United States Patent

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[54] **MICROMINIATURE RELAY**

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[52] **U.S. Cl.**.....**335/193**, 335/203

[51] **Int. Cl.**.....**H01h 3/60**

[58] **Field of Search**.....335/193, 192, 203, 125, 128, 335/104, 105, 276

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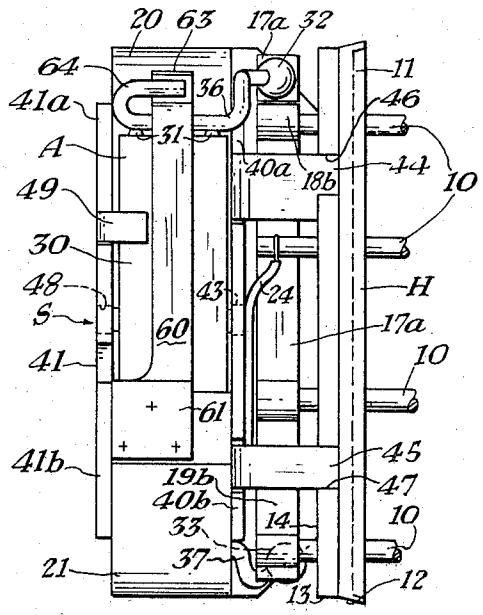
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[57] **ABSTRACT**

An all-welded hermetically sealed microminiature relay is substantially free of armature bounce. The relay includes an electromagnet and a pivotal armature which is spring biased in a unique manner to remove some of the kinetic energy from the armature as it moves to its deenergized position. The relay includes a contact arrangement having a plurality of fixed contacts and at least one movable contact actuated by the movement of the armature for performing the transfer switching functions of the relay. It has been found that the dropout to pickup current ratio of any given relay may be changed by varying the length of the pole faces.

12 Claims, 8 Drawing Figures



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SHEET 1 OF 2

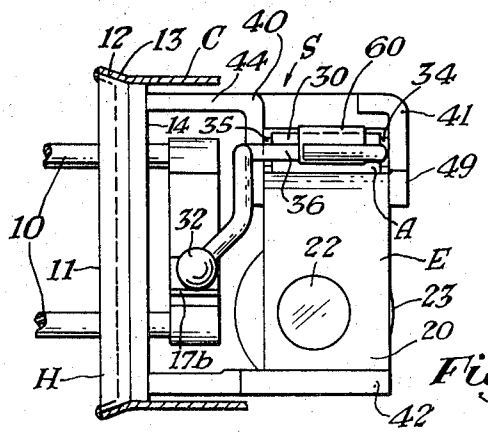


Fig. 2.

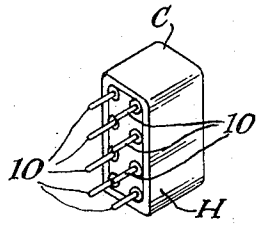


Fig. 1.

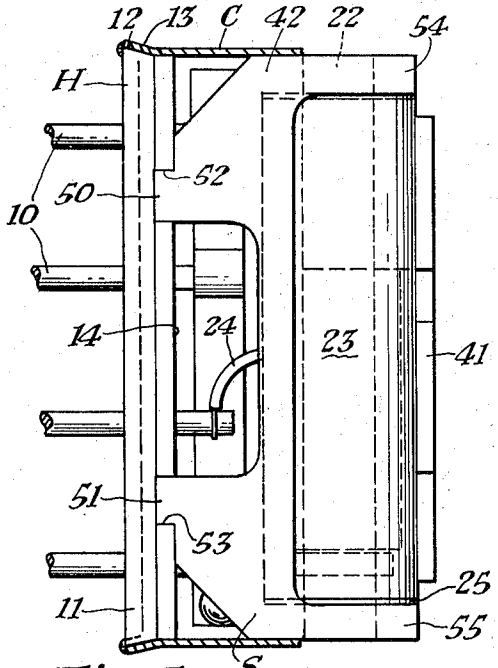


Fig. 3.

