Nov. 12, 1968 W. N. FELLOWS ET AL 3,411,118

VACUUM RELAY WITH IMPROVED ARMATURE MOUNTING AND MOVABLE CONTACT

Filed July 28, 1966 2 Sheets-Sheet 1

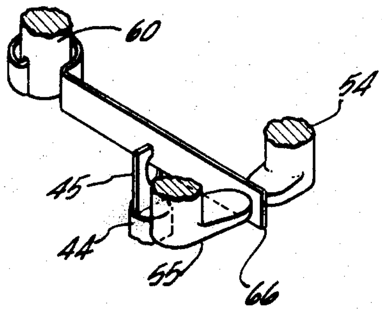


FIG. 5

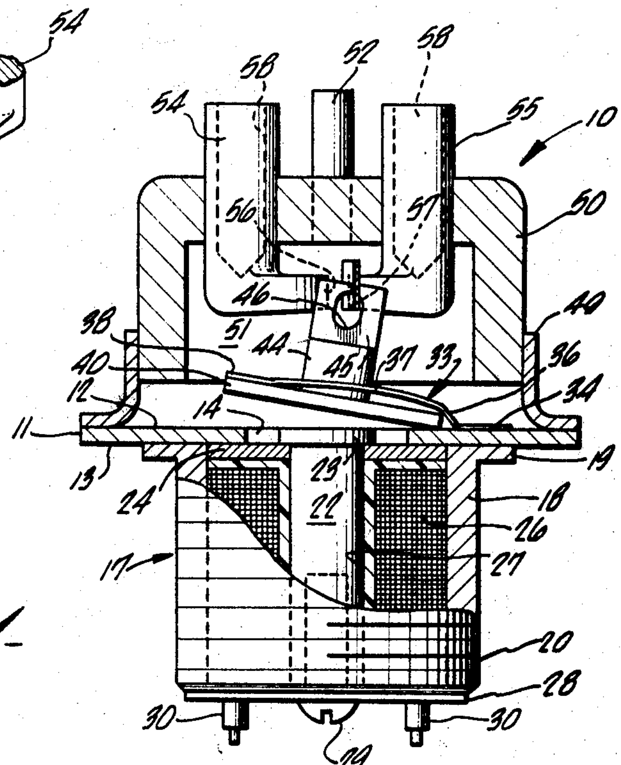


FIG. 1

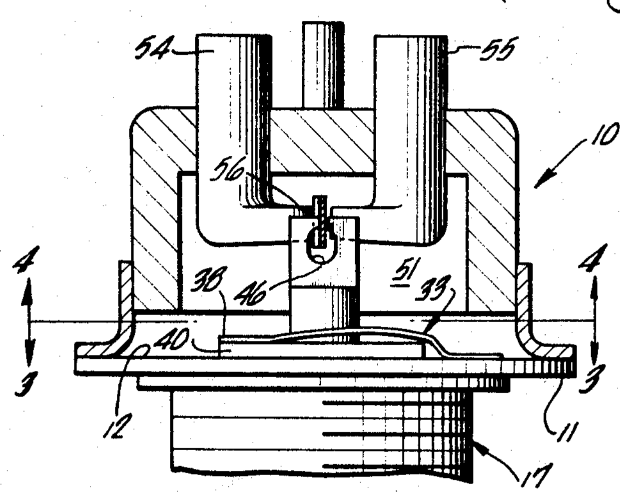


FIG. 2

INVENTORS.
WILLIAM N. FELLOWS
BY MICHAEL E. BALCH

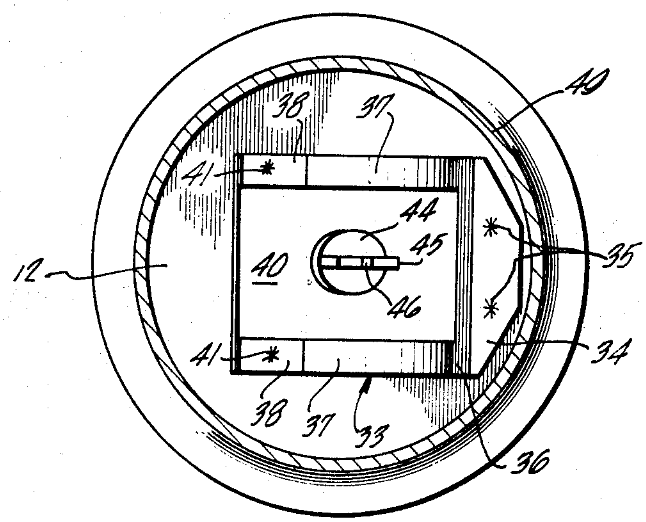
Christie, Parker & Hale
ATTORNEYS

Nov. 12, 1968 W. N. FELLOWS ET AL 3,411,118

VACUUM RELAY WITH IMPROVED ARMATURE MOUNTING AND MOVABLE CONTACT

Filed July 28, 1966 2 Sheets-Sheet 2

FIG. 3



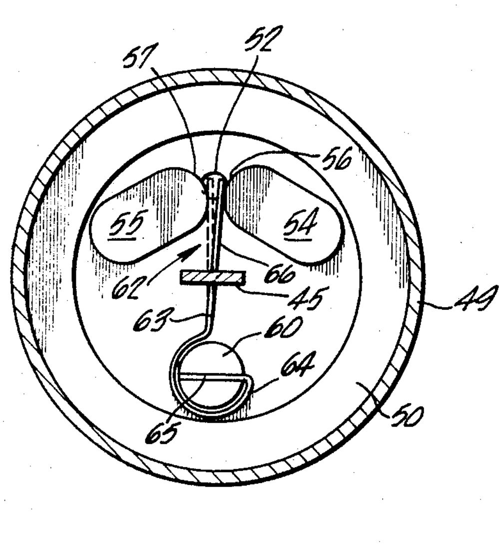


FIG. 4

INVENTORS.
WILLIAM N. FELLOWS
MICHAEL E. BALCH
BY Christie, Parker & Hale
ATTORNEYS.

United States Patent Office

3,411,118

Patented Nov. 12, 1968

1

3,411,118

VACUUM RELAY WITH IMPROVED ARMATURE MOUNTING AND MOVABLE CONTACT

William N. Fellows, Altadena, and Michael E. Balch, South Pasadena, Calif., assignors to High Vacuum Electronics, Inc., Pasadena, Calif., a corporation of California

Filed July 28, 1966, Ser. No. 568,631

4 Claims. (Cl. 335—151)

ABSTRACT OF THE DISCLOSURE

A vacuum relay having an armature which is supported by a U-shaped leaf spring which urges the armature away from a magnet pole piece. A blade-shaped movable contact is coiled around and secured to a terminal post which extends through a dielectric envelope of the relay. An insulated actuator member is secured to the armature and coupled to the movable contact to actuate the relay when the magnet is energized.

