Oct. 25, 1949. G. C. ARMSTRONG 2,486,239

RELAY

Filed April 3, 1945

2 Sheets-Sheet 1

Fig. 1.

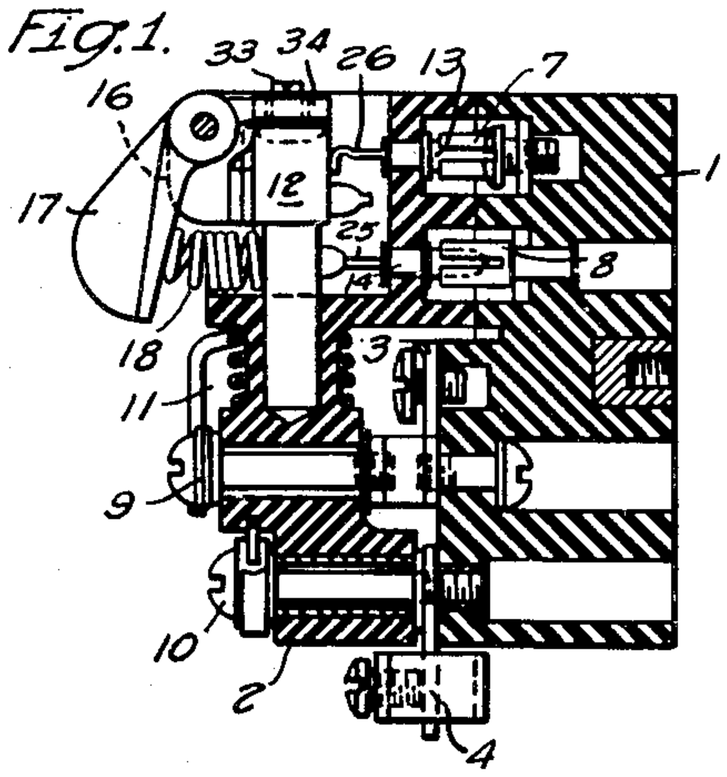


Fig. 2.

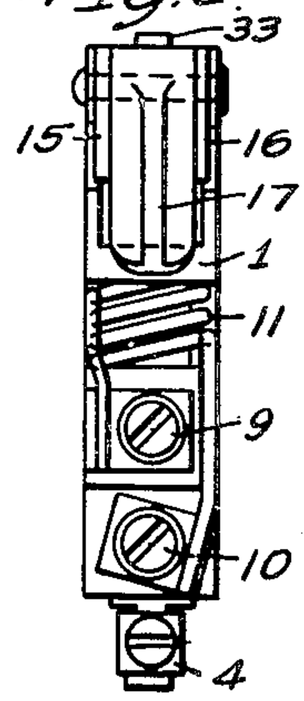


Fig. 3.

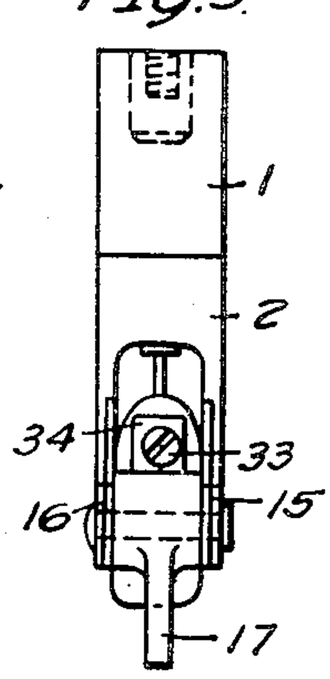


Fig. 4.

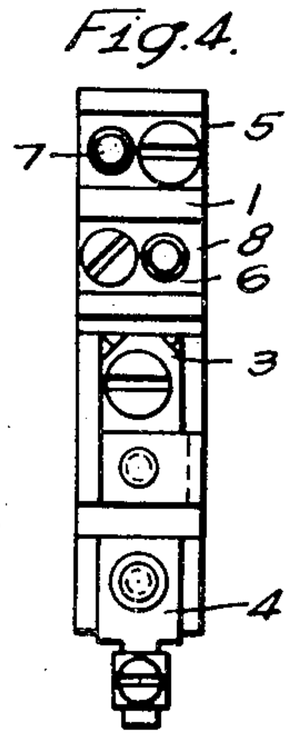


Fig. 5.

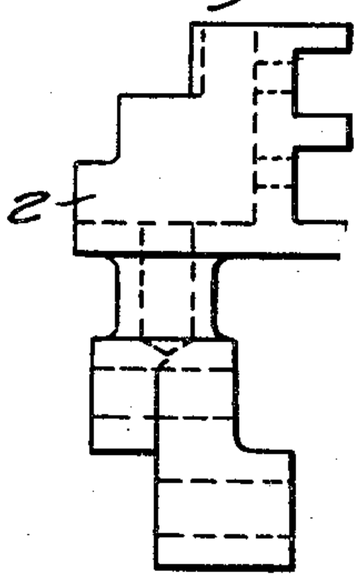


Fig. 6.

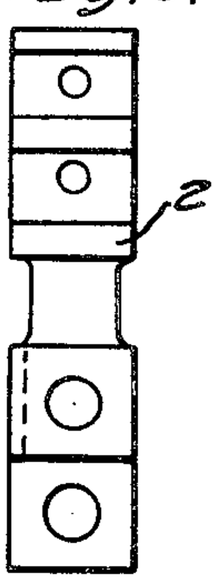


Fig. 7.