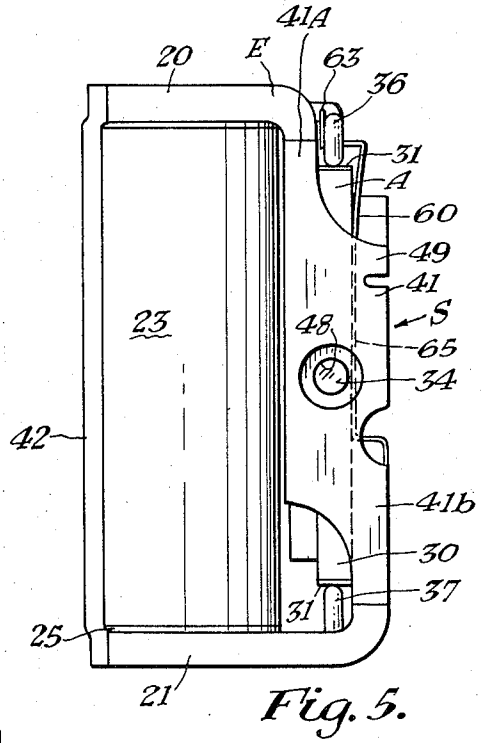


Fig. 5.

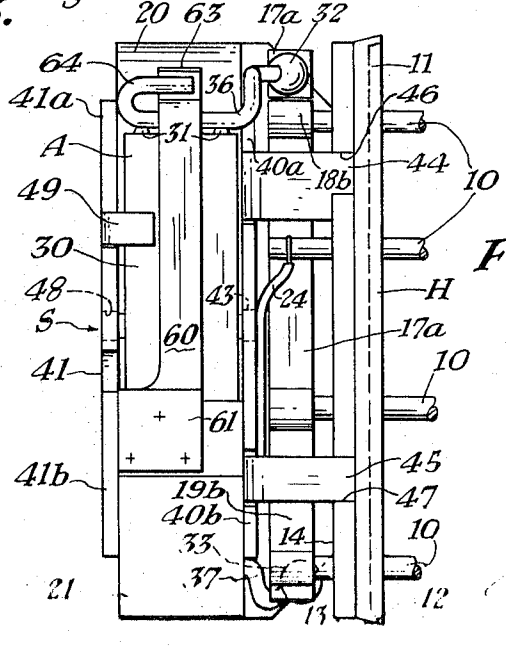


Fig. 4.

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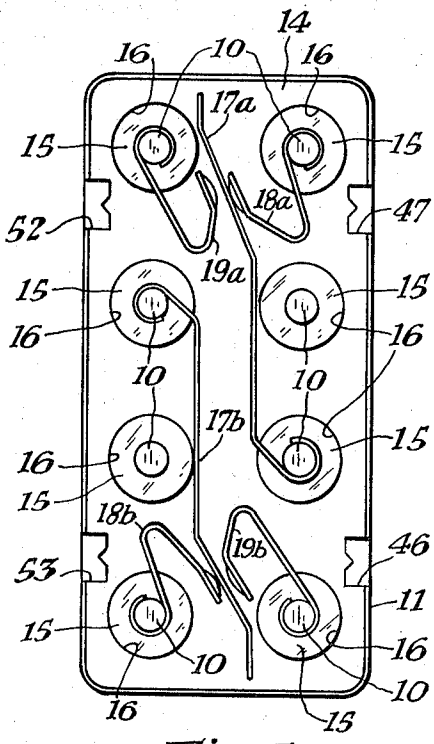


Fig. 7.

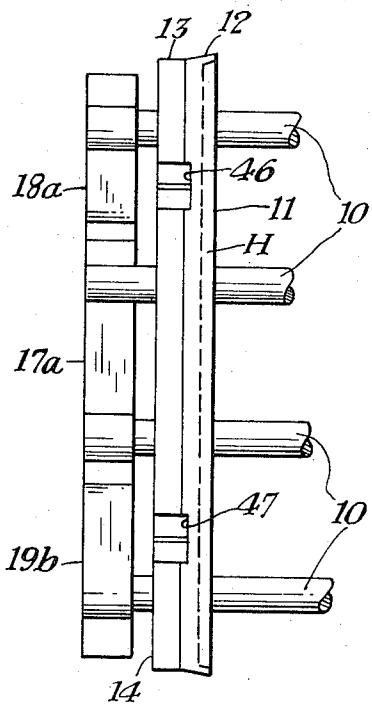


Fig. 8.

