March 7, 1939. C. CHILOWSKY 2,150,053

MERCURY CONTACTOR

Filed May 19, 1937 2 Sheets-Sheet 1

Fig. 1

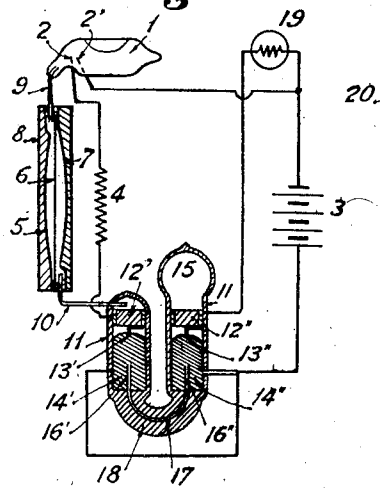


Fig. 2

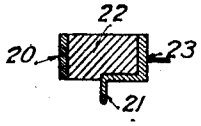


Fig. 3

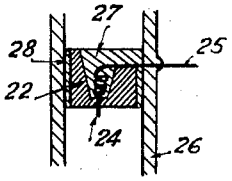


Fig. 5

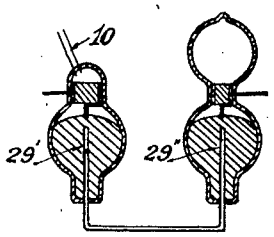


Fig. 4

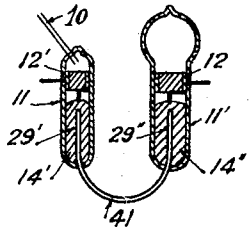


Fig. 6

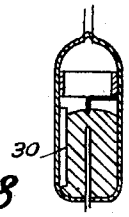


Fig. 7

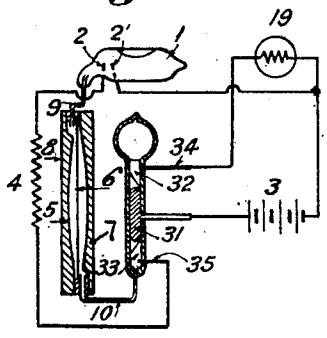
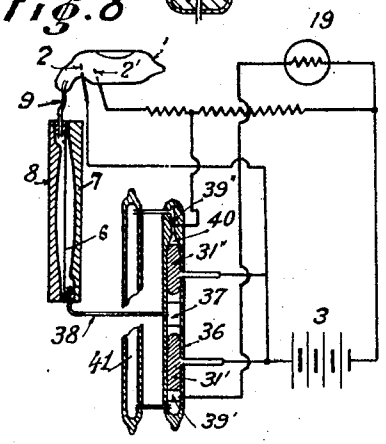


