Dec. 16, 1969 A. O. ADAMS ET AL 3,484,729

ARMATURE AND CONTACT BLADE ASSEMBLY FOR AN ELECTRICAL RELAY

Filed April 24, 1967 2 Sheets-Sheet 1

FIG. 1

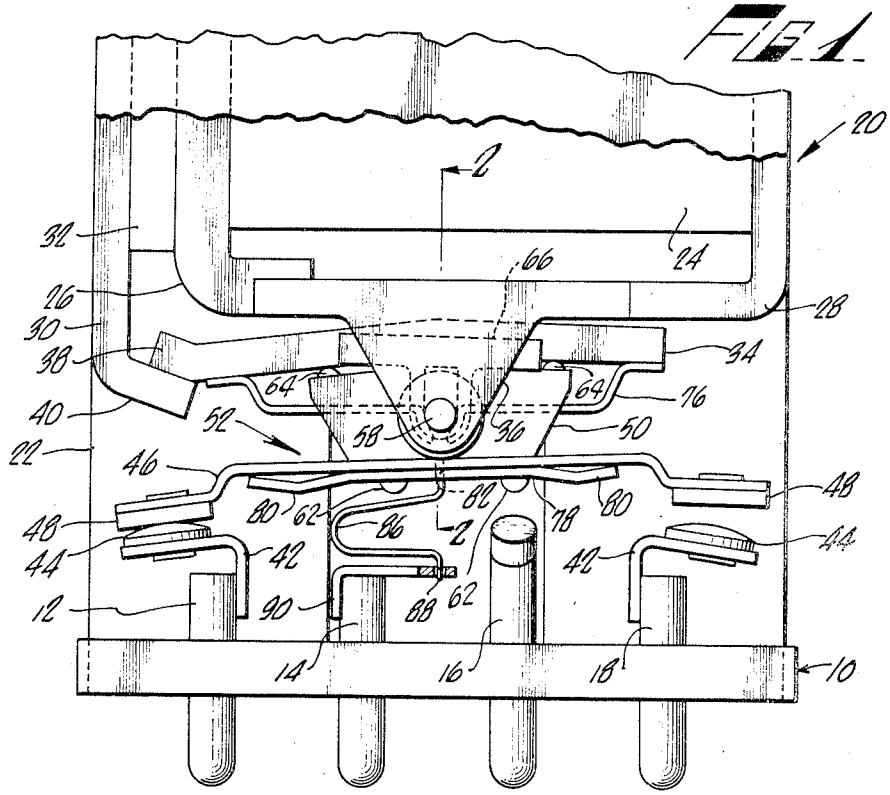
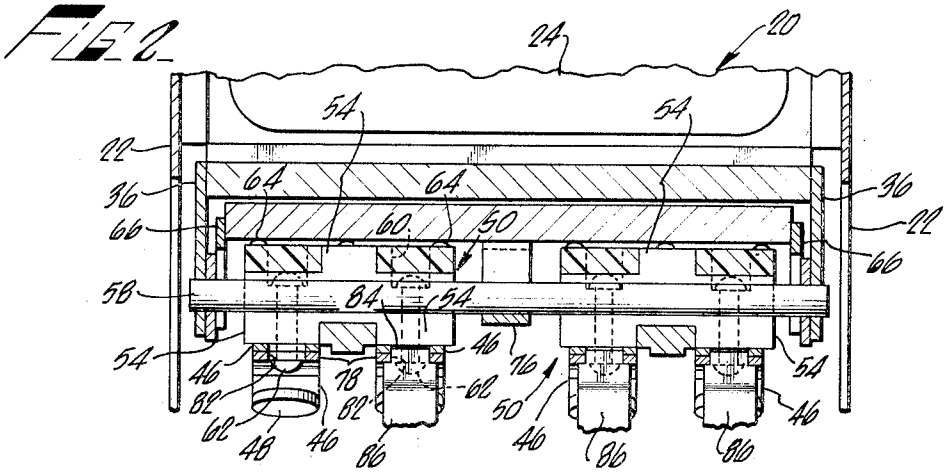