A vacuum relay is an electrical switching device having contacts which are sealed in an evacuated chamber. Such relays are capable of carrying and rapidly switching high currents at high voltages in a small structure, and are widely used in communication equipment, high-voltage power supplies, and many other types of electrical apparatus.

A vacuum relay typically has at least one fixed contact and one movable contact mounted in the evacuated chamber. The movable contact is positioned by an electromagnet having a movable armature coupled to the movable contact. Energization of the electromagnet moves the armature which in turn displaces the movable contact into or out of electrical connection with the fixed contact.

In the past, vacuum-relay armatures and moving contacts have typically been suspended by hinged or pivoted members. This type of suspension is quite satisfactory in gas-filled or unsealed relays because the gas or air serves as a lubricant for bearing surfaces in the hinges. In an evacuated relay, however, there is no vapor lubrication of these surfaces, and hinge binding and seizing has been a serious problem. This binding and seizing usually arises from molecular diffusion between adjacent bearing surfaces which eventually "vacuum welds" the surfaces together.

When the hinge bearing surfaces bind or seize, partial or complete relay failure occurs because the armature is no longer able to move the movable contact in response to energization of the electromagnet. The vacuum-welding problem has limited the reliability and operating life of known vacuum relays in spite of efforts to improve the design of hinged suspension systems. Furthermore, a hinged movable-contact suspension typically carries the electrical current which is switched by the movable contact, and the hinge bearing surfaces are electrically noisy and susceptible to arcing.