Fig. 8



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MERCURY CONTACTOR

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Fig. 10

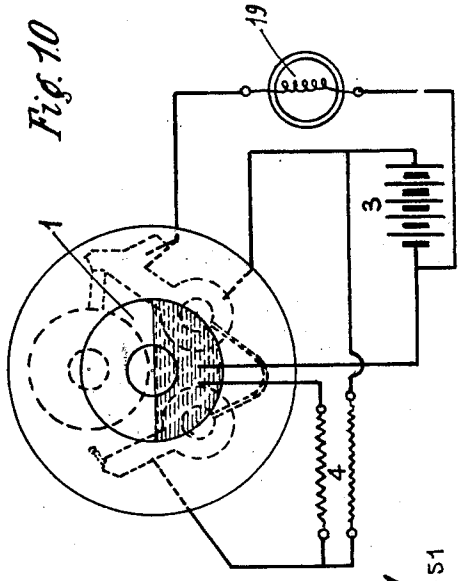


Fig. 11

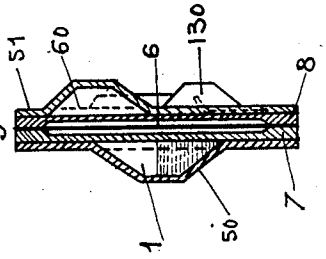
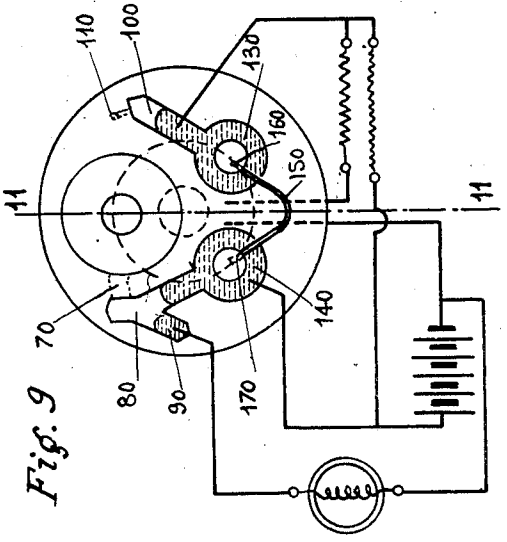


Fig. 9



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By Brown & Seward Atty's.

Patented Mar. 7, 1939 2,150,053

UNITED STATES PATENT OFFICE

2,150,053

MERCURY CONTACTOR

Constantin Chilowsky, Paris, France

Application May 19, 1937, Serial No. 143,489
In France December 12, 1936

14 Claims. (Cl. 200—52)

There exist various apparatus including a mercury column located in a tube of suitable shape, for instance rectilinear or U-shaped, this column moving under the influence of a fluid such for instance as gases, in such manner as to produce the closing or the opening of electric contacts disposed in a suitable manner close to the meniscus of the mercury column.

In apparatus of this type, it may happen that, either in the course of transportation of the apparatus, or in the course of its normal working, for instance in the case in which the apparatus is utilized in circumstances such that it is liable to undergo violent shocks, the mercury column breaks into two or several parts, which may involve disturbances in the working of the apparatus and prevent the correct closing or opening of the contacts controlled by the displacement of this column. In particular, when use is made of mercury columns of small diameter, for instance averaging from 0.5 to 1 millimeter, the column, once broken after any accident is not reestablished by itself, as a consequence of the small section thereof and of the fact that mercury sticks to the wall of the glass tube. In some cases, it is even rather difficult to reestablish the unity of the mercury column by shaking the apparatus.

On the contrary, when the mercury column is of a larger diameter, it is easier to reestablish the unity of the mercury column after breaking thereof but, on the other hand, this breaking is facilitated, so that, the greater the diameter of the column, the greater the danger of having this column broken into parts under the effect of shocks undergone by the apparatus. Besides, this breaking of the column involves another danger, which remains even when the unity of the column is relatively easily restored. This results from the fact that the breaking of the column may permit a portion of the gases which act upon one of the ends of said column of passing through the tube from the chamber located at one end of said tube to the chamber located at the other end thereof, this passage of gases disturbing the working of the apparatus.

The object of the present invention is to provide an apparatus of the type above described which is capable of avoiding breaking of the mercury column and, furthermore, in the unlikely case of such a breaking having taken place, ensures the immediate and automatic restoring of the unity of the column, preventing, at the same time, any passage of gases through the column.

According to the essential feature of the invention, the shape, the section and the length of the mercury column are chosen in such manner that said column behaves as just above mentioned, the tube being eventually provided, in certain embodiments, with supplementary means for ensuring the same result.

Other features of the present invention will result from the following detailed description of some specific embodiments thereof.

In these embodiments, the invention is shown as applied to a photo-relay of the type described in my French Patent No. 795,681, of September 7, 1935.

This apparatus includes a mercury column moving in a U-shaped tube under the influence of the pressure variations occurring in a bulb containing substances subjected to the action of an electrolytic current on the one hand and to the action of light on the other hand, these variations being transmitted to the mercury column through an inert gas.