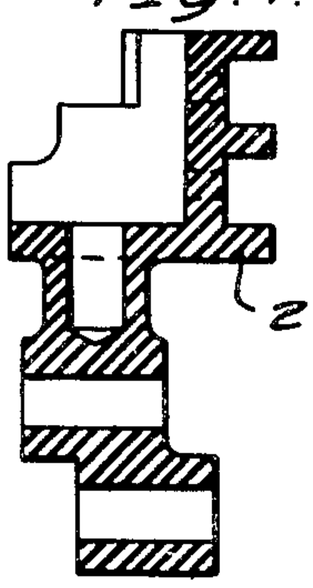
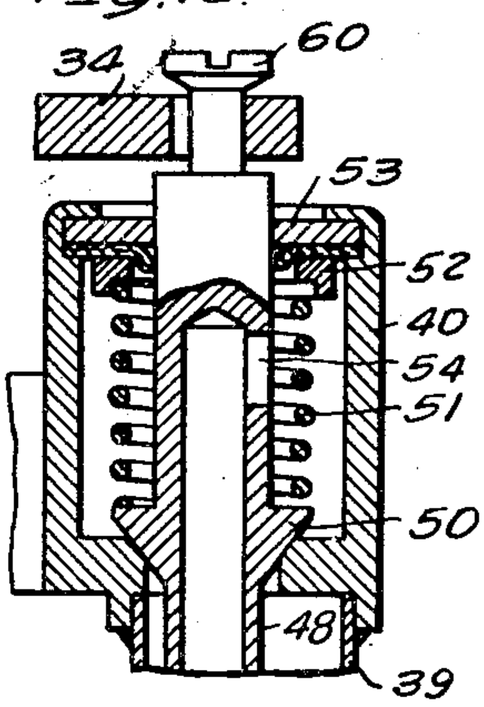


Fig. 12.



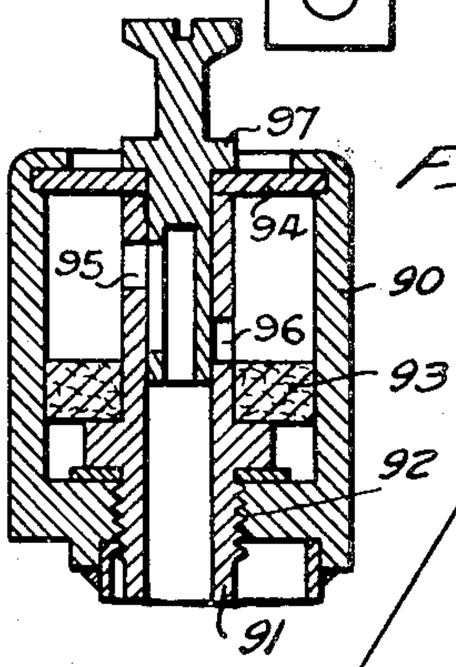


Fig. 14.

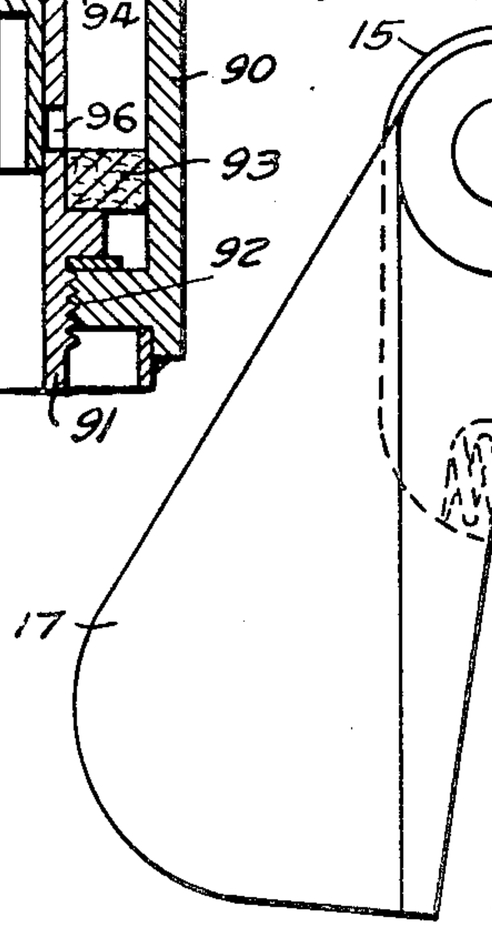


Fig. 13.

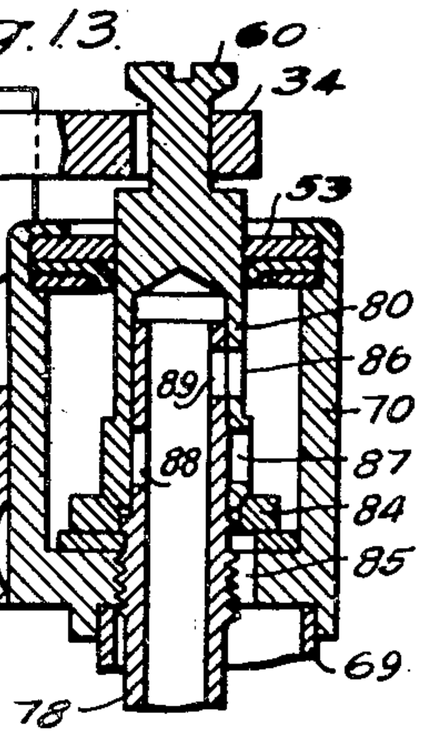


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Fig. 10.

