Sept. 24, 1940. A. CIANCHI 2,215,543

MERCURY SWITCH

Filed July 26, 1937 2 Sheets-Sheet 1

Fig. 1a

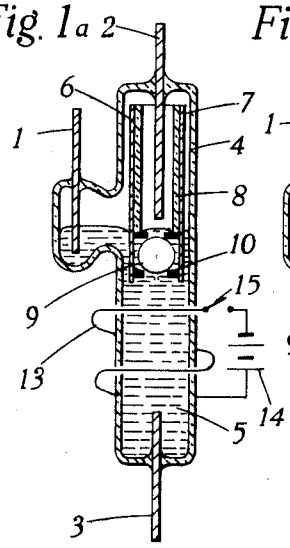


Fig. 1b

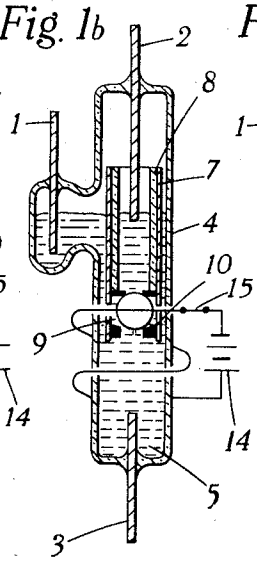


Fig. 1c

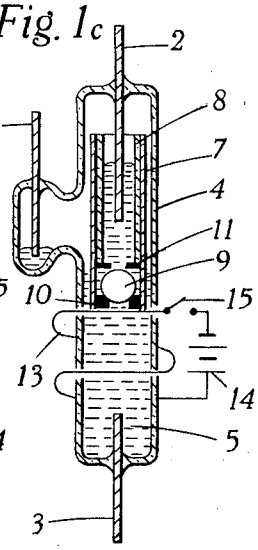


Fig. 2a

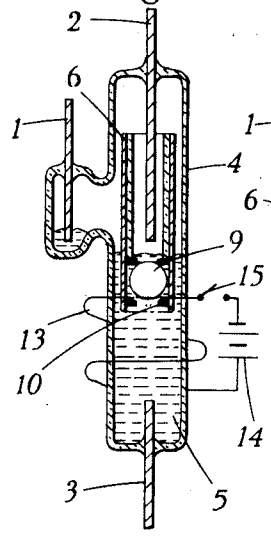


Fig. 2b

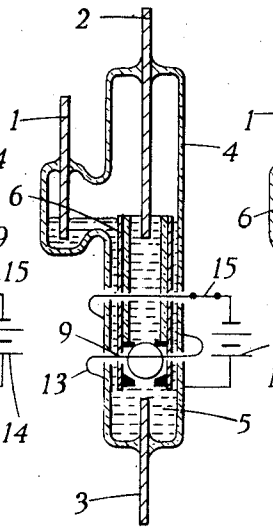


Fig. 2c

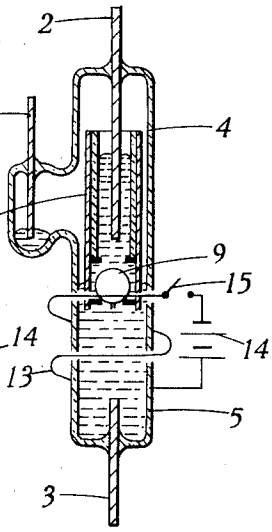
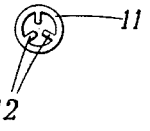


Fig. 4.



Fig. 5



INVENTOR
A. CIANCHI,
BY
Blair & Kilcoyne
ATTORNEYS.