FIG. 2



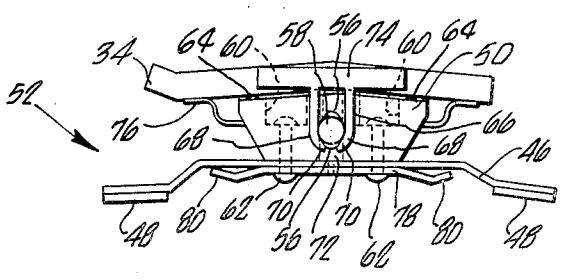


FIG. 3

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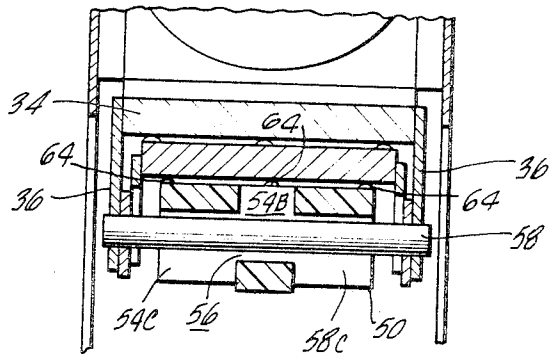


FIG 2A

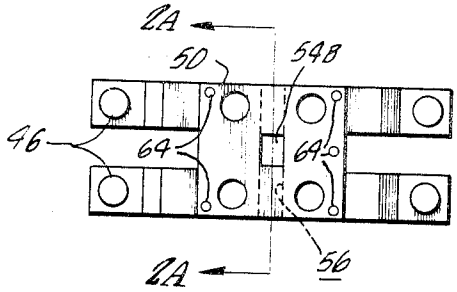


FIG 4

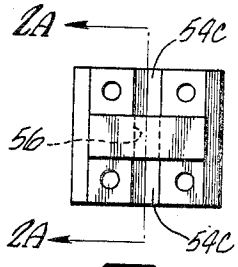


FIG 4A

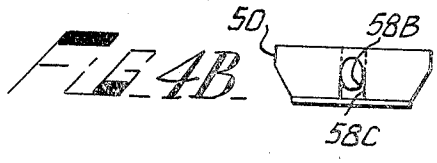


FIG 4B

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ARMATURE AND CONTACT BLADE ASSEMBLY FOR AN ELECTRICAL RELAY

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U.S. Cl. 335—200 14 Claims

ABSTRACT OF THE DISCLOSURE

An electrical relay having a header including a plurality of contact pins, an electromagnetic motor and a shaft pivotally mounting an armature and securing an insulating contact carrier to the armature. The contact carrier is secured to the armature by a member biasing the shaft toward the armature. The shaft is disposed in a substantially wedge-shaped, or oval hole in the carrier. Contact blades, disposed intermediate the carrier and a buffer strip, are attached to the carrier and alternately make or break connections with the contact pins.

BACKGROUND OF THE INVENTION

This invention relates to an electric relay and more particularly to an electric relay of a highly compact construction.

Today's aircraft, aerospace, and electronic industries require electric relays coupling high performance with minimum weight and size. Performance ratings for electric relays are constantly being increased, while weight and physical size are at the same time decreased.

A relay acceptable to the aerospace industry and having a rating of say 10 amperes is required to withstand vibrations of up to 30 G's at 3000 c.p.s., shocks of up to 100 G's, contact bounce of no more than 1 millisecond when the relay is operating at a temperature range of from −70° C. to +125° C. at service altitudes of 300,000 feet. Today such a relay is required to be built in a space of only about one cubic inch.

The high mechanical and electrical ratings together with the miniature size of the relay require the component parts in the relay to combine maximum strength with a minimum size. These stringent requirements have made the manufacture of most component parts extremely critical and expensive. The moving parts in particular those which include the armature of the relay, the contact blades and the means for securing the contact blades to the armature, are small and must be constructed with close tolerances. To insure such tolerances, complicated, time-consuming and difficult manufacturing operations have to be performed, all tending to increase the cost of the operation and the relay.

In the past, movable contact blades have been secured to the carrier in a number of ways such as by means of machine screws or by directly embedding the blades into a molded carrier. The carrier itself is customarily secured to the armature by means of suitable fasteners such as screws or rivets; and in the past even the armatures were embedded in a molded carrier.

The moving components were pivotally secured to the supporting frame or to the electromagnetic motor of the

relay. To connect the parts, an elongated hole had to be drilled through the molded contact carrier to receive a shaft which could then be journaled in a hinge pin bracket or the like.