As a matter of fact, it should be well understood that the invention is in no way limited to the application in question, which is described in detail merely by way of example, this invention being applicable to all mercury contactors containing a column of this metal movable in a tube and serving to open or close electric contacts.

Preferred embodiments of the present invention will be hereinafter described, with reference to the accompanying drawings, given merely by way of example, and in which:

Fig. 1 diagrammatically shows a photo-relay devised according to the present invention;

Fig. 2 shows, on an enlarged scale, a detail of said relay;

Fig. 3 shows a modification of a detail of said relay;

Fig. 4 shows another constructional detail of the apparatus;

Fig. 5 is a partial view showing a modification of the apparatus;

Fig. 6 shows a detail modification of the apparatus;

Fig. 7 shows a contactor system in which the mercury column moves in a linear tube;

Fig. 8 shows another embodiment in which a rectilinear tube is provided with two mercury columns;

Fig. 9 is a front view of still another embodiment of the invention;

Fig. 10 is a rear view corresponding to Fig. 9;

Fig. 11 is a sectional view on the line II—II of Fig. 9.

In Fig. 1, I have shown at 1 an electrolytic bulb

constituting an essential element of the photo-relay, this bulb containing two electrodes 2 and 2', fed with current through a battery 3 inserted in a circuit including a resistance 4 for the adjustment of the electrolytic current. I have shown at 5 an element including an elastic membrane 6, for instance of glass, caught between two plates 7 and 8, for instance also made of glass. The chamber located between plates 6 and 8 communicates through a tube 9 with the inside of bulb 1, and the chamber located between plates 6 and 7 communicates through a tube 10 with the inside of a tube 11 containing the mercury column. This tube 11 is provided at each end with a plug of a porous material which permits gases to flow therethrough but prevents the passage of mercury. These plugs 12' and 12'' carry respective contacts 13' and 13''. I have shown at 14' and 14'' two mercury columns of relatively large section (for instance from 3 to 4 mm.). The two portions of mercury column are connected together by means of two tubes of small section 16' and 16'', open at their upper ends, the lower ends of these last mentioned tubes being connected together by the narrow passage 17 of a capillary tube 18.

The open ends of tubes 16' and 16'' are located in the middle part of the mercury masses, respectively, at 14' and 14''. The apparatus is completed by a lamp 19 which is switched on when the meniscus of column 14'' reaches contact 13''.

It will be readily understood that with such an arrangement, in view of the small height of the space existing between the meniscus of each of the portions 14' and 14'' of the column and the corresponding plug, on the one hand, and of the section of the column, on the other hand, said column cannot break into two portions, and, even in the highly unlikely case of such a breaking taking place, it cannot remain in this broken state, the unity of the column being necessarily restored by any slight shock.

And even when such a breaking takes place, the gases cannot pass from one of the ends of the tube to the other end, that is to say from the space located above plug 12' into chamber 15, in view of the fact that the upper end of narrow tube 16 opens into the middle part of the mercury of column 14', any possible breaking of this column being unable to permit gas to reach this point. Therefore the device ensures perfect safety.

In Fig. 2, I have shown, on an enlarged scale, an embodiment of one of the plugs 12' or 12''. In this embodiment, the plug proper is constituted by a porous mass, for instance of a refractory matter, 22, located in a metallic envelope 20 which may be welded in the glass, and made for instance of platinum or an alloy capable of being welded. I have shown at 21 a metallic contact consisting for instance of a thin extension of the metallic wall of the plug. 23 is a metallic contact extending through the wall of the glass tube. Tube 20 may also be made of a matter such as steatite, which is also capable of being welded to glass. In a likewise manner, the plug also may be made of a matter capable of being welded.

In Fig. 3, I have shown a modification of the plug. In this example, a metallic wire 25 extends through a wall 26 of the glass tube and also through the wall of plug 22. The spiral wound end of this wire is housed in a recess 27 of the plug, filled with a suitable cement, and it projects through the matter of the plug, in such manner as to close contact 24. I have shown at 28 a tubular envelope weldable in glass.