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MERCURY SWITCH

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Fig. 3a

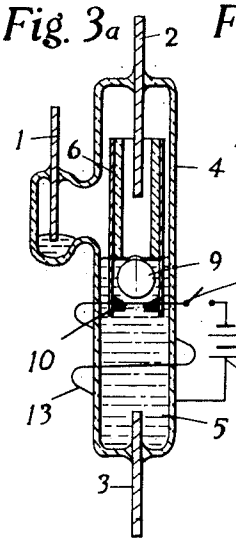


Fig. 3b

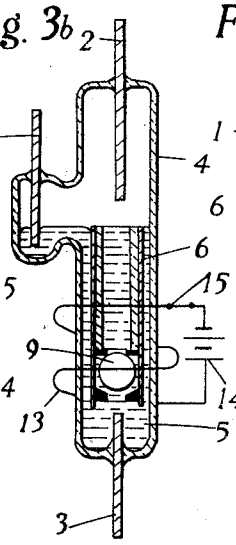


Fig. 3c

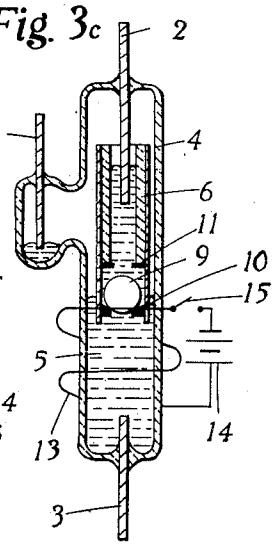


Fig. 7.

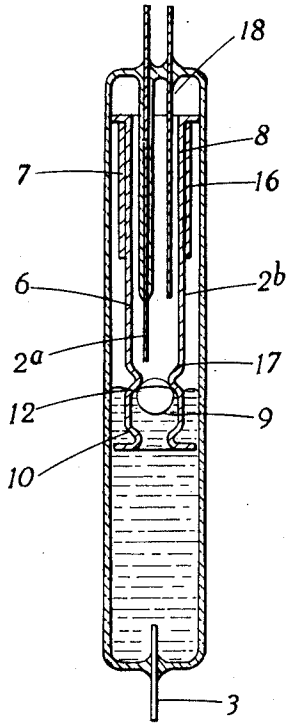
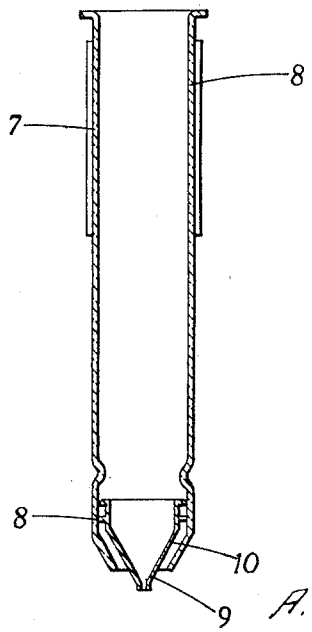


Fig. 6.



INVENTOR
A. CIANCHI.

BY

ATTORNEYS

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UNITED STATES PATENT OFFICE

2,215,543

MERCURY SWITCH

Alfredo Cianchi, London, England

Application July 26, 1937, Serial No. 155,773
In Great Britain July 28, 1936

14 Claims. (Cl. 200—97)

This invention relates to switches of the kind in which contact is made or broken by changing the level of a quantity of mercury or other conducting liquid as a result of varying the extent of immersion in it of an armature or plunger which is acted on by magnetic means arranged outside a sealed vessel enclosing the armature and the liquid, and having contacts passing through it.

According to the present invention, the plunger is drawn down into the mercury or other conducting liquid by the magnetic means and constitutes or forms part of a vessel receiving part of the mercury and the opening through which the conducting liquid passes into the vessel is controlled by a valve which is open when the plunger is drawn down into the conducting liquid but closes when the plunger is allowed to rise due to its buoyancy so as to cause the plunger to lift the conducting liquid in it and thus to cause contact to be made or broken. Thus, the plunger is able to move down quickly when it is acted upon by the magnetic means because the conducting liquid is then able to flow freely through the comparatively large opening left by the open valve. The arrangement of the switch may otherwise be similar to that described with reference to Figures 2 to 5 of the complete specification of my United States patent application Serial No. 51,962, filed 27th November, 1935, Patent No. 2,157,114, May 9, 1939, and the armature or plunger could co-operate with the wall of the containing-vessel so as to form the mercury-receiving vessel in the manner described in that specification.

The arrangement is preferably such that the plunger rises taking the mercury or other conducting liquid with it due to its buoyancy alone, although means such as a spring urging it upwards may be provided to assist the buoyancy. The natural buoyancy of an iron plunger may be increased, for example, by providing it with a liner of comparatively light material. The valve or its seating may be made so that the valve does not quite close the opening on the upward movement of the plunger, or else a separate by-pass may be provided, so that the mercury slowly flows back from the plunger or vessel into the main body of mercury so as ultimately to bring the mercury to the same level inside and outside the vessel or plunger. The by-pass opening is, of course, not large enough to prevent the mercury rising with the plunger.