Since the physical dimension of the parts are very small, the above-identified shaft normally has a diameter of only about 1/32 to 3/64 of an inch while having a length of up to about an inch or more, thus making the tolerance requirements strict. Accordingly, preparation of the molded part was expensive and resulted in a relatively great number of defective parts. Furthermore, the danger that a defective part is undetected and is installed in a relay, raises the possibility that the relay may malfunction when in actual use.

One main source of expense is the drilling of the long and small diameter bore receiving the shaft and the complicated molds that had to be prepared for molding the carrier, and particularly for embedding the contact blades and the armature in the mold. Even with molding equipment constructed to the closest, possible tolerances, the embedded contact blades frequently are misaligned making the part unusable. In addition, repeated operation of the relay results in a loosening of the contact between the blade and the carrier, making the relay unsatisfactory under high performance requirements.

Although today's high performance relays can be constructed, it can only be done by expending large amounts of money. In addition, their life range is limited by the fact that parts become loose after repeated operation of the relay.

SUMMARY OF THE INVENTION

Briefly, this invention provides an electric relay having a header including a plurality of contact pins, an electromagnetic motor secured to the header in a spaced-apart relationship and an armature plate pivotally secured to the motor and disposed intermediate the motor and the contact pins for alternately connecting pairs of contact pins when the armature is pivoted by the motor. The contact blades are secured to an insulating contact carrier that is provided with a plurality of coaxial cavities adjacent each other and which are alternately arranged on opposite sides of the carrier to define an elongated and substantially wedge-shaped, or oval hole, which receives a shaft. A member secured to the armature plate biases the shaft, which simultaneously serves as a hinge pin for pivotally mounting the armature and for securely mounting the carrier to the armature plate. The contact blades are secured to the carrier by rivets which insure a long-lasting and trouble-free connection.

By providing the contact carrier with a plurality of apertures as defined above, it is possible to mold the carrier in a simple shape which includes the hole to receive the shaft for mounting it on the armature plate. The necessity of having to drill a small and relatively long hole is thereby entirely eliminated, resulting in substantial savings in money and time. Moreover, the hole for receiving the shaft need not be of a close tolerance when the shaft is spring-biased toward the armature plate by the biased holding members. These biased holding members force the insulated contact carrier against the undersurface of the armature, and prevents any movement of the carrier relative to the armature during operation and also during periods of vibration.

The contact blades are securely fastened to the carrier

by rivets or other fasteners that are easily applied during assembly.

This relay therefore, not only eliminates a major component in the cost of manufacturing it, but also provides a way wherein the wear of parts during the operation of the relay does not affect its proper functioning.

Preferably, the armature assembly includes a buffer strip, which has the configuration of an elongated leaf spring, secured to the contact blades by the fasteners securing the contact blades to the carrier. This buffer strip may be flat, or it may be curved at the mating point with the contact blades. After the blade and the carrier have been riveted, or otherwise fastened together, the buffer strip takes up any looseness between the contact blades and the carrier that might develop during the operation of the relay. It furthermore restricts the motion of the contact blades during very high levels of vibration and extreme shock conditions; restricts the contact blade from vibrating during the opening and closing of the contracts; delivers a hammer blow to the contact blade when the relay is operated which breaks any weld that might occur between the movable contact blade and the stationary contact due to an extreme electrical load; its surface contact with the blade provides an excellent low contact drop in the system; and, lastly, its intimate contact with the blade serves as an ideal heat sink for the contact blade since the buffer strip is constructed of a material capable of quickly transferring heat.

A U-shaped spring of conductive contact material such as a spring silver alloy or other suitable contact material serves as a power transfer lead between the movable blade and an output terminal pin in the header plate. This U-shaped spring mates with the buffer strip and the movable contacts in a receiving slot therein.

BRIEF DESCRIPTION OF THE DRAWINGS

FIGURE 1 is a side elevation of a four-pole relay with parts broken away;

FIGURE 2 is a fragmentary elevational view, in section taken along line **2**—**2** of FIGURE 1 and with parts broken away;

FIGURE 2A is another fragmentary elevational view of a two-pole relay;

FIGURE 3 is a side elevational detail of an armature assembly;

FIGURE 4 is a top plan view of an insulated contact carrier assembly;

FIGURE 4A is a bottom plan view of the contact carrier and;

FIGURE 4B is an end view of the contact carrier.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring first to FIGURE 1. A relay header **10** for housing a plurality of vertically mounted contact pins **12**, **14**, **16** and **18**. An electromagnetic motor assembly **20** is spaced apart from the header and is secured to the header by a suitable support structure, such as by side walls **22**. Most conveniently, the side walls are secured to the motor assembly and the header by spot welding them thereto.