The vacuum relay of this invention includes leaf-spring suspension systems for the armature and movable contact, and is free of hinged or pivoted joints which suffer the problems just described. The relay is designed for reliable operation over a long operating life, and is adapted for easy visual inspection and electrical testing prior to final sealing and evacuation. The component parts of the relay are readily fabricated, and are designed for simple and quick assembly to provide a low manufacturing cost.

Briefly stated, the vacuum relay of this invention comprises a base having inner and outer faces, and a dielectric envelope sealed to the base to define an evacuated chamber, the base inner face defining a portion of the

2

chamber. An electromagnet is secured to the base, and has a pole piece extending through and sealed to the base. A leaf spring, having a first and secured to the base inner face, extends laterally across and in longitudinally spaced relation to the pole piece. An armature plate is rigidly secured to the leaf spring to extend over and be biased away from the pole piece by the leaf spring. The armature plate is movable toward and away from the pole piece as the electromagnet is energized and de-energized.

A dielectric member is rigidly secured to the armature plate to extend into the evacuated chamber, and an actuator member is rigidly secured to the dielectric member and spaced from the armature plate. A first terminal post is sealed to and extends through the dielectric envelope into the evacuated chamber to define a fixed contact. A movable contact in operative engagement with the actuator member is suspended to be movable against and away from the fixed contact as the actuator plate is moved.

Preferably, the leaf spring is substantially U-shaped, and has a web portion secured to the base inner face, and a pair of spaced-apart legs to which the armature plate is secured. In a preferred form, the movable contact includes a second terminal post sealed to and extending through the dielectric envelope, and a resilient blade rigidly secured to the second terminal post and extending toward the fixed contact. The resilient blade preferably includes a portion which is loosely coiled around the second terminal post, the blade being in engagement with the actuator member whereby the blade is moved against and away from the fixed contact as the armature plate is moved.

The invention will be described with reference to the drawings, in which:

FIG. 1 is a side elevation, partly broken away and in section, of a vacuum relay according to the invention;

FIG. 2 is a side elevation, partly in section, of a portion of the relay, showing the position of the relay armature plate when the electromagnet is energized;

FIG. 3 is a view along line 3—3 of FIG. 2;

FIG. 4 is a view along line 4—4 of FIG. 2; and

FIG. 5 is a perspective view of the relay contacts and actuator member when the relay electromagnet is energized.

Referring to the drawings, a vacuum relay **10** includes a base **11** formed of an alloy such as sold under the trademark "Kovar," and having an inner face **12**, outer face **13**, and a central circular opening **14** therethrough. An electromagnet assembly **17** includes a mild-steel hollow shell **18** having a flanged end **19** which is copper brazed to the outer face of the base. Preferably, shell **18** has external threads **20** to facilitate chassis mounting of the vacuum relay.

An iron pole piece **22** is disposed centrally within hollow shell **18** and has an enlarged end **23** extending through and spaced from the sides of opening **14** to be flush with base inner face **12**. The pole piece is held in place by an an annular, nonmagnetic pole-face separator **24** formed from a material such as monel metal and copper brazed to the base, pole piece, and shell.

A conventional electromagnet coil **26** is wound on a bobbin **27** which fits snugly over the pole piece through an open lower end of the shell to abut pole-face separator **24**. A magnetically conducting plate **28** is secured across the open end of shell **18** by a screw **29** threaded into the end of pole piece **22**. A pair of insulated coil terminals **30** extend through plate **28**, and are electrically connected to coil **26**.

A generally U-shaped leaf spring **33**, best seen in FIG. 3, has a web portion **34** secured to base inner face **12** by a pair of spot welds **35**. An end **36** of the web portion is bent upwardly away from the base inner face, and a pair of spaced-apart legs 37 extend from end 36 over and across the base inner face and end 23 of the pole piece. Leaf-spring legs 37 are slightly curved toward the base inner face (see FIG. 1) and terminate in flattened ends 38. Leaf spring 33 is formed from a nonmagnetic spring material such as stainless steel which is not subject to outgassing in a vacuum.

