

[54] POSITION-INSENSITIVE MERCURY RELAY

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Related U.S. Application Data

[60] Division of Ser. No. 71,294, Sept. 10, 1970, Pat. No. 3,715,546, which is a continuation-in-part of Ser. No. 880,128, Nov. 26, 1969, Pat. No. 3,644,693.

[52] U.S. Cl. 200/214, 200/210

[51] Int. Cl. H01h 29/00

[58] Field of Search..... 200/209, 210, 214,
200/182, 61.47; 335/56

[56] References Cited

UNITED STATES PATENTS

3,144,533	8/1964	Donath	200/214 UX
3,519,965	7/1970	Horowitz	200/210

Primary Examiner—Herman J. Hohauser

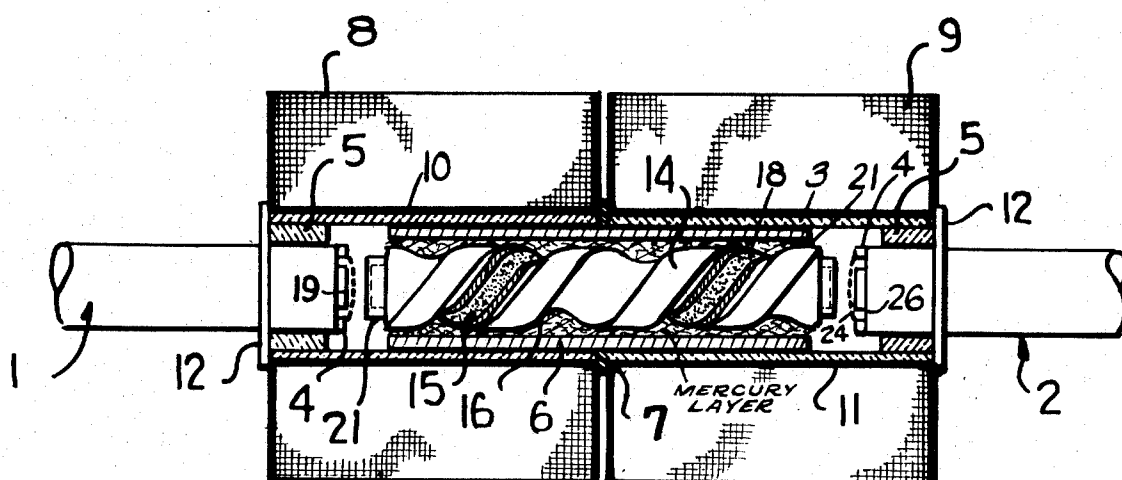
Attorney—Hyman Hurvitz

[57] ABSTRACT

A miniature mercury switch, comprising an enclosure including a tube having a mercury wettable inner surface, within which a contact carrying shuttle is movable along the axis of the tube. The shuttle is not mer-

cury wettable except for a slot or groove extending between its ends and for contact surfaces at its ends, but it rides on a mercury layer attached to the inner surface of the tube. Secured within and extending into the ends of the tubes are unwettable rods of magnetic material having stationary end contacts which are mercury wettable. The contacts on the shuttle ends include tantalum or niobium spacers extending beyond mercury wettable end contact surfaces on the shuttle, the spacers accepting the impacts when the relay contacts operatively close, which implies that the wettable contact areas on the shuttle ends closely approach the stationary end contacts, so that the mercury layers coalesce, but the wettable surfaces do not impact. The quantity of mercury within the enclosure is only sufficient to form a layer of mercury on the mercury wettable surfaces within the enclosure, but insufficient to form a pool of mercury, or to cover unwettable surfaces while wettable surfaces are covered, and the slot or groove in the shuttle facilitates transfer of mercury from end to end of the enclosure, which prevents pooling at either end of the enclosure concomitant with depletion at the other, due to imbalance of mercury transfer during relay operation. Stationary contacts are, for open contact condition, spaced from movable contacts, by mercury unwettable surfaces of the enclosure, and the quantity of mercury available is insufficient to cover these unwettable surfaces and also to form a mercury layer on the mercury surfaces.

