adjustable to afford precise characteristics of operation.

As to adjustment, the back stop 37 for the armature is first adjusted to provide proper armature travel, and is locked, as by solder, in adjusted position. Then, the actuators 40 are adjusted with the armature first clamped against the pole pieces and then clamped against the back stop. Finally, the return spring screw 38 is adjusted to provide the proper operate and release points current-wise for the coil. After adjustment, the screw 38 is locked in position, such as by solder.

The above described embodiment of the invention is a normally released relay operated only upon and during energization of the coil 18. In addition to this embodiment, the present invention provides a latching relay affording all of the advantages of the described relay construction and having the further advantage that it is operated on opposite hands by momentary current pulses of reversed polarity and is retained in the condition to which it was last operated. Constructionally, the latching relay is similar to the relay above described except for the few differences depicted schematically in FIGURE 8. In particular, as shown, the pole pieces 24a and 26a in the latching relay are extended inwardly at the aforesaid inclination to the axis of the core 16a to a position adjacent the transverse or pivot axis of the armature 14a and are then inclined diagonally away from the armature at substantially an equal but opposite inclination. In other words, the terminal part of each pole piece includes an inner portion 24a-1, 26a-1 and an outer portion 24a-2, 26a-2 which portions are relatively inclined and define an obtuse angle therebetween. The degree of angularity between the two portions is generally the difference between 180 degrees and the maximum swing that the armature is to be permitted. Preferably, the two pole pieces have the same angularity and both extend inwardly to locate the juncture between said two portions thereof adjacent the pivot axis of the armature, the portions 24a-1 and 26a-1 and the portions 24a-2 and 26a-2 being parallel and disposed to opposite sides of the armature and its pivot axis. The apex of the angle of each pole piece is disposed adjacent the pivot axis of the armature and the bisector of that angle would intersect the pivot axis of the armature 14a, the axis of the core 16a and the longitudinal axis of the header, all at right angles if the armature pivot axis is not offset, and will essentially do so if the armature pivot axis is offset, due to the small degree of offset necessary to balance the armature.

The armature 14a is a permanent magnet, having high coercive force. The opposite ends of the armature comprise the poles of the magnet, as illustrated by the pole indications in FIGURE 8. Assuming the left-hand end of the armature is the north pole and the right-hand end of the armature is the south pole, and that the armature is in the position shown, the relay is operated by supplying current to the coil 18a in a direction to cause the pole piece 24a to be the south pole and the pole piece 26a to be the north pole of the coil. Thereupon, the north polarity of the portion 26a-1 of the pole piece 26a repels the north pole of the armature while the south polarity of the portion 24a-2 of the pole piece 24a attracts the north pole of the armature, and the south polarity of the portion 24a-1 of the pole piece 24a repels the south pole of the armature while the north polarity of the portion 26a-2 of the pole piece 26a attracts the south pole of the armature. Thus, four forces are at work simultaneously, two repelling and two attracting, to insure positive and rapid operation of the armature by virtue simply of momentary energization of the coil 18a. To return the armature to its original position, the coil is energized in the opposite sense, whereupon four forces are again at work to effect prompt operation of the armature. Once moved, the armature will remain in the posi-

tion to which it was last moved by virtue of its own magnetic properties.

By virtue of the described construction, the armature is moved from equal but oppositely inclined end positions through an arc at the mid point of which the armature is parallel to the core and the header, thereby to afford the advantages described hereinbefore.

To effect operation of the relay in the manner described, a number of control circuits can be employed. For example, the coil may be energized from the same source, or from sources of equal power and opposite polarities, in which case the armature does not require a return spring. Simply by way of example, the coil 18a of the relay could suitably be energized from a battery B via a switch S capable of reversing the flow of current from the terminals of the battery thereby to control the polarity of the field produced by the coil. In this case, the pivot axis of the armature is offset only laterally of the armature to compensate for the actuators, as indicated at CG, and is not offset longitudinally of the armature as there is no return spring. On the other hand, the control circuit might be so devised as to utilize a relatively high power source for operating the armature in the clockwise direction and a relatively low power source for operating the armature in the counter-clockwise direction, in which case a return spring (counterbalanced in the manner illustrated in FIGURE 7) could well be employed to assist the lower powered source in performance of its function.