The motor assembly **20** comprises an electromagnetic coil **24** disposed intermediate a pair of motor pole pieces **26** and **28**. A pole piece **30** is mounted adjacent pole piece **26** and spaced apart from pole piece **26** by a permanent magnet **32**. Pole piece **30** is spot welded to side walls **22** and is simultaneously biased toward the permanent magnet and pole piece **26** such that the magnet is restrained to the space between the two pole pieces by its magnetic forces as well as by frictional forces.

An armature plate **34** is pivotally secured to the motor pole pieces **26** and **28** by suitable means such as a hinge pin bracket **36** which is attached to the pole pieces by welding it onto them. One end of the armature plate includes a slightly angular protrusion **38** which is parallel to and contacts an angular leg **40** of pole piece **30**.

In its relaxed position, i.e. when the electromagnetic coil **24** is de-energized, magnetic flux lines emanating from the permanent magnet **32** attract the protrusion **38** of the armature plate and pivot the armature into a position whereby the protrusion **38** contacts the angular leg **40** of pole piece **30**. If the magnetic motor is energized, magnetic flux lines tend to flow from pole piece **26**, hence through the armature plate and to pole piece **28**. This magnetic flux is so polarized that it is in opposition to the flux produced by the permanent magnet **32**. The result is the holding force at pole **30** is reduced, releasing the armature **34** and allowing it to be attracted toward pole piece **26**, as seen in FIGURE 1, until the pole piece **26** and armature plate **34** are in contact. De-energization of coil **24** causes the flux lines and with it the force attracting the armature plate to pole piece **26** to cease. The force exerted by the permanent magnet then again attract the armature plate and pivot it into a position whereby protrusion **38** contacts the angular leg **40**. The motor action is described in more detail in U.S. Patent 3,317,871.

The motor assembly **20** is energized by an electric current supplied to it from contact pin **16** which is connected with the motor by a lead (not shown), and a second contact pin (not shown) similarly connected with the motor, the second pin being obscured in FIGURE 1 by contact pin **16** and positioned behind that pin. These contact pins are connected with an electric circuit (not shown) which actuates the relay.

The outermost contact pins **12** and **18** are provided with an angular bracket **42** having contact points **44** and **44'**, respectively, suitably secured thereto. A plurality of contact pins such as pins **12** and **18**, may be provided in a spaced-apart relationship and are obscured in FIGURE 1 by the pins shown there. Contact pins **12** and **18** are alternately connected with pin **14** by actuating the relay which causes a contact blade **46** to touch either pin **12** or pin **18** which connects these pins with pin **14**.

The blade **46** is an elongated strip of conductive material, such as copper or a silver alloy, and is provided with contact points **48** and **48'** having a shape similar to contact points **44** and which are suitably secured to the blade such as by welding or riveting them thereto. The blade is secured to a contact carrier **50** which is constructed of an insulating material, such as a plastic or ceramic, the carrier being in turn secured to the armature plate **34**. The blade **46** is additionally connected with pin **14** to enable it to electrically connect pin **14** with either pin **12** or pin **18**.

This invention relates to armature assembly **52**, best shown in FIGURE 3, which comprises the armature plate **34**, the carrier **50** and the contact blade **46**. As best seen in FIGURES 2, 2A, 4 and 4A, the carrier **50** is an elongated block having a roughly trapezoidal cross-section and being provided with a plurality of trough-shaped cavities or slots **54** alternately opening to one or the other side of the carrier.

A contact carrier **50** for a two-pole relay is shown in FIGURE 2A having a shaft **58** passing through the opening **56**. Shaft **58** is secured to armature **34** by two bias spring brackets **66** which are described in more detail hereinafter.

In FIGURE 4, a top cavity **54B** is formed through a portion of the thickness of carrier **50**. In FIGURE 4A, a pair of bottom cavities **54C** are formed through the opposite portion of the thickness of carrier **50** and to the same depth. In FIGURE 4A the movable contact blades **46** are removed for clarity. The cavitied **54B** and **54C** overlap and are longitudinally aligned and adjacent each other. They thereby define a common hole or aperture **56** (see FIGURE 3) extending through the length of the carrier and having substantially an oval shape.