The switch according to the invention may be made in various forms and to carry out various switching operations. Three examples of switches which, though substantially the same, are arranged as a result of slight modification to carry out different switching operations, will now be described with reference to the accompanying drawings as will also two modifications. In these drawings—

Figs. 1*a*, 1*b*, and 1*c* illustrate one form of switch in cross-section, the three figures showing three different conditions of the switch.

Figs. 2*a*, 2*b*, 2*c*, and 3*a*, 3*b*, 3*c* are figures similar to Figs. 1*a*, 1*b*, and 1*c*, illustrating the two other examples.

Figs. 4 and 5 are plans of details.

Fig. 6 is a sectional view of a modified form of valve; and

Fig. 7 is a cross-section of a switch having a modified form of construction of plunger.

In Figs. 1*a*, 1*b*, 1*c*, 2*a*, 2*b*, 2*c*, 3*a*, 3*b*, and 3*c*, **1**, **2** and **3** are contacts fused through the wall of the switch vessel **4** which is usually of glass. **5** is the mercury. **6** is the armature or plunger consisting of an iron tube **7**, and a tubular liner **8** of steatite, porcelain or the like. **9** is the valve in the form of a metal ball, and **10** its seating. The seating **10** is in the form of a ring sprung into the end of the tube **7** with a small gap **10***a* between its ends to form a by-pass opening. Another ring **11** smaller in width is fixed in the tube **7** above the valve **9** and has radial projections **12** to prevent the valve rising unduly. **13** is the solenoid shown diagrammatically and **14** and **15** a battery and switch for energising it.

Contact **1** co-operates with the mercury outside the armature, contact **2** projects down into the plunger and cooperates with the mercury contained in it, and contact **3** is continuously immersed in the general body of mercury. These contacts will be referred to briefly in what follows as **1**, **2** and **3**. The disposition of these contacts with respect to the mercury is different in the three examples illustrated in these figures, and the operation of the three switches will now be described separately.

When the switch of Figs. 1*a*, 1*b* and 1*c* is in its normal condition, with the solenoid de-energised (Fig. 1*a*), contact between **3** and **1** is made by the mercury and contact between **3** and **2** is open. When the solenoid **13** is energised to draw the plunger down (Fig. 1*b*), contact between **3** and **1** remains closed while the general rise of level due to the immersion of the plunger causes **3** and **2** to be bridged also. The valve **9** is open on this down-stroke so that the levels inside and outside the plunger rise together. When the solenoid **13** is de-energised again the plunger rises and at

the beginning of this stroke, the valve 9 closes so that the rising plunger takes the enclosed mercury with it. The drop of level outside the plunger is such as to break contact between 3 and 1 while, of course, contact between 3 and 2 is maintained. The flow of mercury through the by-pass opening 10*a* eventually leads to the original state of affairs being restored.

In the normal condition of the switch of Figs. 2*a*, 2*b* and 2*c*, contact between 3 and 1 is broken as also is contact between 3 and 2. When the solenoid is energised to drawn down the plunger, the general rise in level is such as to bridge 3 and 1 and also 3 and 2. When the solenoid is de-energised and the plunger rises, contact between 3 and 1 is broken quickly, because of the sudden drop of level outside the plunger contact between 3 and 2 is at first maintained but the mercury level inside the plunger eventually drops due to the passage of mercury through the by-pass opening 10*a*, so that contact between 3 and 2 is eventually broken after contact between 3 and 1 has been broken.

In the normal condition of the switch of Figs 3*a*, 3*b* and 3*c*, contact between 3 and 1 is broken as also is contact between 3 and 2. When the solenoid is energised, 3 and 1 are bridged but contact between 3 and 2 remains broken. When the solenoid is de-energised again and the plunger rises, contact between 3 and 1 is broken quickly whereas contact between 3 and 2 is established quickly but eventually broken due to the passage of mercury through the by-pass opening.

