

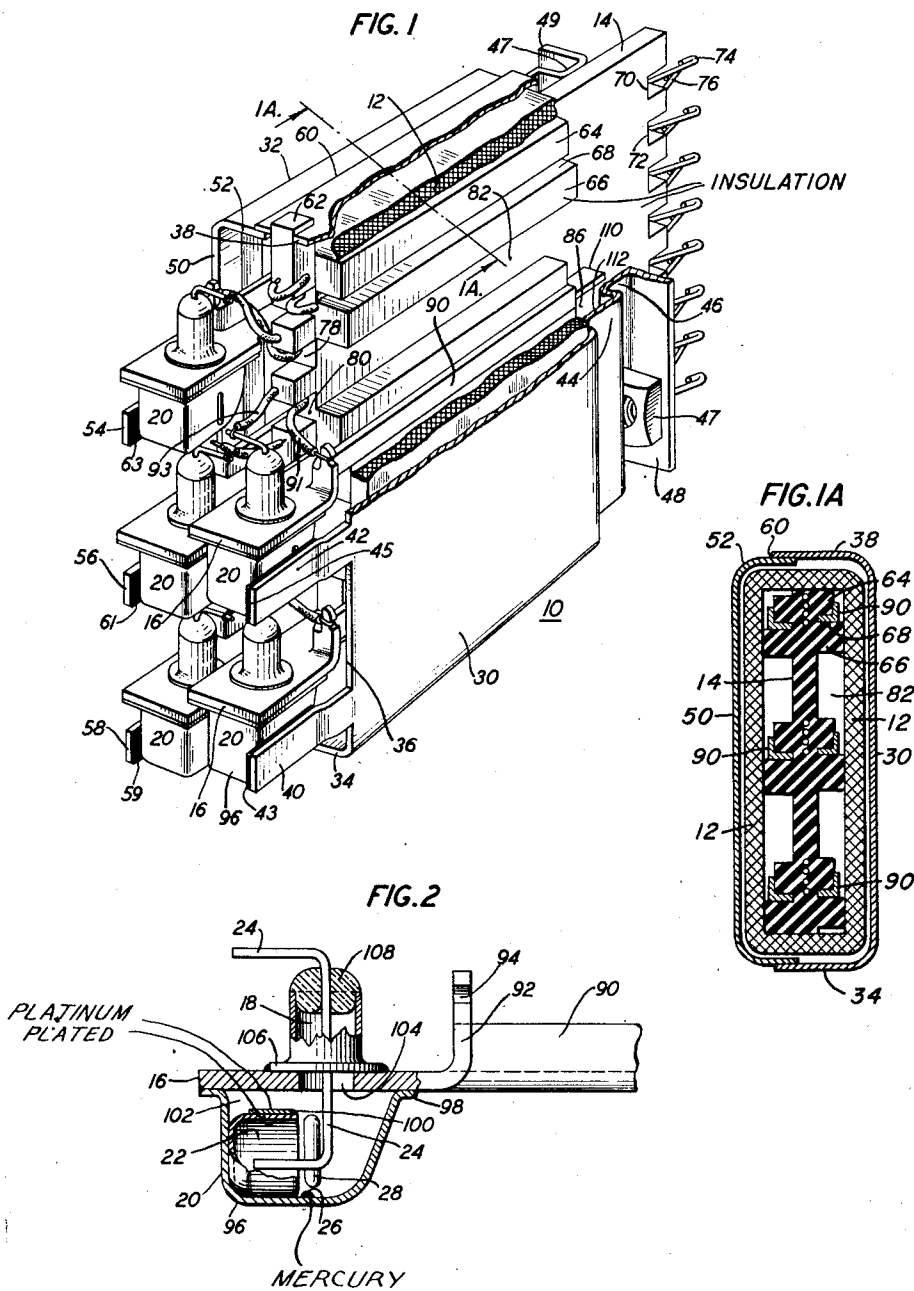
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H. C. HARRISON
MERCURY TYPE RELAY