By constructing the carrier as described in the preceding paragraph, it is possible to mold the hole **56** which is to receive a shaft **58** for mounting the carrier on the

armature plate 34. Additional advantages of providing hole 56 with an oval shape are discussed in greater detail below.

The carrier includes a plurality of recessed bores 60 that extend through the carrier transverse to the longitudinal axis of the cavities 54 and which receive a fastener, such as a rivet 62 for securing the contact blades 46 to the carrier. The side of the carrier facing the armature plate 34 includes spherical protrusions 64 that rest against the plate when the carrier is secured thereto and which space the body of the carrier from the plate. By including the spherical protrusions, the surface of the carrier facing the armature plate may contain uneven portions without affecting the stability of the carrier secured to the plate.

The carrier can have any desired length to mount one or more contact blades thereon. Preferably, however, it is of a length to mount two contact plates in a parallel position and spaced apart from each other since generally electric relays have an even number of contact blades. Depending on the size of the relay, the armature plate is then provided with one or more carriers to connect the blades with the armature plate. FIGURE 2 shows a relay having four contact blades and which is provided with two carriers, each mounting two blades. This enables the use of a single contact carrier for relays of varying sizes and eliminates the necessity of having to provide different molds to mold carriers of varying size for relays of different sizes.

Although the number of cavities 54 that are included in a carrier may vary, it should be an uneven number such that each end of the carrier has a cavity that opens to the side opposite the armature plate 34. The shaft 58 biasing the carrier toward the plate is then supported at the ends of the carrier and the force exerted by the shaft is more evenly distributed. For carriers mounting two contact blades, as shown in FIGURE 2, it is most convenient to provide three cavities, the center cavity opening toward the armature plate 34.

To secure the carrier to the armature plate, shaft 58 is biased toward the armature plate. This is done by exerting a spring force onto the shaft and into a direction toward the plate. As best seen in FIGURE 3, the spring force is exerted by a spring bracket 66 having a pair of substantially parallel arms 68 extending downwardly from the armature plate and embracing the shaft 58. The ends of the arms include protrusions 70, the protrusions being inclined from the vertical at an angle less than 90° and extending toward each other. The ends of the protrusions define a narrow gap 72 between themselves. The arms 68 are spaced apart from each other at a distance slightly greater than the diameter of shaft 58 and are preferably integral with a horizontal crossbar being suitably secured to the armature plate 34 such as by spot welding thereto. One spring bracket 66 is provided on each side of the armature, the spring brackets being aligned with each other and receiving the shaft 58 between the arms 68.

The spring bracket is positioned such that the shaft contacts the protrusions 70 of the arms when it is fully supported against the oval hole 56 in the carrier. To assure that the protrusions exert pressure against the shaft 58, which causes the shaft to be forced toward the armature plate 34, into contact with the oval hole 56 and thereby biases the carrier toward and into contact with the plate, the bracket is secured to the armature plate while the shaft is disposed within the space defined by the arms. With the shaft disposed in the oval hole 56, the bracket is suitably forced in the direction toward the plate before and during welding the bracket to the armature plate 34. The amount of force exerted on the bracket is predetermined. For a relay having two carriers with four contact blades, it has been found that a force of about eight pounds exerted on each bracket gives best results and biases the shaft, together with the carrier, toward the plate such that it is securely fastened thereto. After the brackets have been welded to the armature plate 34, the carrier is immovable relative to the plate even under the most severe operating conditions.

In order to better equalize the pressure exerted by the shaft onto the carrier and if there is no more than one carrier mounted on the armature plate, an elongated clamping strip 76 is disposed intermediate the carriers 50, embraces the shaft 58, and is secured to the armature plate by spot welding it thereto. The clamping strip 76 is preferably U-shaped, as shown in FIGURE 1, to give it springiness and to enable it to exert a force onto the shaft even if the distance between the shaft and the armature plate varies.