In Fig. 4, I have shown a modification in which the communication between the two portions 14' and 14'' of the mercury column is ensured through a small size metallic tube 41, which replaces the capillary tube 18 of Fig. 1. In this example, the ends of tube 41 extend inside the mass of mercury 14' and 14''. These ends of tube 41 are closed at the top but are each provided with an orifice corresponding substantially with the center of the mercury mass, as shown at 29' and 29''. Besides it is clear that tube 41 might also, according to the invention, stop at these center points of the mass, in the same manner as tubes 16' and 16'' of Fig. 1.

In a modification illustrated by Fig. 5, the glass tubes 11 and 11' are provided with bulging portions in the middle, in such manner as to further increase the safety and to prevent penetration of the gases into the orifice 29', in the unlikely case of a breaking of the mercury mass.

As above stated, it is very difficult to imagine a possibility of breaking of the mercury column, and, even in this case, it is clear that the separate portions of the column would immediately reunite under the action of gravity.

This is quite sure in the case of a column of a diameter averaging 4 millimeters. However, if the diameter of the column is reduced, for instance down to 3 millimeters, mercury (as taught by experience) may stick, under the effect of a kind of molecular attraction, to the upper part of the tube and to plugs 12' and 12''. However, even in this case, the whole of the column adheres to the tube and does not break in the middle, which may be obtained in particular by making use of an especially short column, according to the invention. However, experience also teaches that it suffices in this case to shake the apparatus downwardly or to give it a downward shock for bringing back the column immediately to its correct place. In all cases a complete breaking of the column in the middle thereof, that is to say at the level of the inlet orifices 29'' and 29' of tube 41 (in the case of Fig. 4), and still more the passage of gases from one chamber into the other one is extremely unlikely, and even impossible practically. This passage of the gases is made still more impossible in the embodiment of Fig. 5 in which the tube has bulging portions at the level of the orifices 29' and 29'' of tube 28.

However, the invention includes an embodiment permitting of making use of columns of a diameter smaller than 3 millimeters. According to this arrangement, I establish in any suitable manner a communication along the mercury column between the space located above the meniscus and the bottom of the tube. With such an arrangement, in the case of the mercury column, of a relatively small diameter, coming, as a consequence of a shock throwing it upwardly, to adhere against the plugs, and of a gas pocket being formed under the column and preventing it from moving back downwardly, the gases might escape through this communication in an upward direction, thus permitting the column to move down. This communication between the top and the bottom can be created through any suitable means. A simple arrangement is shown by way of example in Fig. 6. In this embodiment, the communication between the top and the bottom of the chamber containing the mercury mass is established through a wire or tube 30 disposed along

the inner wall of the tube. This wire may be disposed as indicated or again in spiral, winding around the mercury column. Another arrangement consists in providing channels in the tube wall or in giving said tube a non-circular section, for instance a polygonal section with sharp angles. It is also possible, in order to obtain this result, to give a rough surface to the inside of the tube.

All these arrangements are intended to prevent mercury from sticking to the whole periphery of the tube by capillarity and thus preventing any communication between the top and the bottom.