The switches described above are merely examples. The invention could be applied to a simple make-and-break switch, which may be similar to the switches already described but with two contacts, one permanently immersed in the body of mercury such as 3, and the other, such as 2, arranged to project down into the tubular plunger but so as normally to be clear of the surface of the mercury. In the initial condition of the switch, these contacts are not bridged by the mercury. When the solenoid is energised the plunger is drawn down into the mercury but the slight general increase in level which now takes place is not enough to bridge the two contacts. When the solenoid 13 is de-energised again, the plunger rises and the valve 9 closes, except for the by-pass opening, and the mercury in the plunger rises and comes into contact with the downwardly-extending contact 2. The mercury now flows slowly back from the plunger to the general body of mercury through the by-pass opening so that after the lapse of a sufficient time, depending upon the size of the opening, equality of levels is restored and contact is broken. Instead of having a contact projecting downwardly into the tubular plunger, it may project down into the space between the plunger and the switch vessel and be normally immersed in the mercury so that contact is normally made. In that case, contact remains made when the plunger is drawn down by the solenoid, but when the plunger rises, contact is broken due to the drop of level outside the plunger consequent on the taking up of a comparatively large amount of mercury in the plunger. Contact is re-established when the switch returns to its original condition.

The valve need not be a ball valve. Fig. 6 illustrates a modified form of valve, in which the valve 9 is of conical form and seats on a cross-shaped seat 10 formed by turning in the lower end of the glass tube 8 which, in this case, forms the lining of the armature.

In the switch of Fig. 7, the plunger 6 is of glass as in Fig. 6 and has the projections 12 made by fusing the glass and pressing it in on the outside, for preventing the valve 9, again shown in the form of a ball, from rising unduly from its seating 10. The seating 10 is formed by fusing and then turning in the lower end of the glass tube. The magnetic portion of the plunger is in the form of an iron tube 7 passed over the glass tube 8. In this case also, instead of the seating 10 of the valve having a gap to act as the by-pass, a small hole 17 is formed in the plunger at a point above the ball 9. In Fig. 7, also, the single upper electrode 2 is replaced by a pair of electrodes 2*a* and 2*b* of different lengths so that the mercury, as it rises, first makes contact with the electrode 2*a* and then with 2*b*. Any number of such electrodes may be provided.

It is to be understood that it is not always necessary to have one contact such as 3 continuously immersed in the general body of mercury. This contact could be arranged just above the normal level of the mercury in some cases so that the mercury first immerses it and then passes on to the other contacts to carry out switching operations such as those described above.

It may sometimes be desirable to reduce the cross-sectional area between the outside of the plunger and the wall of the switch vessel at a part immediately above the normal level of the mercury, so as to amplify the rise of level of the mercury. This could be done by forming an inwardly-extending depression in the wall of the glass tube which need not necessarily extend around the whole circumference.

I claim:

1. An electric switch comprising a closed vessel containing a conducting liquid, a plurality of contact members co-operating with said liquid, a plunger enclosed in said vessel, said plunger forming part of a receptacle receiving part of said liquid and normally floating in said liquid, there being an opening giving communication between the liquid in said receptacle and the liquid outside it, magnetic means acting on said plunger to draw it down into said liquid, a valve controlling said opening, said valve being open when said plunger is drawn down and closing when said plunger is allowed to rise causing said plunger to lift the liquid contained in it to make or break electrical connection between said contact members through said liquid.

2. An electric switch comprising a closed vessel containing a conducting liquid, a plurality of contact members co-operating with said liquid, a plunger enclosed in said vessel, said plunger forming part of a receptacle receiving part of said liquid, and normally floating in said liquid, there being an opening giving communication between the liquid in said receptacle and the liquid outside it, magnetic means acting on said plunger to draw it down into said liquid, a valve controlling said opening, said valve being open when said plunger is drawn down and closing when said plunger is allowed to rise causing said plunger to lift the liquid contained in it to make or break electrical connection between said contact members through said liquid, and an opening by-passing said valve to enable liquid to flow from said receptacle to restore the original condition of the switch.

3. An electric switch comprising a closed vessel containing a conducting liquid, a plunger enclosed in said vessel, said plunger forming part of a receptacle receiving part of said liquid and normally floating in said liquid, there being an opening giving communication between the liquid in said receptacle and the liquid outside it, magnetic means acting on said plunger to draw it down into said liquid, a plurality of contact members co-operating with said liquid, one of said contact members co-operating with the liquid in said receptacle and being spaced from it when said plunger is floating, a valve controlling said opening, said valve being open when said plunger is drawn down and closing when said plunger is allowed to rise causing said plunger to lift the liquid contained in it to establish electrical connection between the liquid in said receptacle and said contact member co-operating with it.