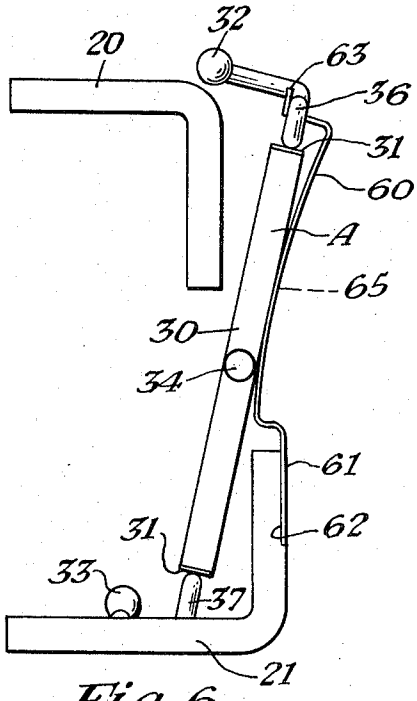


Fig. 6.

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MICROMINIATURE RELAY

My invention relates to an electromagnetic relay and more particularly to an improved microminiature relay which is virtually unaffected by gravitational forces and atmospheric conditions, is substantially free of armature bounce, is effectively protected against external contaminants, is relatively inexpensive, is readily controllable in regard to its electromagnetic characteristics, and is efficient and reliable in operation.

With the ever increasing advancements and developments in our aerospace program, the need for new and improved electromechanical as well as electronic hardware is in constant demand. In the electromechanical field, there is a continual requirement for smaller, lighter and better electromagnetic relays which will succeed in meeting the rigorous standards necessary in mil-spec applications. In addition to the ability to withstand extreme inertial forces caused by shock, vibration, acceleration, deceleration and gravitational changes, the relays must be possessed of various other required attributes which ensure satisfactory operation even under the most extreme environmental conditions. For example, it is desirable from the standpoint of size and weight reduction to minimize the number of relay parts by combining the functions of separate members. In addition, it is advantageous to preferably employ an all-welded construction since mechanical fasteners not only require additional space but also are time consuming. Further, it has been found that erratic operation occurs during deenergization periods of previous types of relays due to armature bounce. Armature bounce usually causes banging of the electrical contacts which is highly undesirable both from the standpoint of mechanical wear as well as electrical contact pitting. The unwanted opening and closing of the contacts is also detrimental to the operation of related circuits or devices which are controlled by the relay. Thus, it has been found exceedingly advantageous to spring bias the armature in such a manner that some of the kinetic energy is removed from the moving armature on its return to its normal position. Further, it will be appreciated that the spacing and preciseness of parts in a microminiature relay must be optimized since there is little, if any, extra room for the necessary components that are employed therein. A further desired feature in the manufacturing of microminiature relays is the ability to control and vary the dropout to pickup current ratio by simply altering or changing the length of the pole pieces of any given batch of relays.

Accordingly, it is an object of my invention to provide a new and improved microminiature relay which encompasses all of the above-mentioned features and advantages.

A further object of my invention is to provide an improved microminiature type relay which is substantially free of armature bounce.

Another object of my invention is to provide a unique electromagnetic relay which employs an improved spring biasing arrangement for urging the relay armature to its normal deenergized position.

Yet another object of my invention is to provide an improved electromagnetic relay which allows an all-welded construction to be employed.

Yet a further object of my invention is to provide a unique microminiature relay which requires a

minimum number of parts due to the employment of a multiple function principle.

Still another object of my invention is to provide an improved microminiature relay having a selectively controllable dropout to pickup current characteristic which is determined by the length of the pole faces of the pole pieces.