2,542,668

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2 Sheets-Sheet 1



INVENTOR
H. C. HARRISON
BY John E. Cassidy
ATTORNEY

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FIG. 3

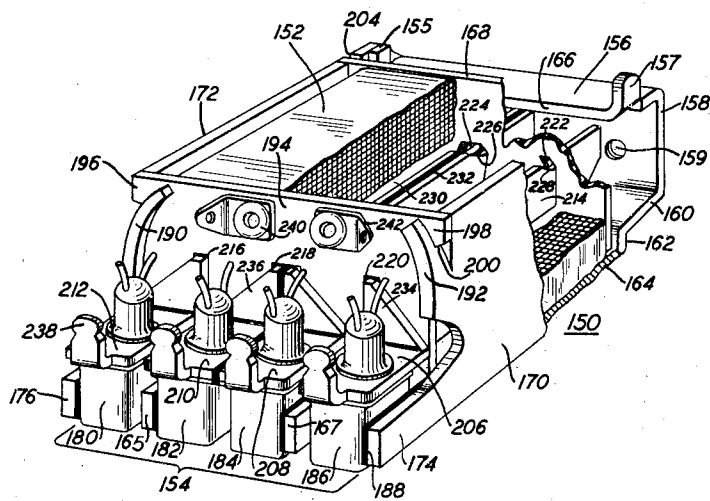


FIG. 4

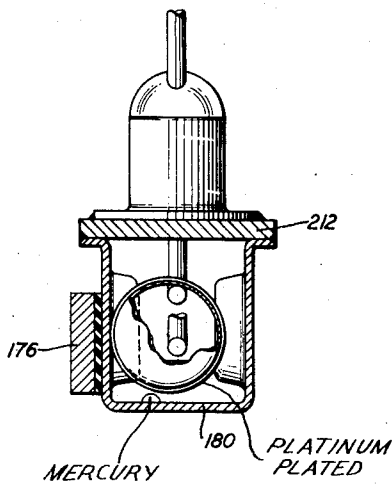
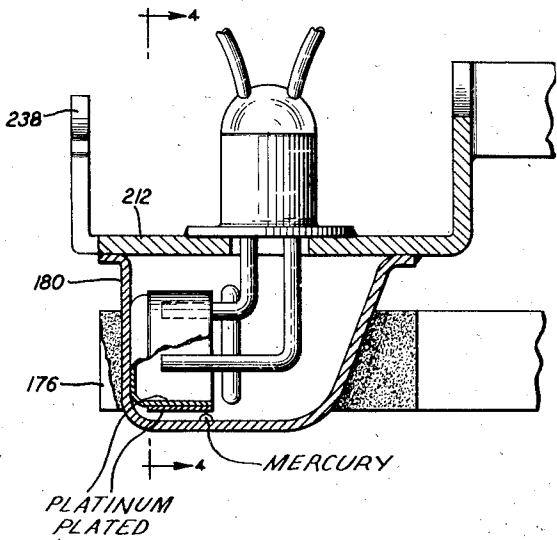


FIG. 5



INVENTOR
H. C. HARRISON
BY *John E. Cassidy*

ATTORNEY

UNITED STATES PATENT OFFICE

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MERCURY TYPE RELAY

Henry C. Harrison, Port Washington, N. Y., assignor to Bell Telephone Laboratories, Incorporated, New York, N. Y., a corporation of New York

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4 Claims. (Cl. 200-112)

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This invention relates to improvements in electromagnetic relays particularly to relays in which electrical contact is established through a conducting fluid such as mercury.

An object of this invention is the improvement of electromagnetic relays particularly such relays in which electrical contact is established through a conducting fluid such as mercury.

A further object of this invention is the provision of an electromagnetic relay in which contact is established through a conducting liquid such as mercury, which relay is responsive to the small amounts of energy to which relays operating in communications systems, for instance, are frequently restricted and which relay is convenient to handle as well as to install and which requires practically no maintenance or adjustment.

A feature of this invention is a mercury contact relay which, with regard to its mounting arrangements, generally resembles the ordinary electromechanical switching relays employed in the communications switching plant and which may be mounted without special provision on an ordinary vertical mounting plate.

A further feature of this invention is a compact electromechanical mercury contact relay arranged to require a minimum amount of space for the mercury contacting unit.

A further feature of the present invention is a fluid contact electromagnetic relay having a plurality of switching units and including relatively simple arrangements for changing the number of switching units up to the maximum possible in a relay as well as for replacing defective switching units.

A further feature of the invention is the provision of a plural contact electromagnetic relay which operates on small amounts of power, which is very reliable and inexpensive.