In Fig. 7, I have shown another embodiment in which the mercury column is located in a rectilinear tube, being also disposed between two plugs in such manner that it cannot break. In this figure I have shown a diagram of a photo-relay similar, as a rule, to that shown by Fig. 1, the contactor being used, by way of example, in combination with such a device. The mercury column shown at 31 is located, as just above stated, between two plugs 32 and 33. This column may have a diameter substantially smaller than that of the preceding example, for instance from some tenths of a millimeter to one millimeter. The height of the mercury column is also relatively small, for instance lower than one centimeter. The distance between plugs 32 and 33 is such that the mercury column has no room for breaking under the effect either of shocks or a capillary sticking of a mercury drop or of a portion of the mercury column to the glass wall. In the case of separation due to shocks, the column has a tendency to bear against one of the plugs and cannot break into separate portions. In the case of the separation of a portion, the latter is immediately absorbed by the column when it comes to bear against one of the plugs. The plugs shown by Fig. 7 are made, for instance, of a refractory material surrounded by a metallic sheath, welded in the glass, each of these sheaths being connected through a wire welded in the wall with the remainder of the circuit. These conductors are shown at 34 and 35. Fig. 7 shows a preferred embodiment in which the metallic sheaths are bevel-shaped at their inner ends, the points of the bevels forming the two electric contacts. In the median position, the column touches both contacts, whereas in each of its extreme position, it leaves one or the other of these contacts. It will be readily understood that with this embodiment also, the dimensions of the column are chosen in such manner, with respect to the dimensions of the tube containing this column, that the column cannot break and the gases cannot pass through the column.

In Fig. 8, I have shown a modification of the device of Fig. 7 in which tube 36, which contains the mercury column, is arranged in such manner that the column is divided into two portions 31' and 31''. The mercury column is preferably of a relatively small diameter. The two portions of the column are separated by a porous plug 37 through which the gas pressure from element 8, transmitted through tube 38, acts on the inside of tube 36. The increases and decreases of this pressure produce displacements of both columns 31' and 31'', which move simultaneously in such manner as to get nearer to, or farther from, plug 37, provided between them. In the lower part of tube 36, there is provided a porous plug 39', substantially of a section equal to that of column 31'. This plug also acts as an electric contact. In the upper part of tube 36, there is provided a second plug 39'', which also plays the part of an electric contact. The section of this plug is smaller than that of column 31'', the portion of the glass tube 36 through which said column communicates with the plug having a frusto-conical shape, as shown at 40.

In this way, when the pressure which exists in the median part of tube 36 increases, column 31' moves in a downward direction in a tube of cylindrical section, whereas column 31'' is pushed into the conical part of the tube, which slows down its displacement under the effect of the capillary forces. Owing to this arrangement, column 31' moves before column 31'' and begins to close contact 39'. On the contrary, column 31'' starts moving only when the pressure reaches a certain value higher than that necessary for producing a displacement of column 31'. Contact 39'' therefore closes at a pressure higher than that corresponding to the closing of contact 39'. This arrangement, given as an example of the various possibilities of operation of a contactor according to the invention is intended to ensure the working of a photo-relay intended to switch on and off lamp 19 as a function of the variations of the illumination.

The operation of this apparatus takes place as follows:

When the illumination decreases, the pressure on the inside of element 8 and therefore in the median part of tube 36 decreases; column 31' moves in a downward direction, closing contact 39'. This closing produces the switching on of lamp 19, in circuit with battery 3. If the darkness persists the pressure further increases and column 31'' is brought into movement and finally closes contact 39'', which partially short-circuits the electrodes 2 and 2' of bulb 1, in such manner as to reduce the potential at the terminals of these electrodes down to a value insufficient for producing electrolysis. The electrolytic current is stopped and the pressure ceases to increase. When the day breaks, when the illumination increases, contact 39'' is first broken, electrolysis is again started and finally lamp 19 is switched off as a consequence of the breaking of contact 39'.

Figs. 9 to 11 illustrate the application of the invention to a "mono-block" apparatus of the kind above described, such a photo-relay apparatus being formed by the combination of a plurality of glass plates at least one of which is shaped in such manner as to contain all the chambers, recesses and conduits that are necessary.

In this embodiment of the invention, the electrolysis chamber, corresponding to the bulb of the preceding examples, and designated by reference character 1, is formed in a suitably shaped glass plate 50 welded under pressure to plate 7.

The U-shaped contactor tube for the mercury column is replaced by a suitably shaped glass plate 51 welded under pressure to plate 6.