Still yet another object of my invention is to provide a unique microminiature type of electromagnetic relay having a spring biased balanced armature and having preselected sizes of pole pieces for establishing the dropout to pickup current ratio for a particular relay.

Still yet a further object of my invention is to provide a new and improved electromagnetic relay that is extremely small, light and compact, that has low frictional wear, that is immune to shock and vibrations, that has lower power consumption, and that has improved operational characteristics.

Yet still another object of my invention is to provide a new and improved microminiature relay which is simple in construction, economical in cost and efficient and reliable in operation.

Further objects, features and advantages of my invention will become more apparent as the following description proceeds and the ingenuity and novelty which characterizes my invention will be pointed out particularly in the appended claims which form part of my specification.

Generally, my invention relates to a microminiature relay comprising a header and contact assembly having a plurality of insulated contact pins including external terminal portions and internal stationary and movable contact portions. The relay includes an electromagnetic assembly having an energizable coil wound around an elongated cylindrical magnetic core. An L-shaped pole piece is fixedly secured to each end of the elongated cylindrical magnetic core. The pole faces of the L-shaped pole pieces are directed toward one another and are arranged in parallel relationship with the longitudinal axis of the elongated cylindrical magnetic core. A flat rectangular armature member is disposed adjacent the pole faces and is mounted between an upper and lower bearing bracket. Each bearing bracket includes a circular opening for accommodating a central pivot portion located on the upper and lower edges of the armature member. The upper bearing bracket is securely fastened to the upper surfaces of the pole faces while the lower bearing bracket is securely fastened to the lower surfaces of the pole faces. The upper bearing bracket includes an integrally formed dependent tab which operates as a stop member for the armature member. The lower bearing bracket includes a pair of dependent supporting legs, the lower extremities of which are securely fastened to the header. A supporting plate includes a pair of upstanding arms which are fixedly secured to the sides of the respective pole pieces. The supporting plate also includes a pair of dependent legs, the lower extremities of which are securely fastened to the header. A contact actuator is secured to each end of the armature member. Each actuator is adapted to engage a movable contact for providing a transfer switching action between the movable contact and a pair of respective stationary contacts. A biasing leaf spring urges the armature member against the backstop tab when the coil

is deenergized. One end of the leaf spring is securely fastened to one of the pole faces while the other end of the leaf spring is retained by a hook portion formed on the end of one of the actuators. The intermediate portion of the leaf spring is in rubbing engagement with the adjacent surface of the armature member so that some kinetic energy is removed from the armature member as it moves from its energized position to its deenergized position. The removal of the kinetic energy effectuates a damping action which prevents the armature from bouncing against the stop member. A cover completely encloses the internal structure and is securely fastened to the header for providing a hermetically sealed microminiature relay.

A better and more complete understanding of my invention will be had by reference to the drawings, in which similar characters of reference refer to similar parts throughout the several views and in which:

FIG. **1** is an actual size perspective view of an electromagnetic relay, with the cover on, constructed in accordance with the present invention.

FIG. **2** is an end elevation view, greatly enlarged, of the relay of FIG. **1** with the cover partly removed and shown in section.

FIG. **3** is a side elevation view of the coil side of the relay with the cover shown in section.

FIG. **4** is a side elevation view of the armature side of the relay with the cover totally removed.

FIG. **5** is a top plan view of the relay in its energized condition.

FIG. **6** is a top plan view of the armature, pole pieces, actuators and biasing spring, with the relay in its deenergized condition.

FIG. **7** is a top plan view of the header and contact assembly of the relay, with the electromagnet, armature and support assemblies and cover omitted for clarity.

FIG. **8** is a side elevation view header and contact assembly as observed from the right of FIG. **7**.

Referring now to the drawings, there is shown in FIG. **1** the actual size of a microminiature type of relay in accordance with the present invention. The various internal assemblies which make up the relay are completely enclosed and hermetically sealed by the cover C which is preferably welded to an associated flange of the header assembly H so that the relay is impervious to dust, moisture and other contaminants which may be present in the operating environment. The various electrical circuit connections are made through the connecting leads or connecting pins **10**, which will be described in greater detail hereinafter.