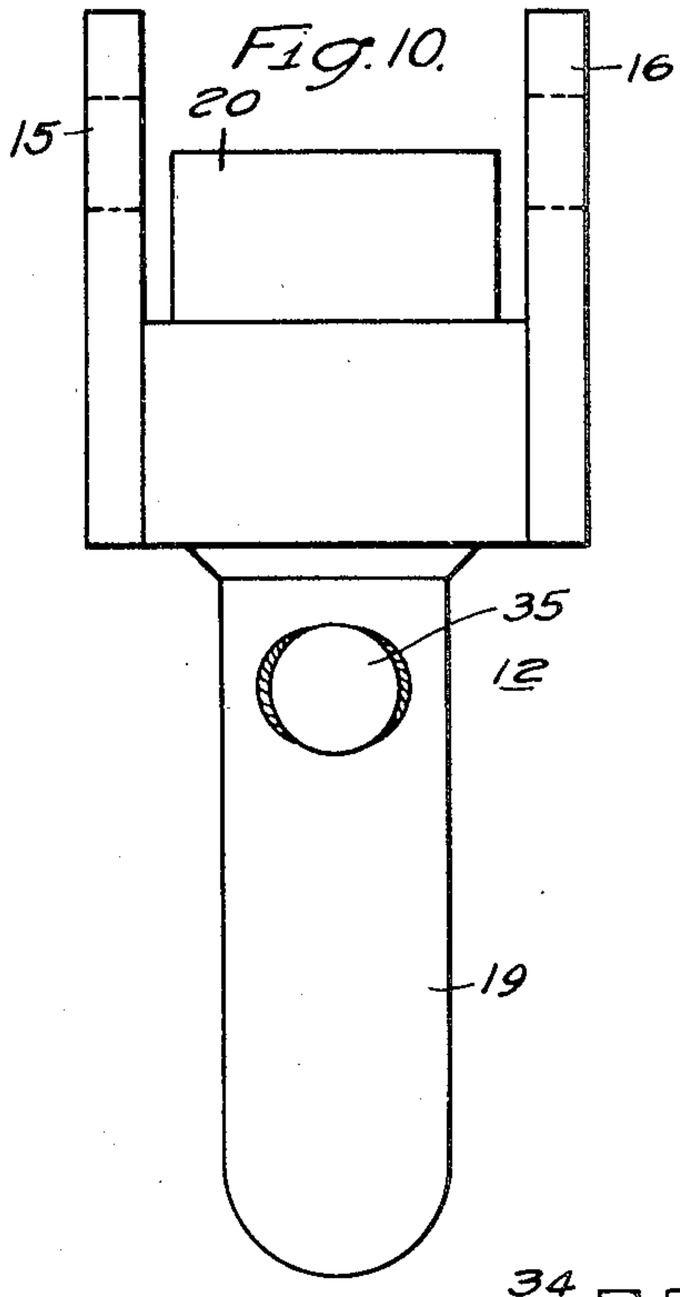


Fig. 8.