By constructing the armature assembly as just described, the part can be manufactured with relative broad tolerances yet accurate positioning of all parts relative to each other is nevertheless maintained. The danger of loosening of the parts should one or more of them become worn is substantially eliminated. By prestressing the shaft when it is mounted, initial variations in material thickness such as the diameter of the shaft, the thickness of the carrier, or the exact location of the protrusions 70 of the spring bracket 66 are taken up and affect neither the assembly operation nor the accuracy of the final assembly. If, during operation, a part, say the shaft, becomes worn, the carrier remains securely attached to the plate. Thus, the wear or any tendency to loosen is prevented from occurring by the spring bracket 66. In the past when parts had to be manufactured to close tolerances, these tolerances were necessary to adequately and accurately secure the carrier to the plate. But wear of one of the parts resulted in loosening of the assembly and in ultimate failure of the relay.

Since the carrier 50 is generally constructed of either a plastic or ceramic, the hole through it receiving the shaft frequently becomes deformed and enlarged after an initial period of operation. Thus, as little as .0001 inch of deformation in the hole result in the loosening of the fit between the hole and the shaft. The parts become loose, the relay vibrates excessively and malfunctions under severe operating conditions. By providing an oval hole wherein the shaft does not contact the vertex of the hole and is supported by a portion of the outwardly extending sides defining the hole as shown in FIGURE 3, any looseness of the carrier is immediately taken up by the shaft which is forced in the direction of the armature plate 34 by the spring bracket 66. In addition, any deformation of the carrier does not affect the radial alignment of the shaft in the hole since the shaft is constantly biased into the vertex of the oval hole by the sides defining the hole. Were the hole circular, any deformation of it other than in the center causes misalignment of the carrier and the shaft.

A buffer strip 78 is preferably secured to the contact blade 46 by the rivets 62 securing the blade to the carrier 50. The buffer strip is an elongated metal strip arcuate in a longitudinal direction and provided with protrusions 80 extending toward the contact points 48 of the blade. When the buffer strip is secured to the blade, the rivets flatten it whereby an additional force is exerted on the rivets. Should the carrier be compressed or deformed by the pressure from the rivets such that the rivets become longitudinally movable, the deformation is taken up by the buffer strip acting as a spring. Looseness of the contact blade 46 relative to the carrier 50 is thereby eliminated. The protrusions 80 of the buffer strip are adjacent to or in contact with blade 46 and restrict the vibrational motion of the blade during high vibration levels, extreme shock conditions, or during the opening and closing of the contacts. Failure of the relay due to movements under the vibrational or shock forces is thereby substantially reduced or eliminated. In addition, since the buffer strip is constructed of a highly conductive metal such as silver

alloy, for example, it absorbs heat at a rapid rate that might accumulate in the contact blade from electric overloads and reduces the danger of damage to the blade therefrom.

A slot **82** extends transverse to the longitudinal axis of the blade and the buffer strip, as best seen in FIGURES 1 and 2, and receives a tongue **84** of a U-shaped contact spring **86**. The other end of the spring is provided with a similar pair of tongues **84** which extend into slots **88** in a metatl bracket **90** which is secured to contact pin **14**. The U-shaped spring flexibly connects contact pin **14** with blade **46** and enables the blade to connect pin **14** with either pin **12** or pin **18** when the relay is in either a relaxed or an energized position, respectively.

Difficult assembly operations such as soldering at inaccessible places and the danger of crystallization of the homogeneous metal connection, friction, fatigue, and ultimate breakage are substantially eliminated by the U-shaped contact spring **86**.

In operation, contact pins **12, 14** and **18** are connected with the relay contact load circuit. Any desired number of pins **12, 14** and **18**, which are not shown because obscured by the first pins shown in FIGURE 1, are arranged in a spaced apart side-by-side relationship and parallel to each other. In the relaxed position, a circuit is completed between contact pins **12** and **14**. When energized, the armature plate pivots, contact points **44** and **12** are disconnected, and the contact point **48'** touches the contact point **44'** of pin **18**, thereby connecting pins **14** and **18**. If the relay is subjected to accidental overloads which might cause the contact points to become tack-welded together, energization of the electromagnetic motor assembly **20** causes the armature plate **34** to pivot, transmitting that pivotal movement onto buffer strip **78**. The sticking contact points then tend to bend the blade downwardly while the protrusion **80** of the buffer strip moves rapidly in the opposite direction. A hammer blow is thereby transmitted onto the blade which breaks tack-welds. The relay continues to operate satisfactorily where others, built without this feature, would have failed.

As can be seen from this description, a relay constructed according to this invention has superior operating characteristics and longer life under the severe conditions in today's aerospace applications than was attained in the past. It couples minimum space requirements with maximum reliability and reasonable low cost.