As shown in FIGS. **2, 3, 4** and **5**, the relay simply consists of five principal parts, namely, a header and contact assembly H, an electromagnetic assembly E, an armature assembly A, a support assembly S, and a cover C, all of which will now be described.

The header and contact assembly H, which is best shown in FIGS. **2, 3, 4, 7**, and **8**, comprises a rectangular base plate or header **11** having an inclined peripheral portion **12** and a straight peripheral portion **13** which is orthogonal to the plane of internal flat surface **14**. As previously mentioned, the portions **12** and **13** are designed to cooperate with the lower rim portion of the cover C. The cover C is telescoped over the internal relay assemblies and is welded in cooperative association with the header, as is shown in FIGS. **2** and **3**. As shown in FIGS. **7** and **8**, the base plate **11** also includes a pair of notches **46, 47** and **52, 53** on each side for receiving a pair of legs of the supporting assembly as will be described in detail hereinafter. The plurality of dual-in-line connector pins or leads **10** protrude outwardly from the header plate **11** and afford external connections with the inner contacts of the relay. Each of the connector pins or leads is secured in place by being embedded in a mass of suitable insulating material **15**, such as glass, which fills each of the openings **16**, as best shown in FIG. **7**. Thus, an air-tight bond exists between external terminal portions on one side of the header plate **11** and the internal contact assembly which performs the various transfer switching functions on the other side of the header plate **11**. The contact assembly includes a pair of leaf spring type of movable contacts or switch blades **17*a*** and **17*b***, the one end of each of which is suitably secured, such as by being welded, to the respective connector pins **10**. The other end of the movable contacts or blades **17a** and **17b** is suitably disposed and normally biased into cooperative association with one of a pair of stationary contacts. One end of each of the stationary contacts **18*a***, **18*b*** and **19*a***, **19*b*** is securely fastened, such as welded, to the respective connecting pins **10**. The other end of each of the stationary contacts **18*a***, **18*b*** and **19*a***, **19*b*** is provided with a dimpled contact point. Each of the spring contacts is reversely bent into a substantially U-shaped configuration. Thus, the free ends of each pair of stationary contacts are arranged to overlap each other so that the outer free ends of movable contacts **17*a*** and **17*b*** provide a make-and-break contact arrangement for selectively performing the desired switching functions. Thus, as shown in FIGS. **7** and **8**, the stationary and movable contacts form two independent single-pole double-throw (SPDT) switches. While a multiple SPDT switching arrangement is illustrated in the drawings, it is readily understood that a single SPDT switching arrangement or a multiple SPST as well as a single SPST contact arrangement may be equally employed in practicing the present invention. The two remaining connector pins are employed for providing the necessary electrical connection between the electromagnetic coil and a suitable source of electrical power, as will be presently described.

The electromagnetic assembly E, which is best illustrated in FIGS. **2, 3, 4**, and **5**, includes a pair of L-shaped pole pieces **20** and **21**, a cylindrical magnetic core member **22**, and an energizable coil **23** prewound on bobbin **25**. Each end of coil **23** is electrically connected by wires or leads **24** to inner portions of the two remaining pins, as previously mentioned. One leg of the L-shaped magnetic pole piece **20** is secured, by staking or the like, to one end of core **22** while the one leg of the L-shaped magnetic pole piece **21** is similarly secured to the other end of core **22**. The other legs of the L-shaped pole pieces extend toward each other so that confronting surfaces form the pole faces of the electromagnet. Thus, the pole faces are disposed in parallel relationship with the longitudinal axis of the core **22**.

The armature assembly A, which is best illustrated in FIGS. **2, 4**, and **5**, comprises a spring-biased balanced armature member **30** consisting of a flat rectangular

piece of suitable magnetic material. As shown, each end of the armature **30** is provided with a contact actuator or pusher arm such as **36** and **37**. Each actuator is attached such as by being projection welded to a pair of triangular protuberances **31** formed on the respective ends of armature **30**. Each of the actuators includes a lateral extending arm which terminates with nonconducting spheres, such as glass balls **32** and **33**, or other suitable insulating material. As will be described in greater detail hereinafter, the insulating balls are arranged to engage and to transfer the movable contacts **17***a* and **17***b* from stationary contacts **18***a*, **18***b* to stationary contacts **19***a*, **19***b*, respectively. The armature member includes an upper and a lower pivot pin **34** and **35**, respectively, which cooperate with bearing portions formed in a pair of brackets, as will be presently described.