It should be understood, of course, that the angles of the pole pieces as illustrated in FIGURES 4 to 6 and 8 have been exaggerated for purposes of convenience and clarity of disclosure. Those skilled in the art may readily determine the appropriate angles from the foregoing description and upon consideration of the degree of armature travel desired.

While I have shown and described what I regard to be the preferred embodiments of my invention, it will be appreciated that various changes, rearrangements and modifications may be made therein without departing from the scope of the invention, as defined by the appended claims.

I claim:

1. In a relay structure having a coil core, a header disposed in spaced parallel relation to the core, a plurality of movable contacts on said header movable in the direction of the axis of said core, an elongate armature extending in the direction of said core in the space between said header and said core, said armature being mounted for movement in a predetermined arc about a transverse pivot axis disposed generally centrally thereof and extending in spaced parallel relation to said header, actuators extending generally perpendicularly from said armature to said movable contacts, a first pole piece fixed to one end of said core and including a portion extending between said armature and said core at one side of said pivot axis, and a second pole piece fixed to the other end of said core and including a portion parallel to the said portion of said first pole piece and extending between said armature and said header at the opposite side of said pivot axis, the improvement comprising that the said portions of said pole pieces are inclined away from the axes of said core and said header respectively toward said armature at an inclination equal approximately to one-half the arcuate movement of said armature whereby the armature at the mid-point of its movement is substantially parallel to said header and at one extremity of its arcuate movement is substantially parallel to said portions of said pole pieces, and that said actuators at the said mid-point of armature movement are engaged with substantially the center line of the respective movable contacts to minimize imposition of twisting forces on said contacts.

2. In a relay having a coil core, pole pieces including first portions extending outwardly in the same direction from opposite ends of the core and second portions ex-

tending toward one another outwardly of one side of the core, an elongate armature extending generally in the same direction as said core at the said one side of said core, said armature being pivotally mounted on an axis extending transversely of said core and located substantially centrally of the armature, the said second portions of said pole pieces being opposed respectively to the surfaces of said armature facing toward and away from said core, and a leaf spring adjacent the latter pole piece for normally biasing the armature away from the pole pieces, the improvement comprising that the said latter pole piece includes a third portion extending between the said first and second portions thereof and disposed at an inclination to the plane of said spring, and an adjusting screw threaded through said third portion of said latter pole piece and engageable with said spring.

3. In a relay structure comprising a stacked arrangement of a coil having an axial core, a header disposed in spaced parallel relation to the core, an armature sandwiched between the header and the core and pivoted for movement in a predetermined arc about a transverse axis disposed generally centrally thereof, a pair of pole pieces fixed to opposite ends of the core and including first portions extending from the core toward the header and second portions extending into the space between the header and the core between the core and the armature and between the armature and the header respectively, a plurality of pairs of movable contacts mounted on the surface of said header adjacent said armature, and pairs of actuators carried by said armature and extending to and engageable with said pairs of contacts, the improvement comprising U-shaped straps fixed at the bights thereof to the opposite ends of said header and at the legs thereof to the first portions of the respective pole pieces for constituting the core, the pole pieces, the straps and the header a rigid frame, said second portions of said pole pieces being inclined away from said core and said header respectively toward said armature at an inclination equal approximately to one-half the arcuate movement of said armature whereby the armature at the mid-point of its movement is substantially parallel to said header, a leaf spring on said armature at the end thereof adjacent the pole piece extending between said armature and said header for normally biasing the armature to a position inclined oppositely to said second portions of said pole pieces, the last-named pole piece including a third portion between said first and second portions thereof inclined inwardly and toward said header, a screw threaded through said third portion and engageable with said spring at an angle to the plane thereof for effecting adjustment of said spring, said screw being accessible between the legs of the respective U-shaped strap, the pivot axis of said armature being offset longitudinally of the armature in the direction of said spring for counter-balancing said spring and also being offset laterally of the armature in the direction of said actuators for counter-balancing the actuators, the actuators of each pair extending into respective adjacent holes formed in the armature and being secured therein by a common upset of the material of the armature and the pair of actuators, the actuators at the said mid-point of armature movement engaging with substantially the center line of the respective contacts.