What is claimed is:

1. A contact blade assembly for use in electric relays comprising a magnetic armature, a contact blade, an insulating contact carrier positioned between the armature and the contact blade, means securing the contact blade to the carrier, the carrier having a plurality of adjacent cavities alternately arranged to open on opposite sides of the carrier, the cavities being aligned with adjacent cavities partially overlapping to form a common opening passing through the carrier intermediate said opposite sides, and means for holding the carrier firmly in position relative to the armature including a member passing through said common opening formed by the cavities with the ends of said member projecting outwardly of the carrier on either side, and means securing said projecting ends of the member to the armature for holding the carrier in fixed relation to the armature.

2. Apparatus as defined in claim **1** wherein said member is a round shaft and wherein the cavities are formed with sloping converging walls such that the round shaft is held in wedged position by the walls of the cavities to prevent any lateral movement of the shaft in the common opening formed by the cavities.

3. Apparatus as defined in claim **2** wherein said sloping converging walls are oval-shaped in cross section to form a substantially oval-shaped common opening for receiving the shaft.

4. A contact blade assembly for use in electric relays comprising an armature, a contact blade, an insulating carrier positioned between the armature and the contact blade, the carrier having an opening therethrough, a shaft extending through the opening in the carrier with the end portions projecting outwardly on either side of the carrier, and means anchoring the end portions directly to the armature for holding the carrier and shaft in fixed relation to the armature.

5. Apparatus according to claim **4** wherein the anchoring means includes a spring member secured to the armature and engaging the shaft for urging the shaft toward the armature.

6. Apparatus according to claim **5** wherein the spring member comprises a pair of parallel arms each having an angular protrusion extending toward the other arm and adjacent the other protrusion, the arms and the protrusions being disposed around and in contact with the shaft, there being two said spring members, one at either end of the shaft, the spring member being secured to the armature plate.

7. Apparatus according to claim **4** including a buffer strip secured to the contact blade, the buffer strip having a protrusion extending toward the end of the contact blade.

8. Apparatus according to claim **7** including a plurality of carriers arranged side-by-side with their openings being longitudinally aligned.

9. Apparatus according to claim **8** including means between adjacent carriers for biasing the shaft toward the armature.

10. An electric relay comprising an electromagnetic motor, a movable contact assembly actuated by said motor, the assembly including an insulating carrier, a contact blade secured to the carrier, an armature plate, a shaft extending through an opening in the carrier, spring means interconnecting the shaft and the armature, the spring means urging the armature toward the shaft to securely clamp the carrier between the shaft and the armature, and hearing means connected to said motor for rotatably supporting the shaft in fixed relation to said motor to permit rotatable movement of the contact assembly by the electromagnetic motor.

11. A relay according to claim **10**, further including an electrical terminal member, means for holding the terminal member in fixed, electrically insulated relationship to the motor and spaced opposite the contact blade, the contact blade and the terminal member each having a slot with said slots positioned in opposing relationship, and a flat U-shaped spring conductor having tips at either end adapted to engage and pivot in said opposing slots, the conductor being held in position by the spring force urging the tips apart and into the slots.

12. Relay according to claim **10** wherein a plurality of insulating carriers are arranged side-by-side and wherein the shaft spans all of the carriers and including means between adjacent carriers for biasing the shaft toward the armature plate.

13. An electric relay comprising an electromagnetic motor, a movable contact assembly actuated by said motor, the assembly including an armature, a contact blade, an insulating carrier positioned between the armature and the contact blade, the carrier having an opening therethrough, a shaft extending through the opening in the carrier with the end portions projecting outwardly on either side of the carrier, means anchoring the end portions directly to the armature for holding the carrier and shaft in fixed relation to the armature, and bearing means connected to the motor for rotatably supporting the shaft in fixed relation to said motor to permit rotatable movement of the contact assembly by the electromagnetic motor.

14. A relay according to claim **13**, further including an electrical terminal member, means for holding the terminal member in fixed, electrically insulated relationship to the motor and spaced opposite the contact blade, the contact blade and the terminal member each having a slot with said slots positioned in opposing relationship,

and a flat U-shaped spring conductor having tips at either end adapted to engage and pivot in said opposing slots, the conductor being held in position by the spring force urging the tips apart and into the slots.

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