The support assembly S, which is best shown in FIGS. **2**, **3**, **4**, and **5**, comprises a pair of bearing brackets **40** and **41** for pivotally supporting armature **30**, and a support plate **42** for supporting the coil side of the relay. The lower bracket **40** includes a centrally located bearing opening **43** which provides a pivot point for pin **35**. The bracket **40** is securely held in position by projection welding end **40***a* to the underside of pole piece **20** and by projection welding end **40***b* to the underside of pole piece **21**. The bracket **40** includes a pair of depending legs **44** and **45**, the lower extremities of which are fitted into notches **46** and **47**, respectively, and are securely fastened thereto, such as by welding. Thus, the bracket not only provides a pivotal bearing for armature **30** but also operates as a standoff and support for the armature side of the relay. The upper bracket **41** also includes a centrally located bearing opening **48** which is in alignment with opening **43**. The circular opening **48** is arranged to accommodate the upper pivot pin **34** of the armature **30**. The bracket **41** includes a depending tab portion **49** which functions as a stop member to limit the clockwise rotational movement of the armature **30**, as viewed in FIG. **5**. The bracket **41** is securely held in position by projection welding end **41***a* to the upper side of pole piece **20** and by projection welding end **41***b* to the upper side of pole piece **21**. Thus, the bracket **41** not only operates as a bearing support for the armature **30** but also functions as an adjustable stop for establishing the air gap between armature **30** and pole pieces **20** and **21**. In addition, the pole pieces **20** and **21** perform the dual function of providing a magnetic flux path as well as a support for bearing brackets **40** and **41**. The coil side of the relay is rigidly held in position by the four-legged support plate **42**. The two lower legs **50** and **51** are fitted into notches **52** and **53**, respectively, formed in the header **11**, and then the legs are preferably welded to the header. The upper leg **54** is projection welded to the edge of pole piece **20** while the upper leg **55** is projection welded to the edge of pole piece **21**. Thus, the electromagnetic and armature assemblies are securely held in spaced relationship with the contact and header assemblies by brackets **40** and **41** and support plate **42**. Preferably, the bracket and plate are stamped from suitable nonmagnetic sheet metal.

As previously mentioned, the armature **30** is spring biased and urged against the stop member **49** by an elongated leaf spring **60**. The leaf spring **60** has an enlarged offset end **61** which is fitted into a cutout notch **62** formed in the outer face of the pole piece **21** and is secured thereto, such as by welding. The other end **63** of leaf spring **60** is also offset and is arranged to pass through the eyelet of the hook portion **64** formed out of the free end of actuator **36**. Thus, offset **63** of the leaf spring **60** passes over the welded leg of the hook **64** and under the unattached leg of the hook **64**. Thus, it will be appreciated that the actuator **36** also plays a dual function, namely, that of opening and closing the contacts **17***a*–**18***a* and **17***a*–**19***a* and that of retaining the free end of spring **60**.