A further feature of this invention is a multiple mercury contact electromagnetic relay which is both exceedingly rugged and compact in construction and which is arranged so that the dimensions of the mercury contacting units, per se, are a minimum so that a number of the units may be incorporated in a single relay which, in mounting space requirements, general method of mounting and general all around utility is comparable to relays of the spring contact type while affording the well-known advantages of mercury contacts.

The relay of the present invention solves the problem of a compact rugged plural mercury contact relay which may be mounted in the same

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manner as the ordinary communications switching relay.

The drawings show two preferred embodiments in which the plural mercury contact relay of the present invention is incorporated but the invention is not so limited and may be incorporated in other embodiments which will readily suggest themselves to those skilled in the art.

In the drawings:

10 Fig. 1 is a perspective view partly in section and having portions broken away to disclose the details of one preferred embodiment of the relay of the present invention;

15 Fig. 1A is a sectional view through line 1A in Fig. 1.

Fig. 2 is an enlarged vertical elevation, partly in section, and having portions broken away, of the contact unit of Fig. 1;

20 Fig. 3 is a perspective view, partly in section and having portions broken away, of a second preferred embodiment of the relay of the present invention;

25 Fig. 4 is an enlarged end elevation, partly in section and having portions broken away, of the contact unit of Fig. 3; and

Fig. 5 is an enlarged side elevation, partly in section and having portions broken away, of the contact unit of Fig. 3.

Refer now to Figs. 1 and 2.

30 The relay per Figs. 1 and 2 comprises a number of major units to be described hereinafter in detail comprising a casing or shell 10 of magnetic material, a current conducting coil 12, a combination terminal block and spacer plate 14, pole-pieces 16 of magnetic material, conductor lead-in assembly or eyelet 18 and impervious container 20 which houses the mercury contact elements.

40 The casing or shell has a front portion 30 and a rear portion 32 each formed of a single bent plate of magnetic material. The front portion 30 has a horizontal base 34, a vertical wall 36 and a horizontal top 38. At the left-hand end of the vertical wall 30 are three spaced depressed rectangular tabs such as 40 and 42 to the inner surfaces of which are cemented rectangular insulators such as 43 and 45. At the right-hand end of the vertical wall 30 is an irregularly-shaped portion comprising a first depressed portion 44 having an L-shaped cross-section, and a second further depressed portion 46 having a generally U-shaped cross-section which terminates in a mounting flange 48 at right angles to the vertical wall 30.

55 The rear portion 32 of the casing has a vertical

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wall 50, a horizontal base, not shown, and a horizontal top 52. At the left-hand end of the vertical wall 50 are three spaced depressed rectangular tabs 54, 56 and 58 to the inner surfaces of which are cemented rectangular insulators 59, 61 and 63. At the right-hand end of the rear portion 32 the vertical wall 50 is bent into a shape which is the inverse of the right-hand end of the front vertical wall 36. The bottom 34 and top 38 of the front portion 30 overlap the bottom and top of the rear portion 32 and the front and rear portions 30 and 32 may be welded together along the outer edges of the overlap as at 60. A square notch is cut at the left-hand end of the top 38 equidistant the vertical walls 36 and 50 to accommodate a square projection 62 in the left-hand end of the top edge of the terminal strip 14 and a corresponding notch, not shown, is cut in the bottom 34 to accommodate a corresponding projection in the left-hand end of the bottom edge of the terminal strip 14.

The terminal strip and spacer 14 is a vertically disposed generally flat rectangular plate, preferably molded of insulating material, having twelve projecting rectangular guide blocks such as 64 and 66, six on the front and six on the rear surface of terminal strip 14, arranged in three pairs on each surface. The unit blocks of each pair are spaced vertically, each from the other, to provide a horizontal slot such as 68 between the units of each pair and there is a larger separation such as 82 between pairs. The pairs of blocks on the front of plate 14 are displaced vertically with respect to corresponding pairs on the back of the plate. The right-hand end of the terminal strip has seven rectangular notches such as 70 and 72 to provide alternate protruding and depressed vertical surfaces individual to each of fourteen conductors molded in the terminal strip 14, through which surfaces alternate terminals, such as 74 and 76 of the conductors project. The lower of each succeeding two terminals is bent upwardly and to the rear to form a paired group with the upper of the two terminals. Six of the seven pairs of terminals project entirely through the terminal block 14 from right to left to provide one pair for each of the six mercury contact assemblies. The seventh or lowest pair of terminals which connect to the terminals of the coil 12 extend only part way through the block 14 to the right-hand end of coil 12 where one projects through the front and the other through the rear surface of block 14 and each is connected to a terminal of coil 12. Terminal block 14 at its left-hand end has six rectangular notches such as 78 and 80 to provide alternate protruding and depressed vertical surfaces through each of which surfaces an individual conductor of a pair projects for connection to the mercury contact units.