4. An electric switch comprising a closed vessel containing a conducting liquid, a plunger enclosed in said vessel, said plunger forming at least part of a receptacle receiving part of said liquid and normally floating in said liquid, there being an opening giving communication between the liquid in said receptacle and the liquid outside it, magnetic means acting on said plunger to draw it down into said liquid, a plurality of contact members co-operating with said liquid, one of said contact members co-operating with the liquid in said receptacle and being spaced from it when said plunger is floating, a valve controlling said opening, said valve being open when said plunger is drawn down and closing when said plunger is allowed to rise causing said plunger to lift the liquid contained in it to establish electrical connection between the liquid in said receptacle and said contact member co-operating with it, and in an opening by-passing said valve to enable liquid to flow from said receptacle to restore the original condition of the switch.

5. An electric switch comprising a closed vessel containing a conducting liquid, a plunger enclosed in said vessel and forming part of a receptacle receiving part of said liquid and normally floating in said liquid, there being an opening giving communication between the liquid in said receptacle and the liquid outside it, a plurality of contact members, one of said contact members co-operating with the liquid inside said receptacle and the second of said contact members co-operating with the liquid outside it, magnetic means acting on said plunger to draw it down into said liquid, said liquid being out of contact with said first contact member and in contact with said second contact member when said plunger is floating, a valve controlling said opening, said valve being open when said plunger is drawn down and closing when said plunger is allowed to rise, the drawing down of said plunger raising the level of said liquid to make contact between it and said first contact member and the rising of said plunger lowering the level of said liquid outside said receptacle to break contact between said liquid and said second contact member.

6. An electric switch comprising a closed vessel containing a conducting liquid, a plunger enclosed in said vessel and forming part of a receptacle receiving part of said liquid and normally floating in said liquid, there being an opening giving communication between the liquid in said receptacle and the liquid outside it, a plurality of contact members, one of said contact members co-operating with the liquid inside said receptacle and the second of said contact members co-operating with the liquid outside it, magnetic means acting on said plunger to draw it down into said liquid, said liquid being out of contact with said first contact member and in contact with said second contact member when said plunger is floating, a valve controlling said opening, said valve being open when said plunger is drawn down and closing when said plunger is allowed to rise, the drawing down of said plunger raising the level of said liquid to make contact between it and said first contact member and the rising of said plunger lowering the level of said liquid outside said receptacle to break contact between said liquid and said second contact member, and an opening by-passing said valve to enable liquid to flow from said receptacle to restore the original condition of the switch.

7. An electric switch comprising a closed vessel containing a conducting liquid, a plunger enclosed in said vessel and forming part of a receptacle receiving part of said liquid and normally floating in said liquid, there being an opening giving communication between the liquid in said receptacle and the liquid outside it, a plurality of contact members, one of said contact members co-operating with the liquid inside said receptacle and the second of said contact members co-operating with the liquid outside it, magnetic means acting on said plunger to draw it down into said liquid, said liquid being out of contact with said first and said second contact members when said plunger is floating, a valve controlling said opening, said valve being open when said plunger is drawn down and closing when said plunger is allowed to rise, the drawing down of said plunger raising the level of said liquid inside and outside said receptacle to bring it into contact with said first and said second contact members, and the rising of said plunger lowering the level of said liquid outside said receptacle to break contact between said liquid and said second contact member.

8. An electric switch comprising a closed vessel containing a conducting liquid, a plunger enclosed in said vessel and forming part of a receptacle receiving part of said liquid and normally floating in said liquid, there being an opening giving communication between the liquid in said receptacle and the liquid outside it, a plurality of contact members, one of said contact members co-operating with the liquid inside said receptacle and the second of said contact members co-operating with the liquid outside it, magnetic means acting on said plunger to draw it down into said liquid, said liquid being out of contact with said first and said second contact members when said plunger is floating, a valve controlling said opening, said valve being open when said plunger is drawn down and closing when said plunger is allowed to rise, the drawing down of said plunger raising the level of said liquid inside and outside said receptacle to bring it into contact with said first and said second contact members, and the rising of said plunger lowering the level of said liquid outside said receptacle to break contact between said liquid and said second contact member, and an opening by-passing said valve to enable liquid to flow from said receptacle to restore the original condition of the switch.