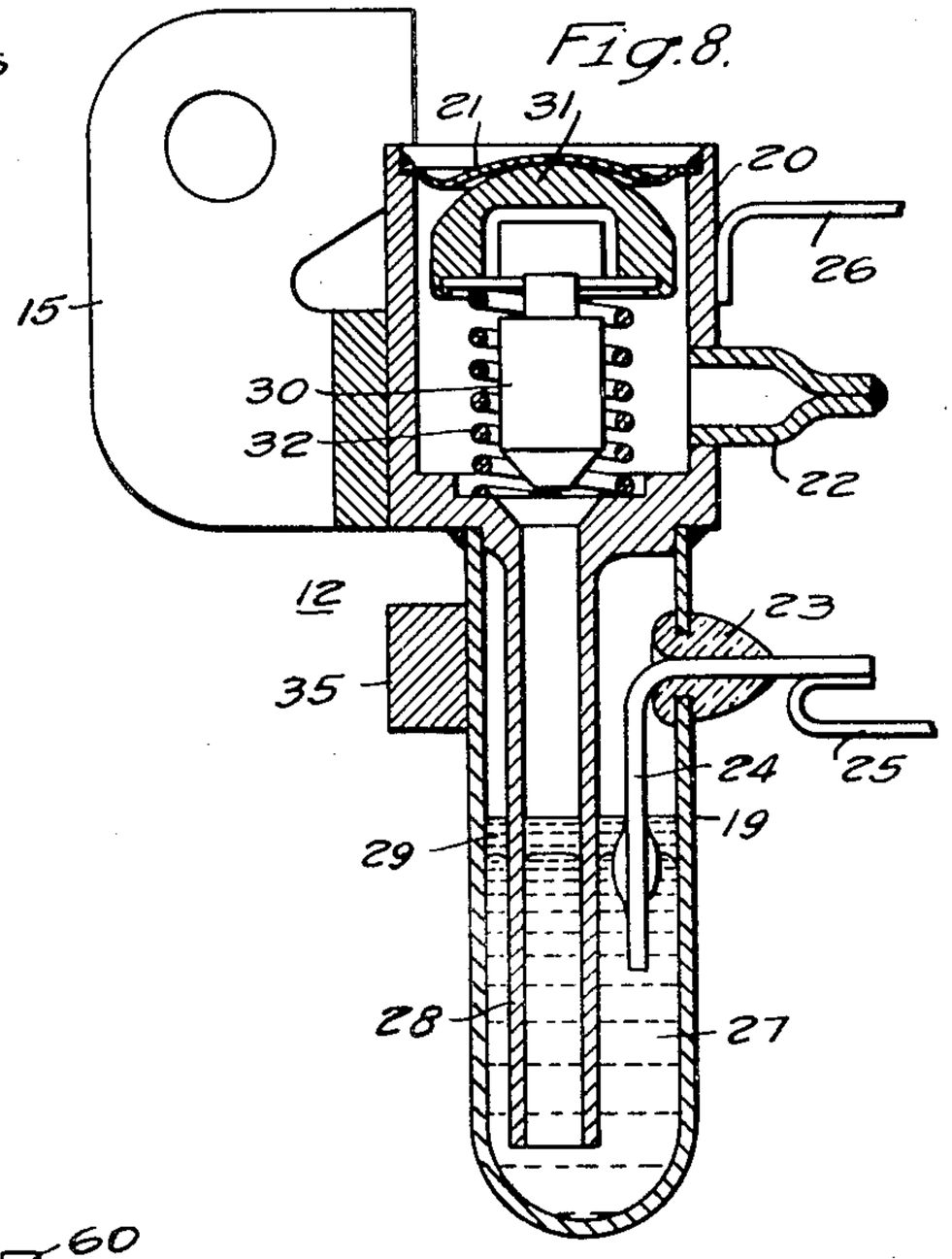


Fig. 11.

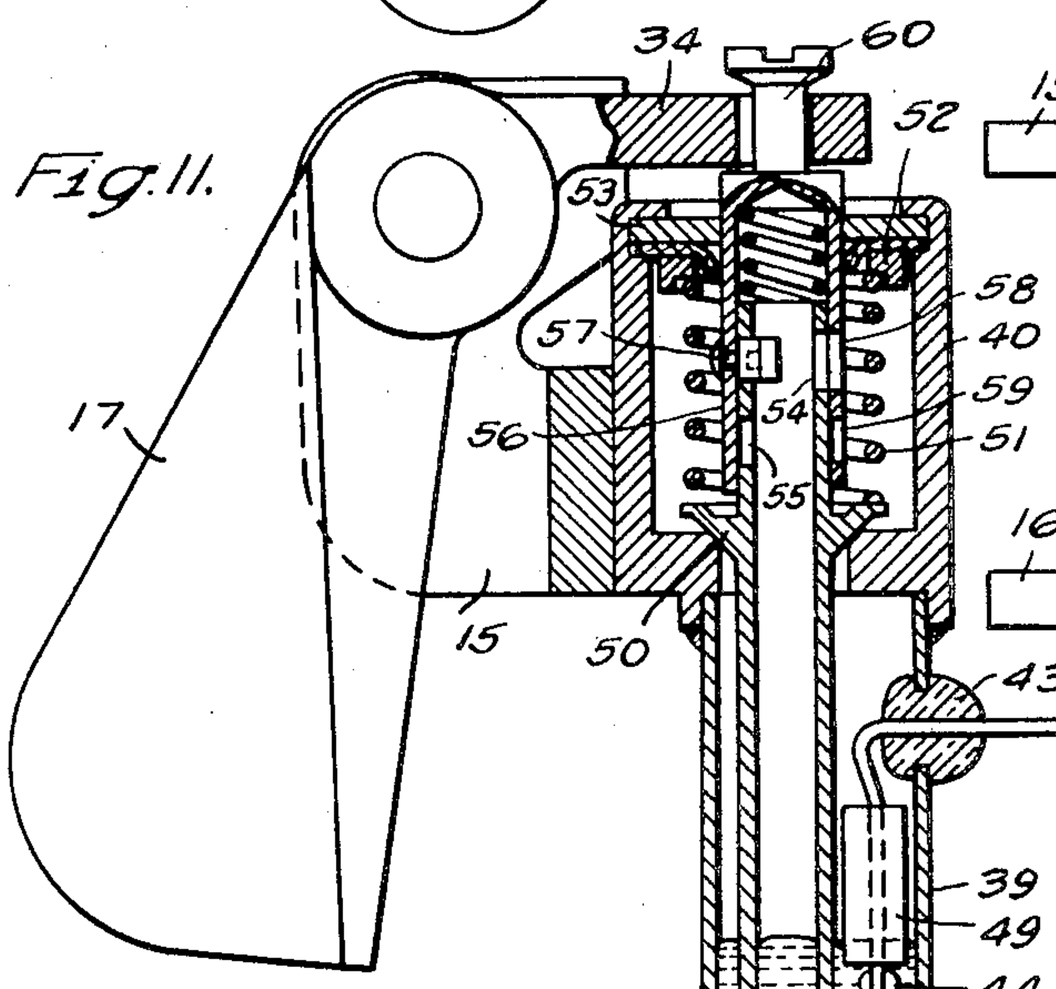
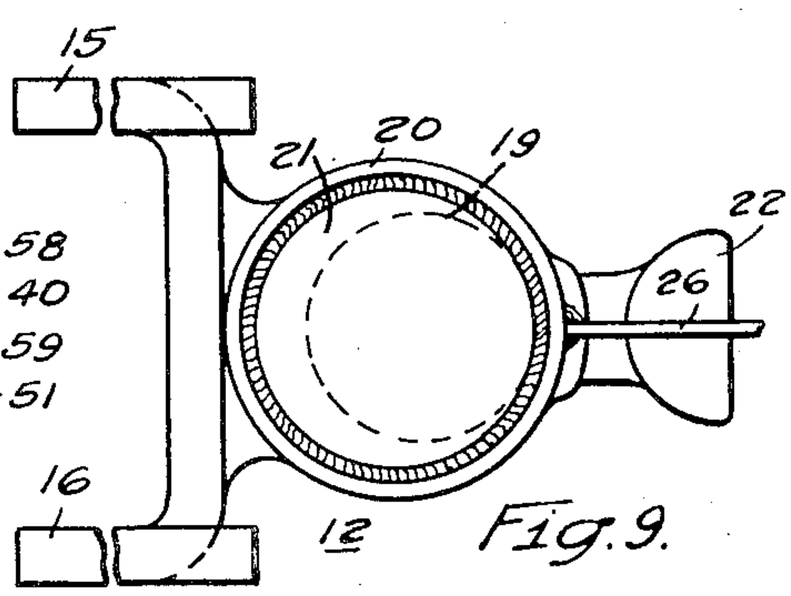