The coil 12, which may be of enamel insulated conducting wire, is wound transversely around the insulating plate 14 from a position to the right of projection 62 to the right-hand end of the guide blocks such as 64. A rectangular aperture, not shown, is provided in the inner wall of the U-shaped depression such as 46 in the front and rear casings 30 and 32 and the terminal strip 14 is provided with a rectangular depression in its front and rear surfaces in alignment with the aperture. A mounting nut, such as 47, is welded to the left-hand surface of the mounting flange. The inner edge of the nut projects through the corresponding aperture and into the aligned rectangular depression to lock the terminal strip assembly in position. The mounting flanges 48

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and 49 are apertured in axial alignment with the tapped hole in the nuts 47 through which mounting screws may project to engage with the threads in the nuts.

The pole-piece 16, as seen in Figs. 1 and 2, may be formed of a single flat plate of magnetic material. A rectangular notch 86 is cut from its right-hand front corner and a front section 90 of the plate extending from the left-hand end of the notch toward the left to a point to the left of the guide blocks is bent upwardly to form an L section. A short terminal tab 92 is also bent upwardly at the left-hand end of vertical section 90 and at right angles thereto to provide a terminal opening 94 in which a conductor such as 91 may be soldered. The three pole-pieces which are mounted on the rear of the insulating block 14 have elements corresponding to notch 86, L section 90, terminal tab 92 and terminal opening 94 except that they are cut and formed along the rear edge instead of the front edge of the pole-piece plate.

A relatively small rectangular box-like impervious container 20 of non-magnetic material, such as stainless steel, is welded along its four flanged top edges, such as 98, to the bottom left-hand end of the pole-piece 16. To anticipate, the welding, both of the container 20 and of the glass beaded alloy eyelet 18, to be described hereinafter, may be performed simultaneously generally in accordance with the procedure described in the patent issued to me jointly with John B. Little, 2,326,296, issued August 10, 1943. Opposed raceways such as 28 are pressed into the front and rear side walls of the container. A small shallow cylindrical cup 22 of magnetic iron preferably drawn out of a flat sheet, platinum plated on both surfaces and having its side wall folded over so as to provide a smooth rounded edge 100, is inserted in the container. The folded edge 100 serves the purpose of insuring a smooth edge both for permitting the cup to roll about its own horizontal axis and to provide a continuous platinum surface for the capillary flow of mercury between the outside and inside of the cup. The cup is supported with its cylindrical surface adjacent the interior bottom surface of the container so that the cup is free to roll; its relatively flat bottom surface abuts the interior surface of the left-hand side wall. The height of the container 20 is greater than the diameter of the cup 22 to leave an air-gap 102 between the upper cylindrical surface of the cup and the bottom surface of the pole-piece 16 which forms the top inner surface of the container chamber. The cup 22 is so proportioned relative to internal dimensions of the container 20 that electrical contact is maintained at all times between some portion of the wetted conducting surfaces of the cup and of the container 22. The raceways 28 may be spaced slightly to the right of the right-hand end of the cup 22 as indicated in Figs. 2 and 5 so long as contact is maintained between the wetted surfaces of the left-hand end of the cup 22 and the inner surface of the left-hand end wall of container 20.