As shown in FIGS. **5** and **6**, the intermediate portion **65** of the leaf spring **60** is slightly bowed so that it is in constant engagement with the outer surface of the armature **30**. It will be noted that the bow is less severe when the relay is energized, as shown in FIG. **5**, than when the relay is deenergized, as shown in FIG. **6**. The change in curvature of the bow causes the free end of the leaf spring **60** to move slightly so that a certain amount of motion will exist between the offset portion **63** and the hook portion **64**. Further, it will be appreciated that movement of the armature causes the contiguous surfaces, namely, the intermediate bow portion **65** and surface of armature **30**, to rub against each other. The rubbing action is effective in removing some kinetic energy from the armature as it moves from its energized to its deenergized position. The removal of the kinetic energy prevents the armature from bouncing on the stop member **49** so that the actuators **36** and **37** will not momentarily open the normally closed contacts **17***a*–**18***a* and **17***b*–**18***b* when the relay is deenergized. It will be noted that the surface contact area between the leaf spring **60** and the armature **30** is greatest when the relay is energized. Thus, a greater amount of rubbing action will occur upon initial movement of the armature **30** from its energized position and a slightly lesser amount of rubbing action will occur during final movement of the armature **30** to its deenergized position. Such operation is advantageous in that for any given leaf spring, the amount of kinetic energy removed from the armature is maximized. Further, it will be appreciated that the amount of kinetic energy removed from the armature on its return to neutral may be varied simply by changing the width of the leaf spring or by varying the curvature of the bow since both of these changes vary the amount of surface area existing between the leaf spring **60** and armature **30**.

Further, it has been found that the dropout to pickup ratio of the relay may be changed by simply varying the length of the pole faces of pole pieces **20** and **21**. If the length of pole pieces **20** and **21** is increased toward the armature pivot **34**, the dropout to pickup ratio is increased. Conversely, if the length of the pole pieces is decreased, the dropout to pickup ratio is decreased. This principle of changing the lengths of the pole faces to change the dropout to pickup characteristic is highly advantageous in that the ampere-turns of the relay coils may remain fixed for a given range of dropout to pickup ratios.

After all the parts have been assembled and welded, various adjustments may be necessary to comply with the specification and performance requirements of the given type of relay being manufactured at the time. The

contacts and actuators are adjusted to ensure that a normally open and a normally closed contact are not closed simultaneously. The backstop **49** may be adjusted by being bent to set the air gap distance and to give the correct operating time. The hook end **64** of the actuator **36** may be adjusted to increase or decrease the amount of rubbing action. Finally, the leaf spring **60** may be bent to achieve the correct return force. After all the adjustments have been made, the entire structure is enclosed within the metallic cover C which has the peripheral rim or edge tightly fitted against the inclined periphery **12** of header **11** and thereafter preferably welded thereto. If it is desired, the inside of the relay may be evacuated, charged with a suitable gas, such as dry nitrogen which prevents electrical breakdown and arcing and reduces the possibility of corrosion and contamination.

In operation, the armature of the relay normally assumes a position that is shown in FIG. **6** when the electromagnetic coil **23** is not energized. Under this condition, the armature is released and the spring **60** constantly urges the armature **30** against the stop member **49** (not shown in FIG. **6**) so that a predetermined air gap exists between each pole face and the adjacent surface of the armature member **30**. Viewing FIGS. **6** and **7**, with the armature in its released position, the insulating contact balls **32** and **33** permit the movable switch blades **17***a* and **17***b* to electrically contact and engage the stationary contacts **18***a* and **18***b*, respectively. Accordingly, a completed circuit path exists between movable contact **17***a* and stationary contact **18***a* and also between movable contact **17***b* and stationary contact **18***b*. A better and more reliable electrical contact is realized when the stationary contacts are dimpled or provided with buttons since a slight wiping action occurs when the contacts make and break.

Now when the electromagnetic coil is energized by connecting the respective coil leads or pins to a suitable source of electrical power, the armature member **30** is attracted toward the pole faces and the armature assembly A is caused to rotate about its pivotal axis, namely, shaft or pin **34** in a counterclockwise direction, as viewed in FIG. **5**. That is, the energization of the coil **23** causes the armature **30** to be drawn against the pole faces of the pole pieces **20** and **21** so that the armature member **30** assumes the position, as shown in FIGS. **2**, **3**, **4**, and **5**. The counterclockwise rotational movement and picking up of the armature **30** causes movement to be imparted to the actuators **36** and **37**. The corresponding movement of the spherical insulating balls **32** and **33** causes the movable contact blades **17***a* and **17***b* to break contact with the stationary contacts **18***a* and **18***b* and to make contact with the stationary contacts **19***a* and **19***b*. Thus, the circuits common to the stationary contacts **18***a* and **18***b* are interrupted and the circuits common to the stationary contacts **19***a* and **19***b* are established. The armature **30** will remain attracted so long as sufficient current flows through the coil of the relay. When the source of voltage is removed from the respective coil leads or pins, the armature **30** will be returned to its neutral or deenergized position by the biasing spring **60**. As previously mentioned, no contact bounce and little, if any, armature bounce occurs when the armature strikes the stop member **49** due to the removal of some of the kinetic energy by rubbing action of the spring member **60**. Thus, the spring **60** not only biases the armature **30** toward its neutral position but also removes some energy from the armature to prevent contact bounce.