Fig. 9.



WITNESSES:

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UNITED STATES PATENT OFFICE

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RELAY

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Application April 3, 1945, Serial No. 586,287

9 Claims. (Cl. 200—122)

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My invention relates to thermally operated electric relays, for instance for overload protection, and has for its object to provide relays which combine especially small size with virtually no contact friction and good accuracy and constancy of calibration.

In order to achieve these objects, and in accordance with one feature of my invention, I provide an electric relay with a heatable container structure which contains mercury and a volatile liquid so that the mercury is displaced and changes its level when sufficient heat is applied to volatilize the liquid; and the change in level is used for causing the mercury to make or break an electric connection between contacts associated with the structure. According to other features of the invention, I provide a a rigid container for the mercury and equip the container with a conduit which extends into an upper container portion where the mercury may be trapped. According to still another feature of the invention, I provide such a relay with means for adjusting the relay for manual or automatic resetting operation.

These and other objects and features of my invention will be apparent from the drawings, in which:

Figure 1 is a vertical section through an overload relay according to the invention;

Fig. 2 is a front view of the same embodiment;

Fig. 3 represents a top view also of the same relay;

Fig. 4 shows a front view of the base portion of the relay;

Figs. 5, 6 and 7 are two different views and a cross section, respectively, of an insulating body which forms part of the front portion of the relay;

Fig. 8 shows a longitudinal section through the contact and thermo-responsive actuating unit of the relay, while

Figs. 9 and 10 are a top view and a side elevation, respectively, of the same unit;

Fig. 11 is a sectional illustration of a modified form of the thermo-responsive contact unit;

Figs. 12, 13 and 14 show partial and sectional views of three further modifications of such a unit.

Referring to the embodiment illustrated in Figs. 1 through 10, and at first with particular reference to Figs. 1 through 4, numeral 1 denotes the insulating base portion of the apparatus. An insulating body 2 is mounted on the front surface of the base portion so as to be removable therefrom. The front face of the base portion 1 is provided

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with four contact terminals denoted by 3, 4, 5 and 6, respectively, and best apparent in Fig. 4. Terminals 5 and 6 are each provided with a slotted socket 7 and 8 respectively (Figs. 1 and 4) for the reception of contact pins. Terminals 3 and 4 have each a threaded bore to be engaged by a connecting screw 9 or 10 which fastens a heater coil 11 to the removable front portion of the apparatus. Terminals 3 and 4 serve for connecting the two leads of a load circuit to the relay so that the load current flows through the heater coil 11, while terminals 5 and 6 serve to connect to the relay a circuit to be controlled in response to the occurrence of overload in the load circuit.

The thermo-responsive contact unit to be acted upon by the heater coil 11 is denoted as a whole by numeral 12. It has two contact pins 13 and 14 (Fig. 1) which in the assembled condition of the relay engage the sockets 7 and 8 thereby connecting the contact unit electrically between the terminals 5 and 6. Two ears 15 and 16 are attached to the contact unit and serve as a bearing for a handle 17 which forms an angular lever and is biased by a spring 18 toward the position illustrated in Fig. 1.

Details of the thermo-responsive contact unit are illustrated in Figs. 8 through 10. According to these figures, the unit 12 has a container structure composed of a lower portion 19 and an upper portion 20 both consisting of metal. The upper portion 20 is hermetically sealed by means of a diaphragm 21 and has a sealing tube 22 for connecting the unit to a vacuum pump during the course of its manufacture. The tube 22 is pressed flat and sealed by welding as shown in Fig. 8 when the unit is in finished condition. The lower portion 19 of the container has an insulating seal 23 through which a contact 24 passes into the interior. Two leads 25 and 26 are attached to the contact 24 and the wall of the upper container portion 20, respectively, and connect these two parts with the contact pins 14 and 13 (Fig. 1), respectively.