Each pole-piece 16 is apertured as at 104. A cylindrical eyelet 18, having a flange 106 surmounts the aperture 104 and is welded together with container 20 simultaneously, generally in the manner described in the heretofore mentioned patent, to pole-piece 16. The eyelet 18 has a glass bead 108 sealed in its upper end and sealed in the glass bead is a conducting wire 24 which projects through the hollow interior of the

eyelet 18 and the aperture 104 into the interior of the impervious container 20 to a position slightly above the lower interior cylindrical surface of the cup 22 for make contacts or just above the level of the upper interior cylindrical surface, so that the cup 22 may hang on the wire, for break contacts where it is bent at right angles and projects into the cup. One of the wires, such as 93, of a pair is soldered to each lead in conductor such as 24. The coefficient of expansion of the conductor, the glass bead and the cylindrical eyelet are matched so that the seal will not be affected by temperature changes. Such eyelet and lead-in conductors are available commercially and are well known in the art. As a step in the welding process described in the above-identified patent a globule of mercury is introduced into container 20. The mercury wets the surfaces of cup 22 and is drawn by capillarity into the interior of the cup to maintain constantly a fresh contacting surface.

It is particularly pointed out that although only a single switching contact in each container is illustrated in Fig. 2, the invention is not so limited but may be practiced with more than one switching contact by bringing into the chamber 20 whatever number of contacts may be necessary and disposing them in the required relationship to the cup 22 or to a plurality of cups such as 22 within a single modified container to effect the required switching. For instance as shown in Figs. 4 and 5 two conductors may be introduced into the container 20. The cup 22 may be hung on one conductor to provide a break contact. The second conductor may be disposed as illustrated in Fig. 2 to provide a make contact. Two-conductor eyelets are available commercially for this purpose and other arrangements of lead-in conductors are feasible and are within the scope of the invention.

The six pole-piece assemblies, or whatever number less than six may be employed in a particular relay to effect whatever switching is required of the relay, may each be pushed into an individual slot, such as 68, with its inner straight edge abutting the surface of terminal strip 14 and the inner surface of the vertical section 90 abutting the front surface of the upper block, such as 64, of the pair of guide blocks, such as 64 and 66. The magnetic circuit for a particular contact assembly extends from the left-hand end of a particular pole-piece 16 through the pole-piece from left to right, through a small gap between the right-hand edges of the pole-piece to the adjoining depressed portion such as 44 of the vertical wall such as 36, back along the vertical wall 36, to a tab such as 40, across a gap to the rear surface of a magnetic cup and then finally through a gap above the magnetic cup back to the lower surface of the left-hand end of a pole-piece 16.

The magnetic cup 22 normally rests at the bottom of the container 20 and in electrical contact with the container 20 through films of mercury on the exterior surface of the cup and on the interior surface of the container. For a make contact the lead-in conductor 24, which is coated with mercury, is electrically disengaged from the cup. The lower horizontal surface of the conductor 24 is separated from the lower inner surface of the cup by a small gap. When the coil 12 is energized all cups 22 in a particular relay are raised and contact is established between the thin films of mercury coating the interior of the cups

22 and the surfaces of rods 24 which closes the electrical circuit through the exterior mercury film of the cup, the mercury film on the surface of container 20, pole-piece 16 and conductors such as 91 and 93. For a break contact the electrical circuit is normally established through the mercury contacting films coating the conductor 24 and the cup 22 which is just barely suspended above the inner surface of the bottom of container 20 on the horizontally projecting portion of wire 24 with the circuit maintained through the mercury surfaces on the exterior of cup 22 and the interior of container 20. When the coil 12 is energized the cup 22 is raised sufficiently to break the contacting film between the conductor and the cup.

In a particular embodiment the cup 22 may be about $\frac{1}{8}$ inch deep and $\frac{3}{8}$ inch in diameter made of magnetic iron about .006 inch thick. The shell or casing may be of magnetic iron $1\frac{1}{2}$ inch in height, $\frac{1}{8}$ inch wide and .020 inch thick. The inside opening of the coil may be $\frac{1}{8}$ inch wide, $1\frac{1}{2}$ inch high and the length may be $1\frac{1}{2}$ inches. The thickness of the terminal block may be $\frac{3}{8}$ inch.

Using present commercial manufacturing methods the height of the chamber within container 20 may be controlled so that its variation is limited to $\pm .003$ inch. The diameter of the cup 22 may be controlled so that its variation is limited to $\pm .002$ inch. The magnetic gap could therefore be .065 inch to .060 inch. These limits could be still further reduced after manufacture by indenting the bottom of the container 20 to give a definite value of operate current. The armature in the particular embodiment would weigh about .100 gram. The operate current would be about 20-ampere turns for the .060 inch gap. At 60-ampere turns the operate time would be less than .010 second.