3 Claims, 6 Drawing Figures



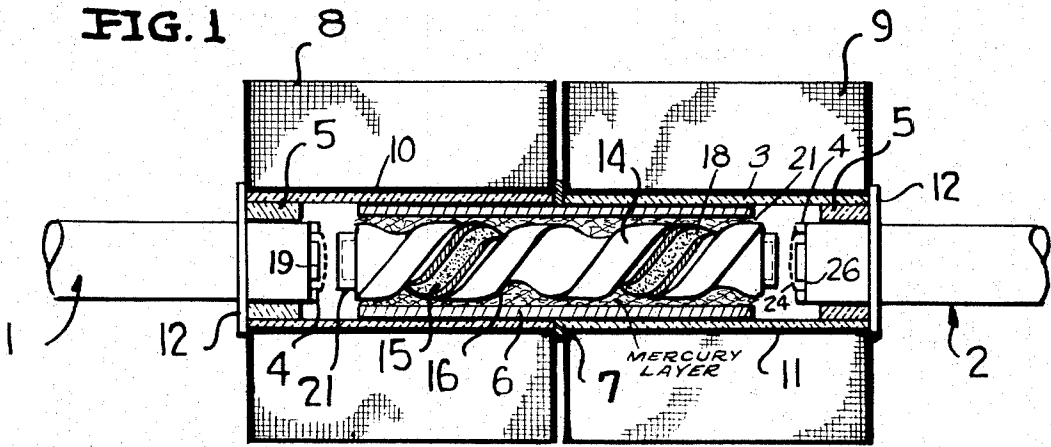


FIG. 2

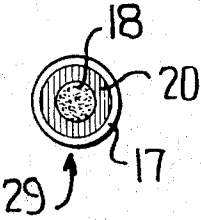


FIG. 3

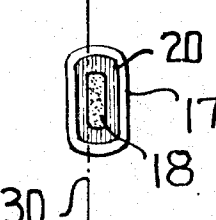


FIG. 4

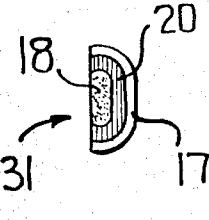


FIG. 5

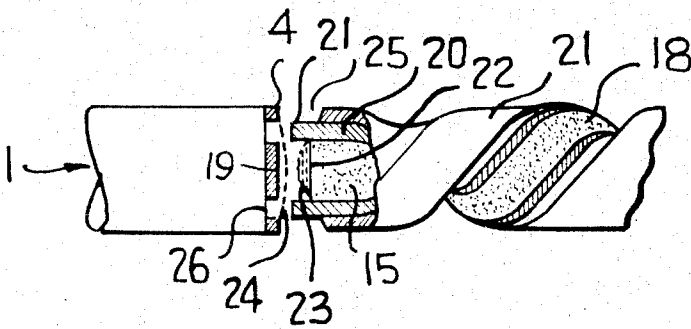


FIG. 6

POSITION-INSENSITIVE MERCURY RELAY

CROSS REFERENCE

This is a division, of application Ser. No. 71,294, filed Sept. 10, 1970, now U. S. Pat. No. 3,715,546 which is a continuation-in-part of Bitko, Ser. No. 880,128, filed Nov. 26, 1969 now U.S. Pat. No. 3,644,693 entitled: NON-STICKING RELAY CONTACTS, assigned to the assignee of this application.

BACKGROUND OF THE INVENTION

This invention is an improvement of the relay disclosed in U. S. Pat. to Donath, U. S. Pat. No. 3,144,533, issued Aug. 11, 1964. That patent includes a non-wettable shuttle riding on a layer of mercury sustained by the inner mercury wettable surface of a metallic tube. The contacts of the relay are mercury wettable, one at each end of the tube, each contact coating with mercury wettable contacts formed on the ends of the shuttle. It is found that after long shelf life or many closures of the Donath switch the contacts of the Donath relay tend to stick, the numbers of trouble-free operations decreasing with increase of temperature. Study of the mechanism of sticking indicates that it is caused by diffusion of metal between contacts due to proximity or current flow, and that this occurs despite the mercury layers on the contacts and perhaps because of it, since mercury wettable metal tends to be soluble in mercury. All attempts to discover metals which while mercury wettable and therefore suitable as contacts, are also totally non-soluble and non-transferable under proximity or current flow were unsuccessful.