As shown in Fig. 8, a conduit or tube 28 extends from the upper container portion 20 downwardly to near the bottom of the lower container portion 19. The tube 28 in the embodiment of Figs. 8 through 10 consists of metal and forms an integral part of the structure 20. A quantity of mercury, denoted by 27, is disposed in the container portion 19 so that it establishes normally an electric connection between the contact 24 and the container. Consequently, the circuit between leads 25 and 26 or terminals 5 and 6 is normally closed through the mercury. A quantity of vol-

atile liquid denoted by 29 is disposed on top of the mercury within the upper space of the container portion 19. When the portion 19 is heated by the surrounding heater coil 11 (Figs. 1 and 2) to an extent sufficient to volatilize the liquid 29, the increase in pressure thus produced in the upper space of container portion 19 forces the mercury column 27 into the tube 28. As a result, the level of the mercury in the container space surrounding the tube 28 is lowered until the circuit between contact 24 and the container is interrupted. This interruption is used for controlling a protective or indicating operation. The volatile liquid may consist of alcohol or of various other substances which may be selected in accordance with the desired boiling point.

A stud 35 is soldered to the container portion 19 (Figs. 8 and 10) and serves as an abutment for the return spring 18 of the handle 17 (Figs. 1 and 2). The container portion 20 is equipped with a mercury trap which in the embodiment of Figs. 8 through 10 consists of a valve type mechanism. A valve body 30 forms, at its bottom surface, a conical valve surface for engagement with a conical seat surface formed at the entrance of the tube 28 into the upper container portion 20. The valve body 30 is provided with an actuating head 31 with respect to which it is movable in a limited extent in order to permit the valve disk to adjust itself freely on the seat when the valve is moved into closing position. A spring 32 tends to hold the valve in the open position as illustrated in Fig. 8. In the assembled condition of the relay, however, an adjusting screw 33 seated in the upper arm 34 of the handle 17 (Fig. 1) rests against the diaphragm 21 (Fig. 8) and under the bias of spring 18 (Fig. 1) pushes the actuating head 31 toward the valve seat in opposition to the valve spring 32 permitting the valve body 30 to seat gravitationally. Consequently, the valve is normally closed. When the container structure is heated due to the occurrence of an overload current in the heater coil 11 and causes the liquid 29 to boil and volatilize, the pressure exerted on the mercury in the annular space around the tube 28 is high enough to force part of the mercury upwardly through the tube 28 against the valve body 30 thereby forcing the valve open and entering into the upper container portion 20. When the heating effect ceases due to a control action caused by the interruption of the circuit connection between tube 23 and contact 24, the mercury in the upper container portion 20 is trapped by the valve so that the controlled circuit remains interrupted. It is then necessary to push the handle 17 against the front face of the relay in order to permit the valves spring 32 to open the valve so that the trapped mercury flows back into the bottom portion of the container structure, thereby resetting the relay for a repeat operation.

It is also possible to design a relay on the principles of my invention which permits the mercury a free return flow upon cessation of the overload in order to reset the relay automatically, or to equip the relay with selective automatic or manual resetting means. A modification of the latter type is exemplified by the embodiment shown in Fig. 11.

The contact unit according to Fig. 11 can be inserted into a relay apparatus otherwise designed in accordance with Figs. 1 through 7. The contact unit comprises a container structure composed of a lower portion 39 and an upper portion

40. A contact 44 located in the lower portion 39 passes through an insulating seal 43 and is provided with a porous body 49 which absorbs a quantity of volatile liquid. A quantity of mercury denoted by 47 establishes an electric connection between the contact 44 and a metal tube 48 when the relay is in the illustrated normal condition. As in the preceding example, the heater coil of the relay, when traversed by a current of sufficient magnitude, causes the absorbed liquid to volatilize and thus increases the pressure in the annular space above the mercury in the upper part of the container portion 39 so that the mercury rises in the tube 48. The tube 48 in the embodiment of Fig. 11 is movable in its axial direction and forms a valve surface 50 which is biased by a helical compression spring 51 against a conical seat at the bottom opening of the upper container portion 40. The spring 51 abuts against a collar 52 which rests against a substantially rigid closure plate 53.

The part of the tube 48 above the valve surface 50 is provided with two openings 54 and 55 and is surrounded by a sleeve 56 which is revolvable but not axially displaceable relative to the tube 48. A lug 57 attached to the sleeve 56 and engaging a peripherally extending slot of tube 48, serves to limit the angular displacement of the sleeve 56 and to prevent its axial displacement relative to the tube. The sleeve 56 is provided with two openings 58 and 59. In the illustrated position of the sleeve, the openings 54 and 58 are in registry while the opening 55 is closed by the sleeve. The upper end of sleeve 56 carries a slotted head 60 whose neck portion is engaged by the arm 34 of the handle 17.

When the mercury is forced upwardly into the tube 48, due to the above-mentioned effect of an overload in the heating coil, part of the mercury spills through the openings 54 and 58 onto the bottom of the upper container portion 40 where it is trapped. Consequently, upon cessation of the overload conditions, the relay must be reset by actuating the handle 17 thereby pulling the sleeve and tube assembly upwardly and lifting the valve surface 50 from its seat so that the mercury can flow back into the lower container portion.

The relay can be adjusted for automatic resetting by turning the sleeve head 60 so that the opening 59 is placed in registry with the opening 55 while the opening 54 is covered by the sleeve 56. Upon the occurrence of an overload, the mercury is forced through the openings 55 and 59. Since these openings are near the bottom of the upper container portion, the mercury will flow back during the cooling period of the relay.