A generally square armature plate 40, formed from a magnetic material such as iron, is disposed over pole piece 22 between the base inner face and the leaf spring, and is secured to flattened ends 38 of the leaf spring by spot welds 41. As best seen in FIG. 1, leaf spring 33 biases the armature plate away from the pole piece, and the bowed shape of the leaf spring provides clearance between the leaf spring and the armature plate, permitting mechanical stresses to be spread over the length of the leaf spring. Stress concentration and resulting fatigue of the spring is avoided, and the magnetic force required to draw the armature against the electromagnet pole piece is reduced. This clearance also permits a slight lateral translation of the free end of the armature plate as it moves downwardly into the position shown in FIG. 2 when the electromagnet is energized.

A dielectric member such as a ceramic wafer 44 has a metalized end face which is copper brazed to the central part of the armature plate. An actuator member 45 is copper brazed to a metalized upper end of ceramic wafer 44, and extends upwardly (see FIGS. 1–2) away from the armature plate. The upper end of the actuator member has a keyhole-shaped slot 46 extending downwardly toward the ceramic wafer.

A seal ring 49 formed from an alloy such as "Kovar," is heliarc welded to base inner face 12, and extends upwardly away from the inner face. A ceramic, dielectric envelope 50 is copper-silver brazed to the seal ring, and extends above and across the base upper face. The inner surfaces of the base, pole-face separator 24, pole-piece end 23, seal ring 49, and the dielectric envelope define a chamber 51.

The chamber is evacuated through a tubulation 52 which is sealed to and extends through the dielectric envelope, and the tubulation is pinched off when the pumping operation is completed. All exposed surfaces in the evacuated chamber area formed from materials which do not outgas, permitting a high vacuum of say 10^{-8} millimeters of mercury to be maintained in the chamber. Similarly, the brazing and welding techniques used in assembly of the relay are selected to produce bonds which do not outgas.

A pair of generally L-shaped terminal posts 54 and 55 extend through and are copper-silver brazed to the dielectric envelope. The lower ends of the terminal posts are flattened and extend toward each other to define a pair of spaced-apart fixed contacts 56 and 57. The terminal posts are drilled to define bores 58 in which external electrical connections (not shown) are soldered. The bores also compensate for thermal expansion during brazing of the terminal posts to the dielectric envelope. The terminal posts are preferably formed from oxygen-free high-conductivity copper.

A generally cylindrical terminal post 60 (see FIGS. 4 and 5) extends through and is copper-silver brazed to the dielectric envelope. The outer part of terminal post 60 includes a bore (not shown) to accept an electrical lead in the same manner as bores 58. A movable contact 62 is formed from a resilient blade 63 having a curved end 64 which is loosely coiled around terminal post 60 and brazed in a slot 65 in the end of the terminal post. The resilient blade has a free end 66 which extends through slot 46 in the actuator member and terminates between fixed contacts 56 and 57.

Free end 66 is urged against fixed contact 57 by leaf spring 33 acting through the armature plate, wafer 44, and actuator member 45, and is also resiliently urged against fixed contact 57 by spring force developed in the resilient blade itself. The hairspring-like configuration of the resilient blade relieves stress, and permits use of a long and relatively thick blade to provide long operating life without fatigue.

When electromagnet assembly 17 is energized by passing a current through coil 26, armature plate 40 is drawn downwardly against pole piece 22 and base inner face 12 as shown in FIG. 2. As the armature plate moves downwardly and in a slightly arcuate path as guided by leaf spring 33, actuator member 45 moves laterally and carries with it the free end of the resilient blade to position the movable contact against fixed contact 56 of terminal post 54 as shown in FIG. 2 and in phantom in FIG. 4. The keyhole shape of slot 46 provides freedom for the free end of the resilient blade during this lateral translation.

Relay 10 thus operates as a single-pole, double-throw switch, completing a circuit through terminal posts 55 and 60 when the electromagnet is de-energized, and completing a circuit between terminal posts 54 and 60 when the electromagnet is energized. Many other contact configurations are of course useful with the basic relay structure shown in the drawings. For example, additional poles can be added, or the movable contact can be re-oriented to move against the two fixed contacts simultaneously to provide a single-pole, single-throw switch between terminals 54 and 55.