Between these two plates 51 and 6, I thus provide chamber 60, which is connected through a conduit 70 with chamber 80, provided with a separate recess 90 forming the electric contact. The second branch of the mercury column is formed by a chamber 100 which is connected through a hole 110 with the space adjoining the flexible membrane 6, made of glass. Chambers 80 and 100 are widened at the bottom so as to form spherical recesses 130 and 140 filled with mercury, and which are in communication with each other through a tube 150 formed in the mass of glass and the ends 160 and 170 of which open

into the centers of the two respective mercury masses present in chambers 130 and 140.

The glass flexible membrane 12 is welded on the periphery between the two systems of glass plates above mentioned, constituted one by plates 50 and 7, and the other by plates 51 and 8.

Passages 70 and 110 correspond to slots of a height of about one hundredth of a millimeter, which permit gas to flow easily therethrough but practically stop mercury.

Conduits 80 and 100 for the displacement of the mercury column, and also recess 90, formed by the welding together of two glass plates, preferably have a triangular section, the edges of said glass plates along which they are welded together for forming these conduits making relatively sharp angles. In view of the resistances of the capillary forces, mercury cannot penetrate into these angles, which remain filled with the gas. Owing to this arrangement, the mercury column, under the influence of gravity returns automatically to its normal position and has a mobility which prevents any wedging thereof.

The metallic tube 150 is sufficiently close to the peripheral zone to be in the welded part of the periphery, which improves the fluid tightness of its fixation in the glass elements.

It is clear from the above mentioned examples that the invention is applicable to all kinds of mercury contactors for preventing the breaking of the mercury column and the passage of gases through said mercury column.

In a general manner, while I have, in the above description, disclosed what I deem to be practical and efficient embodiments of the present invention, it should be well understood that I do not wish to be limited thereto as there might be changes made in the arrangement, disposition and form of the parts without departing from the principle of the present invention as comprehended within the scope of the appended claims.

What I claim is:

1. A device which comprises, in combination, a U-shaped hollow structure including two parallel tube elements of relatively large section and a conduit of small section forming the bottom of the U, extending to a distance upwardly in said tube elements, electric contacts in said tube elements, a plug at the upper part of each of these tube elements capable of allowing gases to flow therethrough but of stopping the passage of mercury, and a mercury column present in said tube elements and said conduit.

2. A device which comprises, in combination, a U-shaped hollow structure including two parallel tube elements of relatively large section and a conduit of small section forming the bottom of the U, extending to a distance inside said tube elements, plugs in the upper parts of said tube elements respectively including a porous central portion and a metal sheath surrounding said porous portion, said metal sheath being provided with two projections, one extending through the wall of the tube element and the other extending downwardly from said plug, so as to form electric contacts, and a mercury column present in said tube elements below said plugs and in said conduit, said mercury column being adapted to cooperate with the last mentioned projections of said metal sheaths.

3. A device which comprises, in combination, a U-shaped hollow structure including two parallel tube elements of relatively large section, a capillary tube forming the bottom of the U and interconnecting said tube elements and short metallic tubes of small section prolonging said capillary tube to a distance inside said tube elements, respectively, a mercury column present in said tube elements and said capillary tube so that said metallic tubes open into the central parts of the mercury masses in each of said tube elements respectively, a plug at the upper part of each of these tube elements capable of allowing gases to flow therethrough but adapted to stop the flow of mercury, and electric contacts in said tube elements adapted to cooperate with said mercury column.

4. A device which comprises, in combination, a U-shaped hollow structure including two parallel glass tube elements of relatively large section and a conduit of small section forming the bottom of the U and extending to a distance inside said tube elements, plugs in the upper parts of said tube elements respectively, including each a core of a refractory porous material provided with a recess, a metallic conductor fixed in said recess projecting, on the one hand, laterally through the glass wall of the corresponding tube element, and, on the other hand, downwardly from the under face of said plug so as to form an electric contact, and a mercury column present in said tube elements below said plugs and in said conduits, said mercury column being adapted to cooperate with the last mentioned projections of said metallic conductors.