The modification represented by Fig. 12 is similar to that of Fig. 11 except that it is designed only for manual resetting of the relay. In the embodiment of Fig. 12, the tube 48 is provided with a single opening 54 and carries the head 60 which, as in the preceding embodiments, is engaged by the arm 34 of the resetting handle. A valve portion 50, forming an integral part with the tube 48, is normally forced by a spring 51 against a seat surface in the bottom of the upper container portion 40. During overload conditions, the mercury rises in tube 48 and flows through the opening 54 into the bottom section of container portion 40. When the resetting handle is actuated, the tube 48 with its valve disk 50 is lifted in order to permit the return flow of the mercury.

The embodiment of Fig. 13 is designed for se-

lective automatic or manual resetting operation, but contains an interior tube which is immovably attached to the container structure. The lower container portion **69** of the embodiment shown in Fig. 13 is provided with a tube **78** and also with a contact, a quantity of mercury, and a quantity of volatile liquid in order to operate in accordance with the principle explained in the foregoing. The tube **78** is screwed into the bottom opening of the upper container portion **17** and hence is not moved during the resetting operation. The upper part of tube **78** is surrounded by a sleeve **80** which is revolvable and axially displaceable relative to the tube. The sleeve **80** forms a valve disk at **84** which normally closes a connecting duct **85** between the upper and lower container portions. The sleeve **80** has a slotted adjusting head **60** in engagement with the arm **38** of the actuating lever **17**. Due to the force of the spring **18**, the sleeve **80** is normally pushed downwardly so that the valve disk **84** closes the duct **85**. The sleeve has two openings **86** and **87** to cooperate with two openings **88** and **89** of the tube **78**. In the illustrated position, the openings **86** and **89** are in registry while the opening **88** is covered by the sleeve **80**. During an overload-responsive operation of the relay, the mercury rising in the tube **78** flows through the openings **89** and **86** onto the bottom of the upper container portion **70**. In order to reset the relay, the handle **17** must be pushed against the force of spring **18** so that the valve disk **84** is lifted and opens the return duct **85**. In order to adjust the relay for automatic resetting, the head **60** of sleeve **80** is turned by means of a screw driver so that the opening **89** is covered by the sleeve while the opening **87** is placed in registry with the opening **88**. The rising mercury can then enter through the openings **88** and **87** into the upper portion **70** and is free to flow back through the same openings when the heater cools down to normal temperature.

The relay partially represented in Fig. 14 has its mercury container provided with a closure plate **94** of porous material whose pores are small enough to prevent the loss of mercury but sufficiently large to permit the slow passage of gases in order to avoid the development of back pressure within the upper container portion **90** and to maintain the internal pressure equal to the external atmospheric pressure, thus fixing the boiling point of the volatile liquid. The upper container portion **90** is further provided with means for protecting the mercury from oxidizing under the influence of air which may enter through the pores of the plate **94**. In other respects the embodiment of Fig. 14 may be similar to the modifications previously described. More in detail, the interior tube **91** according to Fig. 14 is screwed at **92** into the bottom of the upper container portion **90**; and a ring **93** of felt or the like absorbent material is placed close to the bottom of the upper container portion to be contacted by the mercury when it rises into the upper portion through the opening **95**. The body **93** is saturated with a protective liquid such as dibutyl phthalate which wets the surface of the mercury and does not evaporate under all operating conditions of the relay while exerting no chemical effect on the mercury and the other materials of the construction. The mercury trapped in the upper container portion is permitted to flow through the hole **96** back into the tube **91** when this hole is opened by lifting the member **97**.

Relays according to the invention and as described in the foregoing can be manufactured with extremely small over-all dimensions as compared with known contact relays of comparable current capacity. The electric creepage distances of relays according to the invention are also favorably large. These advantages in conjunction with the small compass of the device are particularly important for using the relays as a component part of line starters and machine tool controls where space is at a premium. Since the boiling point of the volatile liquid in relays according to the invention is fixed and since the use of mercury avoids the effects of friction and of variable spring pressure, the relay avoids not only most of the causes of failure occurring with relays of other types, but has also the high constancy of performance and recalibration.

The various modifications described in the foregoing will indicate to those skilled in the art that the invention is not limited to the specific embodiments shown in the figures, but can be modified as regards various details without departure from the essential features of the invention as set forth in the claims annexed hereto.

I claim as my invention:

1. An electric relay comprising a container structure having a lower portion and an upper portion separated from each other, a conduit forming a communication between said container portions, a quantity of mercury normally enclosed by said lower portion, a quantity of volatile liquid disposed within said lower portion above said mercury, heating means for causing said liquid to volatilize in order to push mercury through said conduit into said upper portion, valve means effective between said conduit and said upper portion and being displaceable between two positions to permit the flow of mercury only in the direction from said lower portion into said upper portion when in one of said positions while permitting the flow of mercury in said direction as well as in the opposite direction when in said other position, adjusting means for selectively placing said valve means into said respective positions, and manually operable resetting means for releasing said valve means when set in said one position so that then the return flow of mercury from said upper portion to said lower portion occurs only upon actuation of said resetting means, and insulated contacts associated with said container structure to be electrically interconnected and disconnected by said mercury depending upon the change in mercury level caused by said heating means.