4. In a relay structure including a coil having a core, a pole piece fixed to each end of said core, said pole pieces including portions extending outwardly in the same direction from said core and portions extending toward one another outwardly of one side of said coil, said pole pieces and said core comprising frame means, an elongate armature pivotally mounted on said frame means at said one side of said coil for movement in a predetermined arc about a transverse axis located generally centrally thereof, the longitudinal axis of said armature extending generally in the same direction as said core, the portions of said pole pieces extending toward one another extending gen-

erally in the same direction as said core and said armature to opposite sides of said armature, the last-named portions of said pole pieces extending in said direction to substantially the location of the pivot axis of said armature and then extending diagonally away from said pivot axis, said armature comprising a permanent magnet having its magnetic poles at the opposite ends thereof, and means for at least momentarily energizing said coil and for controlling the polarity of its field upon each energization thereof, the improvement comprising that the said last-named portions of the pole pieces are inclined relative to said core and extend toward said pivot axis at an inclination equal approximately to one-half the arcuate movement of said armature and that the said diagonally extending parts thereof extend away from said pivot axis at approximately an equal inclination, whereby the armature is movable substantially equal distances to opposite sides of a position wherein it is parallel to said core.

5. In a relay structure including a coil having a core, a pole piece fixed to each end of said core, a header fixed to said pole pieces in spaced parallel relation to said core and together with said pole pieces and said core comprising a rigid frame, said pole pieces extending outwardly from said core toward said header and extending into the space between said header and said coil, an elongate armature pivotally mounted on said frame in the space between said header and said coil for movement in a predetermined arc about a transverse axis located generally centrally thereof, said pole pieces being disposed respectively to opposite sides of said armature, said pole pieces each including relatively inclined portions defining an obtuse angle therebetween, the juncture of the said portions of each pole piece being located adjacent the pivot axis of said armature at the respective side thereof, the portion of each pole piece to the one side of said juncture thereof being generally parallel to the portion of the other pole piece to the other side of its said juncture, said armature comprising a permanent magnet having its magnetic poles at the opposite ends thereof, and means for at least momentarily energizing said coil and for controlling the polarity of its field upon each energization thereof, the improvement comprising that the apex of the angle defined by each pole piece is disposed adjacent the pivot axis of said armature with the bisector of the angle disposed perpendicular to said header, whereby the armature is movable substantially equal distances to opposite sides of a position wherein it is parallel to said header.

6. In a relay having a coil assembly including a core having at least a first and a second pole piece fixed to the ends of the core, a header disposed in spaced parallel relation to the core, a plurality of movable contacts mounted on said header for movement longitudinally thereof, an elongate armature mounted between said core and said header for arcuate movement about its transverse pivotal axis which extends parallel to said header and transversely thereof, and actuators carried by said armature extending from one side of said armature substantially perpendicular to said armature and said movable contacts, the improvement comprising that portions of said pole pieces are disposed between said header and said core, and inclined away from the axis of said core and said header respectively toward said armature at an inclination equal approximately to one half the arcuate movement of said armature, whereby the armature at the midpoint of its movement is substantially parallel to said header and at one extreme of its arcuate movement substantially parallel to said portions of said pole pieces, and said pivot axis is offset laterally from the center of the armature in the direction of said actuators for counter-balancing said actuators.

7. A relay structure as set forth in claim 6 which includes a return spring carried by one end of said armature for normally actuating certain of said contact means and in which the pivot center of the armature is offset longi-

itudinally of the armature in the direction of the spring
for counterbalancing said spring.

References Cited in the file of this patent

UNITED STATES PATENTS

1,886,372	Bossart	Nov. 8, 1932
2,455,049	Edwards et al.	Nov. 30, 1948
2,585,684	Boggenstein	Feb. 12, 1952
2,588,257	Lewus	Mar. 4, 1952

6

2,629,792
2,718,568
2,767,279
2,777,922
2,810,037
2,824,189
2,871,312
2,923,794
2,960,583

Fitch	Feb. 24, 1953
Somers	Sept. 20, 1955
Hall	Oct. 16, 1956
Horman	Jan. 15, 1957
Faus et al.	Oct. 15, 1957
Zimmer	Feb. 18, 1958
Curry	Jan. 27, 1959
Keeran	Feb. 2, 1960
Fisher	Nov. 15, 1960