The concept was then advanced of including in each of the shuttle contacts an impact absorbing spacer which is non-mercury wettable, and hence not soluble in mercury, but sufficiently hard to absorb impact without substantial deformation. The contacts themselves must be wettable, but these are located so far inward of the spacers that a mercury layer attached to the shuttle contact can reach the mercury layer attached to the stationary contact, yet are so located that no impact or transfer of metal occurs between the mercury wettable surfaces. This concept is broadly disclosed and claimed in Bitko, Ser. No. 880,128, supra, as applied to a reed switch or relay. The present invention relates to the same broad concept as does Ser. No. 880,128, but applied to a shuttle relay, and includes novelty in respect to the fabrication and structure of the shuttle. The envelope is designed to permit of particularly economical assembly from simple parts.

SUMMARY OF THE INVENTION

A mercury relay having a shuttle armature riding on a thin layer of mercury, in which the ends of the shuttle are mercury wettable but provided with non-mercury wettable projections which provide spacing to stationary contacts and thus prevent contact sticking.

BRIEF DESCRIPTION OF THE DRAWINGS

The above and still further objects, features and advantages of the present invention will become apparent upon consideration of the following detailed description of one specific embodiment thereof, especially when taken in conjunction with the accompanying drawings, wherein:

FIG. 1 is a new partly in side elevation and partly in section of a relay according to the invention;

FIGS. 2-5 are sections taken through a solid cylinder of material at various stages in the fabrication of a shuttle for the relay of FIG. 1;

FIG. 6 is a broken away view in side elevation illustrating details of contacts of the relay of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

The relay of FIG. 1 is provided with two stationary contact bearing rods 1 and 2, the contacts being stationary and extending into a sealed envelope 3. Rods 1 and 2 are fabricated of non-mercury wettable magnetic material but each end surface is provided with a coating or layer 4 of mercury wettable material such as platinum. The thickness of the coating or layer may be about 0.0002 inches. The rod must be relatively hard, to withstand repeated impacts without deformation, but the coating or layer may be relatively soft, and therefore may suffer deformation.

A glass annulus 5 surrounds each rod interiorly of the envelope at its ends, and is sealed thereto, providing insulative support.

Interiorly of the envelopes is a thin walled metallic tube 6 of circular cross section, which is metallic and interiorly mercury wettable. From the tube, midway thereof extends an annulus 7, which serves to position actuating coils 8, 9 and also to position two glass cylinders 10, 11 which extend over tube 6 from opposite ends and extend beyond the tube 6 at each end of the tube 6, into superposed conjunction with glass annulus 5. The glass tubes 10, 11 are heated to effect a seal with the metallic tube 6 and with the glass annuli 5 and with the metallic annulus 7, and the enclosure is further end sealed by discs 12. Thereby, an enclosure is formed, which is hermetically sealed so that it may be filled with inert gas.

Within the enclosure is located a shuttle 14, having thereon a helical groove 15 extending along the entire length of the shuttle. The shuttle 14 is generally cylindrical in outline as seen from its end and presents a sliding fit within the tube 6, making allowance for a thin layer of mercury 16 intervening between the shuttle and the tube. The outer surface layer 17 of the shuttle is not mercury wettable. The helical groove 15 extends into a non-magnetic but mercury wettable core 18, and a tantalum or niobium tube 20, which is not wettable, extends between the outer layer of the shuttle and the inner core. The groove provides a path for interchange of mercury between the ends of the envelope, which is required to assure balanced distribution of mercury, at least statistically. If the groove is not provided, mercury may collect in one side of the switch, resulting in a short at that side and possible dry contacts on the other side. The groove also conveys mercury which is integral with or joined with that existent in the thin layer on the tube 6, thereby to provide a low resistance path directly from the core 18 of the shuttle to the outer tube.

The shuttle requires, at each of its ends according to the present invention, an interposer 21 between the movable contact surface 22, which is mercury wettable and always is provided with a layer of mercury 23, and the stationary contact surface 4, which also is mercury wettable and is provided at all times with a layer of mercury 24. The interposer is, for optimum results, an annulus of either tantalum or niobium, but may consist

of other mercury non-wettable hard metals if these are sufficiently hard, which extends beyond the true contact surface 22 by about one mil. While the interposer 21 may be fabricated in a variety of ways, a preferred way is to remove an annulus 25 of the outer end of tube 21, exposing a ring of the interposer metal, and thereafter exposing the interposer metal to a hot hydrogen atmosphere. This treatment causes the interposer metal, if tantalum or niobium, to expand by absorption by hydrogen. However, it is also feasible to remove a layer of metal from the core 15, as by dissolving it in hot mercury. In either case, the interposer is produced as a projecting annulus, which impinges against the contact surface 19 when the contacts close. The interposer metal, being mercury non-wettable, cannot diffuse into the mercury. The layer 19 is relatively soft, and quite thin, while the interposer is relatively hard, so that relatively few operations of the relay produce an annulus recess 26, extending through the layer 4. The interposer 21 is slightly longer axially than the recess 26 is deep, so that the interposer always impinges directly on the end of rod 1, which is itself not mercury wettable. Thereby, the metal layer 4 does not diffuse on impact, and the relay is free of sticking, indefinitely.