2. An electric relay comprising a container structure having a lower portion and an upper portion, a conduit opening into said upper portion and extending downwardly into the lower portion, said conduit having within said lower portion a smaller cross section than said lower portion so that an annular space exists around said conduit at the top of said lower portion a quantity of mercury normally disposed in said lower portion so as to have its level above the lower opening of said conduit, a quantity of volatile liquid disposed in said lower portion in said annular space above said mercury, heating means for causing said liquid to volatilize in order to push mercury through said conduit into said upper portion, insulated contacts associated with said container structure to be electrically interconnected and disconnected by said mercury depending upon the change in mercury level caused

by said heating means, valve means disposed within said upper portion for preventing, when effective, a return flow of mercury into said lower portion upon operation of said heating means, and control means exteriorly operable for selectively rendering said valve effective and ineffective.

3. An electric relay comprising a container structure having a lower portion and an upper portion, a conduit opening into said upper portion and extending downwardly into the lower portion, a quantity of mercury normally disposed in said lower portion so as to have its level above the lower opening of said conduit, a quantity of volatile liquid disposed in the space surrounding said conduit in said lower portion above said mercury, heating means for causing said liquid to volatilize in order to push mercury through said conduit into said upper portion, insulated contacts associated with said container structure to be electrically interconnected and disconnected by said mercury depending upon the change in mercury level caused by said heating means, said conduit being longitudinally displaceable and forming a valve member, said upper portion forming a seat for said valve member so that the mercury is prevented from flowing from said upper portion back into said lower portion, and exteriorly operable control means for displacing said conduit in order to lift said valve member from said seat in order to permit such return flow.

4. An electric relay comprising a container structure having a lower portion and an upper portion separated from each other, a conduit forming a communication between said container portions and extending from near the bottom of said lower portion to above the bottom of said upper portion, a quantity of mercury normally enclosed by said lower portion, a quantity of volatile liquid disposed in the space surrounding said conduit within said lower portion above said mercury, heating means for causing said liquid to volatilize in order to push mercury through said conduit into said upper portion so that it spills onto the bottom of said upper portion, a communication between the bottom of said upper portion and said lower portion, exteriorly operable control means for opening and closing said communication, and insulated contacts associated with said container structure to be electrically connected and disconnected by said mercury depending upon the change in mercury level caused by said heating means.

5. An electric relay comprising a container structure having a lower portion and an upper portion separated from each other, a conduit forming a communication between said container portions and extending from near the bottom of said lower portion to above the bottom of said upper portion, a quantity of mercury normally enclosed by said lower portion, a quantity of volatile liquid disposed in the space surrounding said conduit within said lower portion above said mercury, heating means for causing said liquid to volatilize in order to push mercury through said conduit into said upper portion so that it spills onto the bottom of said upper portion, said conduit being normally open toward said upper portion at a place above the bottom of said upper portion and having a controllable opening toward said upper portion at a place closer to said bottom, exteriorly operable control means for opening and closing said opening, and insulated contacts associated with said container structure to be electrically connected and disconnected by said mercury depending upon the change in mercury level caused by said heating means.

6. An electric relay comprising a container structure having a lower portion and an upper portion separated from each other, a conduit forming a communication between said container portions and extending from near the bottom of said lower portion to above the bottom of said upper portion, a quantity of mercury normally enclosed by said lower portion, a quantity of volatile liquid disposed within said lower portion above said mercury, heating means for causing said liquid to volatilize in order to push mercury through said conduit into said upper portion so that it spills onto the bottom of said upper portion, said conduit being normally open toward said upper portion at a place above the bottom of said upper portion and having a controllable opening toward said upper portion at a place closer to said bottom, a perforated sleeve revolvably seated on said conduit for covering and closing said opening, exteriorly operable means for revolving said sleeve, and insulated contacts associated with said container structure to be electrically connected and disconnected by said mercury depending upon the change in mercury level caused by said heating means.

7. An electric relay comprising a container structure having a lower portion and an upper portion separated from each other, a conduit forming a communication between said container portions and extending from near the bottom of said lower portion to above the bottom of said upper portion, a quantity of mercury normally enclosed by said lower portion, a quantity of volatile liquid disposed within said lower portion above said mercury, heating means for causing said liquid to volatilize in order to push mercury through said conduit into said upper portion so that it spills onto the bottom of said upper portion, said conduit being normally open toward said upper portion at a place above the bottom of said upper portion and having a controllable opening toward said upper portion at a place closer to said bottom, a perforated sleeve revolvably seated on said conduit for covering and closing said opening, exteriorly operable means for revolving said sleeve, in order to thereby set the relay for automatic or manual resetting, and normally closed valve means forming when opened a communication between said upper and lower portions and being exteriorly operable to permit the return flow of mercury by manual resetting of the relay.

8. An electric relay comprising a container having a bottom portion provided with a quantity of mercury and containing an absorptive body above said mercury provided with volatile liquid, a conduit extending upwardly from said bottom portion, heating means for causing said liquid to volatilize in order to push mercury through said conduit into said upper portion, and insulated contacts associated with said container to be electrically interconnected and disconnected by said mercury depending upon the change in mercury level caused by said heating means.

9. An electric relay comprising, a container structure having a lower portion and an upper portion separated from each other, a conduit forming a communication between said container portions, a quantity of mercury normally enclosed by said lower portion, a quantity of volatile liquid disposed within said lower portion above said mercury, heating means for causing said liquid to volatilize in order to push mercury

through said conduit into said upper portion, and insulated contacts associated with said container structure to be electrically interconnected and disconnected by said mercury depending upon the change in mercury level caused by said heating means, and an absorptive body arranged in said upper portion to be contracted by the mercury and provided with protective liquid for preventing oxidation of the mercury.

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