Thus, it is apparent that the new and improved relay of the present invention employs new and improved features which result in a more compact, smaller, lighter, more economical, durable and efficient microminiature relay. Further, the unique all-welded construction provides for a sturdier and a less costly relay. By using the various parts to perform dual functions, a reduced number of elements is realized.

While my invention has been described with reference to a single embodiment thereof, it should be understood that numerous other embodiments and numerous variations may be made by those skilled in the art that will fall within the spirit and scope of my invention. Therefore, it is understood that the invention is not to be limited to the exact details described herein but is to be accorded the full scope and protection of the appended claims.

Having thus described my invention, what I claim is:

1. In an electromagnetic relay comprising, a supporting header and contact assembly, an electromagnetic assembly, an armature assembly, a bearing assembly, a return spring, and a cover, said header and contact assembly including a plurality of contact points extending therethrough and a plurality of movable and stationary contacts secured to respective ones of said plurality of contact points, said electromagnetic assembly having an electrically energizable coil wound around a magnetic core, a first and a second pole piece secured to the respective ends of said magnetic core, said bearing assembly including an upper and a lower bearing bracket with each having an aligned aperture, said armature assembly including an armature member having a pair of pivot portions which are journaled in said aligned apertures, said armature member including at least one actuator for opening and closing said movable and stationary contacts as said armature member moves between its deenergized and its energized positions, said return spring having one end fixedly secured with respect to one of said pole pieces and having the other end retained by said actuator, said return spring having an intermediate portion engaging a surface of said armature member so that armature bounce is prevented when said coil is deenergized and said armature member moves from its energized to its deenergized position.

2. An electromagnetic relay as defined in claim **1**, wherein said return spring is in the form of an elongated leaf spring.

3. An electromagnetic relay as defined in claim **1**, wherein said first and said second pole pieces are L-shaped and said upper and said lower bearing brackets are secured to the respective top and bottom surfaces of the free ends of said L-shaped pole pieces.

4. An electromagnetic relay as defined in claim **1**, wherein one of said upper and said lower brackets includes a bendable tab for adjusting the deenergized position of said armature member.

5. An electromagnetic relay as defined in claim **1**, wherein the other end of said return spring is in hooking engagement with said one actuator.

6. An electromagnetic relay as defined in claim 1, wherein the end remote from said contacts of said actuator is formed with a hook portion which allows free play to exist with the other end of said return spring so that said intermediate portion of said return spring rubs against the surface of said armature member.

7. An electromagnetic relay as defined in claim 1, wherein said armature member is formed of an elongated flat piece of magnetic material which is pivoted about an axis orthogonal to the planar surface of said header, said armature member including an actuator attached to each end of said elongated flat piece of magnetic material.

8. An electromagnetic relay as defined in claim 6, wherein said other end of said return spring is offset so that said return spring passes over one leg of the hook portion and said return spring passes under the other leg of the hook portion.

9. An electromagnetic relay as defined in claim 3, wherein the pole faces of said L-shaped pole pieces extend toward each other and parallel to the longitudinal axis of said magnetic core.

10. An electromagnetic relay as defined in claim 9, wherein the relay dropout to pickup current ratio may be changed by varying the lengths of the pole faces.

11. An electromagnetic relay as defined in claim 9, wherein the relay dropout to pickup ratio may be increased and decreased by increasing and decreasing the size of the pole faces, respectively.

12. An electromagnetic relay as defined in claim 1, wherein said return spring has said one end rigidly attached to said one pole piece.

* * * * *