9. An electric switch comprising a closed ves-

sel containing a conducting liquid, a plunger enclosed in said vessel and forming part of a receptacle receiving part of said liquid and normally floating in said liquid, there being an opening giving communication between the liquid in said receptacle and the liquid outside it, a plurality of contact members, one of said contact members co-operating with the liquid inside said receptacle and the second of said contact members co-operating with the liquid outside it, magnetic means acting on said plunger to draw it down into said liquid, said liquid being out of contact with said first and said second contact members when said plunger is floating, a valve controlling said opening, said valve being open when said plunger is drawn down and closing when said plunger is allowed to rise, the drawing down of said plunger raising the level of the liquid outside said receptacle to make contact between it and said second contact member and the rising of said plunger lowering the level of said liquid outside said receptacle to break contact between said liquid and said second contact member, and bringing the liquid inside said receptacle into contact with said first contact member.

10. An electric switch comprising a closed vessel containing a conducting liquid, a plunger enclosed in said vessel and forming part of a receptacle receiving part of said liquid and normally floating in said liquid, there being an opening giving communication between the liquid in said receptacle and the liquid outside it, a plurality of contact members, one of said contact members co-operating with the liquid inside said receptacle and the second of said contact members co-operating with the liquid outside it, magnetic means acting on said plunger to draw it down into said liquid, said liquid being out of contact with said first and said second contact members when said plunger is floating, a valve controlling said opening, said valve being open when said plunger is drawn down and closing when said plunger is allowed to rise, the drawing down of said plunger raising the level of said liquid inside and outside said receptacle to make contact between it and said second contact member and the rising of said plunger lowering the level of said liquid outside said receptacle to break contact between said liquid and said second contact member, and bringing the liquid inside said receptacle into contact with said first contact member, and an opening by-passing said valve to enable liquid to flow from said receptacle to restore the original condition of the switch.

11. An electric switch comprising a closed vessel containing a conducting liquid, a plurality of contact members co-operating with said liquid, a plunger enclosed in said vessel, said plunger forming at least part of a receptacle receiving part of said liquid and normally floating in said liquid, there being an opening giving communication between the liquid in said receptacle and the liquid outside it, magnetic means acting on said plunger to draw it down into said liquid, a valve controlling said opening, said valve being open when said plunger is drawn down and closing when said plunger is allowed to rise causing said plunger to lift the liquid contained in it to make or break electrical connection between said contact members through said liquid, and resilient means acting on said plunger to assist it to rise.

12. An electric switch comprising a closed vessel containing a conducting liquid, a plurality of contact members co-operating with said liquid, a plunger enclosed in said liquid, the lower part of said plunger forming a receptacle receiving part of said liquid and said plunger normally floating in said liquid, there being an opening giving communication between the liquid in said receptacle and the liquid outside it, magnetic means acting on said plunger to draw it down into said liquid, a valve controlling said opening, said valve being open when said plunger is drawn down and closing when said plunger is allowed to rise causing said plunger to lift the liquid contained in it to make or break electrical connection between said contact members through said liquid.

13. An electric switch comprising a closed vessel containing a conducting liquid, a plurality of contact members co-operating with said liquid, a plunger enclosed in said liquid, the lower part of said plunger forming a receptacle receiving part of said liquid and said plunger normally floating in said liquid, there being an opening giving communication between the liquid in said receptacle and the liquid outside it, magnetic means acting on said plunger to draw it down into said liquid, a valve controlling said opening, said valve being open when said plunger is drawn down and closing when said plunger is allowed to rise causing said plunger to lift the liquid contained in it to make or break electrical connection between said contact members through said liquid, and an opening by-passing said valve to enable liquid to flow from said receptacle to restore the original condition of the switch.

14. An electric switch comprising a closed vessel containing a conducting liquid, a plurality of contact members co-operating with said liquid, a plunger enclosed in said vessel, said plunger forming at least part of a receptacle receiving part of said liquid and normally floating in said liquid, one of said contact members co-operating with the liquid in said receptacle, there being an opening giving communication between the liquid in said receptacle and the liquid outside it, magnetic means acting on said plunger to draw it down into said liquid, a valve controlling said opening, said valve being open when said plunger is drawn down and closing when said plunger is allowed to rise causing said plunger to lift the liquid contained in it to make or break electrical connection between said contact members through said liquid, the conducting liquid in said receptacle only coming into contact with said contact member co-operating with it when said plunger rises.

ALFREDO CIANCHI.