The mercury drop serves to wet the rolling cup armature, the inside of the stainless steel cup and the armature contact wire which are all platinum plated. If there were no oxygen present in the eyelet or on the metal surfaces they would all wet with mercury without any platinum plating being required. In practice it is difficult to prevent a little oxygen being present in the switch. This oxygen distributes itself among the metal surfaces and the mercury according to their several affinities for oxygen. Platinum having very little affinity for oxygen gets very little and maintains a mercury surface. Iron and stainless steel tend to pick up layers of oxide which do not wet with mercury. Mercury in general will not take oxygen away from iron or stainless steel. In the presence of free oxygen and under the action of contact arcs, mercury forms oxide and after a time becomes very pasty. A very small amount of oxygen absorbed in the mercury does not seriously impair its liveliness and contact action.

Mercury dissolves some metals such as gold and silver and hence they are not satisfactory inside mercury switches. Iron, stainless steel and platinum are dissolved by mercury in such extremely slight amounts that they appear to be quite permanent in mercury switches.

In a mercury switch the shapes of the surfaces wet by the mercury and the areas of the contacts determine such matters as load carrying capacity and the distance of travel for break. Over the outside of a wetted sphere the mercury pulls down into a very thin skin whereas on a wetted surface of the inside of a cup the mercury piles up into a mound. A wetted wire pulled out of a

mercury surface lifts out a miniscus of the order of the diameter of the wire before contact is broken. Hence a small wire has to move only a small distance to break contact and only a small force is required.

If the energy liberated at the contact evaporates only a portion of the mercury, there is no permanent wear. The amount of energy liberated and the amount of mercury required at the contact depends on the circuit and particularly on any protection present. The amount of mercury available depends upon the shapes of the contact parts. With different contact designs a great many different results in the matter of times of make and break and load capacity can be obtained.

The rolling cup design provides a few mils thickness of mercury on the inside of the cup for the small contact wire to dip into. The depth of mercury should be sufficient to prevent any contact chatter and the load capacity should be sufficient for the particular application.

Attention is particularly called to the fact that not only are the number of contacting unit assemblies in a particular relay variable up to the maximum which may be accommodated in the particular embodiment, which in that illustrated in Fig. 1 is six, but the arrangement is such that the addition, subtraction or substitution of a unit is exceedingly simple.

Attention is also particularly called to the fact that the relay is quite inexpensive. The component parts of the relay lend themselves to relatively simple manufacturing methods. And in operation the relay is extremely reliable.

The second preferred embodiment of the invention is shown in Figs. 3, 4 and 5. This differs essentially from the arrangement in Figs. 1 and 2 in that: (1) It is arranged to accommodate the pole-pieces and mercury contact assemblies in a single horizontal row instead of in superimposed tiered pairs as in Fig. 1, so that the relay may be mounted on a narrow vertical mounting plate; (2) The relay is arranged for mounting on the front of the plate and is wired also from the front of the plate instead of from the rear of the plate as in Fig. 1; (3) The relay has no terminal strip as has the relay per Fig. 1; (4) The relay is illustrated as equipped with transfer contacts requiring two-conductor eyelets whereas the relay per Fig. 1 is illustrated as equipped with make contacts, but it is to be understood as pointed out in the foregoing that the contact arrangement, whether make, break or transfer is a matter of choice to meet the particular switching requirements.

Refer now to Figs. 3, 4 and 5.

The relay assembly per Fig. 3 comprises three major units, namely a frame 150, a coil 152 and a pole-piece and mercury contact assembly 154. The frame 150 may be formed of a single flat plate of magnetic material. At the right-hand or rear end it is folded to form a mounting bracket having an upper horizontal element 156, from which project two vertical tabs 155 and 157. The mounting bracket folds downwardly to form a vertical back wall 158 which abuts the mounting plate, not shown. In the back wall 158 are tapped apertures 159 to accommodate mounting screws. The mounting bracket then folds forwardly to form a bottom for the mounting bracket and then projects downwardly to form a short vertical wall 162 the left-hand surface of which, together with the left-hand edge 166 of element 156 form an abutment for

the right-hand insulating spool head 168 of coil 152. The frame then projects forwardly to form the bottom 164 of the coil compartment.