A preferred method of fabricating the slug 14 is to start with a cylinder 29 comprising a non-magnetic, mercury wettable core 16, interiorly, an inner tube of tantalum 20, surrounding core 16, and an outer tube of magnetic, non-mercury wettable metal 17, all integral with one another. The cylinder 29 is flattened by rolling, as illustrated in FIG. 3, and cut down along the line 30, as by grinding, to expose the inner core 18, resulting in an elongated member which is generally ovoid for more than half its circumference and flat for the remainder, the flat surface 31 exposing all three metals. The shape of FIG. 4 is further rolled to achieve precise dimensions, and the resultant shape is twisted to form a multi-turn helix, which can be electropolished to precise OD and length dimensions, and to have an essentially circular outline as viewed from an end.

The present relay has the operating properties of the Donath relay, plus the additional property that its contacts do not stick even after many millions of closures. Particularly, it may be mentioned that the switch is inherently bistable, and can therefore be operated in response to a short impulse which need not endure.

The wettable to non-wettable surface ratio of the Donath switch is substantially retained and the O.D., length and general operating characteristics may remain as described in the Donath patent, to which reference is made for a complete discussion of the theory and philosophy of operation.

The helical shuttle or slug 14 should preferably be symmetrical in respect to weight distribution along its length and also in respect to distribution of strip 15, which because it is wettable establishes a drag, and also in respect to the outermost non-wettable surface. The first mentioned objective, i.e. symmetry, is readily achieved by having a helix of an integral number of turns, in the present case, two. Reduction of the area of the non-wettable surface reduces friction, and controlling the depth and width of the inner diameter of 15 of the helix, which is mercury wettable, affects total shuttle mass, because mercury is dragged along the shuttle. The presently described method of making the shuttle enables ready control of the several factors mentioned. There is a problem of so proportioning the

dimensions of the shuttle that it is magnetically symmetrical and also symmetrical in respect to weight distribution, so that on transfer of the shuttle from one location to another it will ride axially and this in any orientation of the relay, which is totally position insensitive. This is accomplished by employing an integral number of helical turns, and conformity of structure along the length of the slug.

It will be appreciated that core 15 need not be non-magnetic.

While I have described and illustrated one specific embodiment of my invention, it will be clear that variations of the construction which are specifically illustrated and described may be resorted to without departing from the true spirit and scope of the invention as defined in the appended claims.

I claim:

1. A switch comprising

an envelope,

at least two contacts,

a pair of mutually insulated conducting liquid layers within said envelope each associated with a different contact surface,

at least one of said contact surfaces being movable toward and away from the other of said contact surfaces,

said conducting liquid layers wetting at least said contact surfaces and being capable of completing the circuit between said contacts when said contacts are operatively closed, the ratio of the total area of the surfaces within said envelope to the area of said conducting liquid layers being less than 2,

wherein at least one of said contact surfaces carries an interposer which is non-wettable by said liquid and which is positioned and dimensioned to absorb impacts occurring on closures of said contact surfaces and to maintain a predetermined physical separation of said contact surfaces during said closures.

2. A relay comprising

an envelope,

a quantity of conducting liquid having high surface tension located in said envelope,

contact surfaces and surfaces mutually insulating said contact surfaces located internally of said envelope,

said contact surfaces only being wettable by said liquid,

said surfaces mutually insulating being unwettable by said liquid,

said surfaces mutually insulating at least in part forming said envelope, the quantity of said liquid being only adequate to cover said contact surfaces with a layer of said liquid and inadequate to form a pool of said liquid in addition to said layer,

wherein at least one of said contact surfaces includes an interposer facing the other of said contact surfaces,

said interposer being unwettable by said liquid and dimensioned to prevent near approach of said contact surfaces by less than about one mil.

3. The combination according to claim 2, wherein said at least one of said contact surfaces is included on a shuttle freely floating in said liquid.

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