A feature of the invention is that the relay may be manufactured in two subassemblies for inspection and testing prior to final assembly and evacuation. The first subassembly includes base 11, electromagnet assembly 17, leaf spring 33, armature plate 40, insulating wafer 44, and actuator member 45. The second subassembly includes seal ring 49, dielectric envelope 50, and the various terminal posts and contacts secured to the dielectric envelope.

After the subassemblies are checked for proper alignment and electrical functioning, they are assembled by welding seal ring 49 to base 11, and the unit is evacuated through tubulation 52 as already described. Assembly of the relay is simple and economical because the various component parts are readily accessible before the two subassemblies are welded together.

There has been described an improved vacuum relay which is adapted for economical manufacture and is characterized by reliable operation and long life. The relay has been described in a presently preferred form, and variations in the preferred form shown in the drawings can be made to suit individual requirements. It is intended that all such variations fall within the scope of the following claims which define the invention.

We claim:

1. A vacuum relay, comprising:

a base having inner and outer faces;

a dielectric envelope sealed to the base to define an evacuated chamber, the base inner face defining a portion of the chamber;

an electromagnet secured to the base and having a pole piece extending through and sealed to the base to be substantially flush with the base inner face;

a substantially U-shaped leaf spring having a web portion secured to the base inner face and a pair of spaced-apart legs extending from the web portion to free ends, the leaf spring extending lateraly across the base inner face and in longitudinally spaced relation to the pole piece;

an armature plate rigidly secured to the leaf-spring legs adjacent the free ends to extend over and be biased away from the pole piece by the leaf spring, the armature plate being disposed between the base inner face and the leaf spring and being movable toward and away from the pole piece as the electromagnet is energized and de-energized respectively, the leaf-spring legs having portions which are spaced from the armature plate and which curve toward the web portion;

a dielectric member rigidly secured to the armature plate and extending into the evacuated chamber;

an actuator member rigidly secured to the dielectric member and spaced from the armature plate;

a first terminal post sealed to and extending through the dielectric envelope into the evacuated chamber to define a fixed contact; and

a movable contact in operative engagement with the actuator member to be movable against and away from the fixed contact as the armature plate is moved.

2. A vacuum relay, comprising:

a base having inner and outer faces;

a dielectric envelope sealed to the base to define an evacuated chamber, the base inner face defining a portion of the chamber;

an electromagnet secured to the base and having a pole piece extending through and sealed to the base;

a leaf spring having an end secured to the base, the leaf spring extending laterally across the base inner face and in longitudinally spaced relation to the pole piece;

an armature plate rigidly secured to the leaf spring to extend over and be biased away from the pole piece by the leaf spring, the armature plate being movable toward and away from the pole piece as the electromagnet is energized and de-energized respectively;

a dielectric member rigidly secured to the armature plate and extending into the evacuated chamber;

an actuator member rigidly secured to the dielectric member and spaced from the armature plate;

a first terminal post sealed to and extending through the dielectric envelope into the evacuated chamber to define a fixed contact;

a second terminal post sealed to and extending through the dielectric envelope into the evacuated chamber; and

a resilient blade-shaped movable contact having a portion loosely coiled around and secured to the second terminal post, the movable contact extending toward the fixed contact and being in operative engagement with the actuator member to be movable against and away from the fixed contact as the armature plate is moved.

3. The vacuum relay defined in claim **2** in which the actuator member includes an upper portion defining an open-ended slot, and the resilient blade-shaped movable contact extends through the slot.

4. The vacuum relay defined in claim **2** and further comprising a third terminal post sealed to and extending through the dielectric envelope to define a second fixed contact, the resilient blade-shaped movable contact extending between the fixed contacts to be against one of the fixed contacts when the electromagnet is energized and the other of the fixed contacts when the electromagnet is de-energized.

References Cited

UNITED STATES PATENTS

3,238,324	3/1966	Roessler	335—154 X
3,275,783	9/1966	DeLucia	200—144 X
3,344,253	9/1967	Roessler et al.	200—144

BERNARD A. GILHEANY, *Primary Examiner.*

R. N. ENVALL, *Assistant Examiner.*