Vertical side walls 170 and 172 are folded upwardly and abut against the edges of the mounting bracket. At a point adjacent the tabs 155 and 157 the vertical walls 170 and 172 are provided with notches such as 204 into which projections of the spool head 168 extend. Extensions of the side walls 170 and 172 project forwardly to form vertical tabs 174 and 176. Portions of the bottom are folded upwardly to form vertical tabs 165 and 167. The tabs each form a portion of the magnetic circuit for particular mercury contact containers 180, 182, 184 and 186 from which each tab is separated by a rectangular insulator such as 188. Segments 190 and 192 are partially severed from the upper portion of vertical walls 170 and 172 and are bent inwardly to clamp the left-hand insulating spool head 194 in position. The spool head 194 has formed therein near its upper edge two projections 196 and 198, the lower surfaces of which abut against shoulders such as 200 in tabs 190 and 192 to secure the spool head 194 against lateral displacement.

The four pole-pieces are each cut and folded out of a piece of magnetic material. All four of the pole-pieces 206, 208, 210 and 212 have vertically disposed longitudinal elements such as 214 which project through apertures 216, 218 and 220 in spool head 194, through a hollow chamber 230 of elliptical cross-section in the interior of the spool and through apertures such as 222 and 224 in spool head 168. The central apertures 218 and 224 are large enough to accommodate the longitudinal elements of two pole-pieces 208 and 210 which are separated by an insulating mat 232. Each of the longitudinal elements is provided with a small rounded notch in its upper edge at the position of spool head 168 and the forward lower edge of the longitudinal element is tapered so that the cross-section enlarges from the forward end of the vertical element to the position of the forward end of the spool head 168. When the vertical element is thrust through spool head 168 it snaps into a secured position. Each of the pole-pieces has a 45-degree section which is folded at right angles to its vertical longitudinal element. Two of these, those in pole-pieces 206 and 208, are folded to the right, as viewed from the front, and two, those in pole-pieces 210 and 212 are folded to the left to form abutments for the pole-pieces against the surface of spool head 194. Each of the four pole-pieces is again bent along the lower edge of the 45-degree section at right angles to form a horizontal base for the eyelet and the mercury contact chamber which are welded to the pole-pieces as heretofore described. A projection such as 238 on the forward end of each of the pole-pieces is bent upwardly and a terminal connection is shaped therein to which a conductor, not shown, may be soldered. Two conductors may be soldered to the two lead-in conductors in each eyelet shown in Fig. 5. Two terminals 240 and 242 are secured to the front surface of spool head 194 in any convenient manner to which the two terminals of coil 152 and two external conductors, not shown, may be connected. The magnetic and electrical circuits and the operation of the relay per Figs. 3, 4 and 5 may be understood from the generally corresponding description in the foregoing.

What is claimed is:

1. An electromagnetic relay having an elongated sheath-like magnetic casing, a current conducting coil within said casing, said coil wound on an elongated terminal strip in said casing, a plurality of conductors secured in and traversing said strip longitudinally, the longitudinal axis of said casing, said coil and said strip in substantial alignment, said strip having a longitudinal aperture, a magnetic pole-piece projecting into said aperture, an impervious container attached to an end of said pole-piece and a mercury contact switching device within said container connected to said conductors, said device responsive to a magnetic circuit extending through said pole-piece and said casing when said coil is energized.

2. A relay in accordance with claim 1 in which said device comprises a displaceable magnetic cup and means for wetting the inside surface of said cup with a conducting fluid by capillarity.

3. A relay in accordance with claim 1 in which said device comprises a magnetic cup having its longitudinal axis disposed horizontally, said cup supported on a horizontally bent contact wire.

4. An electromagnetic relay having a sheath-like, magnetic casing, a single magnetic coil wound on an insulating terminal strip, said terminal strip and coil within said casing, a plurality of magnetic pole-pieces, each of said pole-pieces having, near an end thereof, an individual impervious container secured thereto, a mer-

cury contact switch in each of said containers, terminals for each of said switches external to its respective container, a plurality of longitudinal openings in said terminal strip, said pole-pieces mountable in and demountable from said openings, a plurality of magnetic paths establishable through said pole-pieces individually and through said casing in common, a plurality of conductors secured in and traversing said terminal strip longitudinally, said conductors connectable to said switch terminals and a plurality of individual electrical paths through said conductors controllable through the energization of said single winding and the establishment of said plurality of magnetic paths.

HENRY C. HARRISON.

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