5. A device which comprises, in combination, a U-shaped hollow structure including two parallel glass tube elements of relatively large section and a conduit of small section forming the bottom of the U and extending to a distance inside said tube elements, said tube elements having bulging portions at the levels of the orifices of said conduit, a plug at the upper part of each of said tube elements capable of allowing gases to flow therethrough but adapted to prevent the passage of mercury, electric contacts in the upper parts of said tube elements below said plugs, and a mercury column present in said tube elements and said conduit adapted to cooperate with said contacts.

6. A device which comprises, in combination, a U-shaped hollow structure including two parallel tube elements of relatively large section, a capillary tube forming the bottom of the U and consisting of a metallic tube the branches of which extend upwardly to a distance inside said tube elements respectively, a plug at the upper part of each of said tube elements capable of allowing gases to flow therethrough but adapted to prevent the passage of mercury, electric contacts in the upper parts of said tube elements below said plugs, and a mercury column present in said tube elements in said metallic tube adapted to cooperate with said contacts, the branches of said metallic tube opening respectively in the middle of the mercury masses present in said tube elements.

7. A device which comprises, in combination, a U-shaped hollow structure including two parallel tube elements of relatively large section, and a conduit of small section forming the bottom of the U and extending to a distance inside said tube elements, means in each of said tube elements for ensuring between the top and bottom thereof a connection which cannot be cut off by capillary adhesion of mercury to the walls of said tube elements, a plug at the upper part of each of said tube elements capable of allowing gases to flow therethrough but adapted to prevent the passage of mercury, electric contacts

in the upper parts of said tube elements below said plugs, and a mercury column present in said tube elements and said conduit adapted to cooperate with said contacts.

8. A device according to claim 7 in which said means for ensuring a connection between the top and bottom of the tube elements consists of an elongated metal element of small section disposed along the wall of said tube element.

9. A device according to claim 6 in which the branches of said metallic tube are closed at the top, said branches being provided with apertures in their lateral walls corresponding to the respective centers of the masses of mercury present in said tube elements.

10. A device which comprises, in combination, a rectilinear tube, a plug at each end of said tube adapted to allow gases to flow therethrough but capable of stopping mercury, electric contacts in the ends of said tube, respectively, and a mass of mercury in said column, said plugs being so shaped and spaced apart that, in the central position said mercury mass is in contact with both of the contacts but leaves one of them when it is pushed in one direction or the other.

11. A device according to claim 10 in which said plugs are bevel-shaped.

12. A device according to claim 10 including metallic tubes surrounding said plugs, said plugs, and the metallic tubes surrounding them being bevel-shaped, the contacts being formed by the ends of said metallic tubes.

13. A device which comprises, in combination, a rectilinear tube, a plug in the central part of said tube, said tube being of restricted section at one end thereof, a porous plug at each end of said tube adapted to permit the flow of gases therethrough but capable of stopping mercury, a contact at each end of said tube, so that one of said contacts is in said part of restricted section, and a mercury column in each of the portions of said tube limited by said central plug on the one hand and said end plugs, respectively, whereby, upon the admission of a gas under pressure into the central part of the tube, the mercury column in the tube portion having an end of restricted section is moved into cooperation with the corresponding contact only after the other mercury column has been brought into cooperative engagement with the other contact.

14. In combination with a photo-relay of the monoblock type comprising a plurality of glass plates assembled together by welding, a U-shaped system of passages including two parallel tube elements of relatively large section and a conduit of small section forming the bottom of the U and extending upwardly within said tube elements, said tube elements and conduit consisting of recesses formed in at least one of said glass plates, electric contacts in said tube elements, a plug at the upper part of each of these tube elements capable of allowing gases to flow therethrough but of stopping the passage of mercury, and a mercury column located in said tube elements and said conduit.

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