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MERCURY CONTACT SWITCH HAVING AN ALLOY CONTACT

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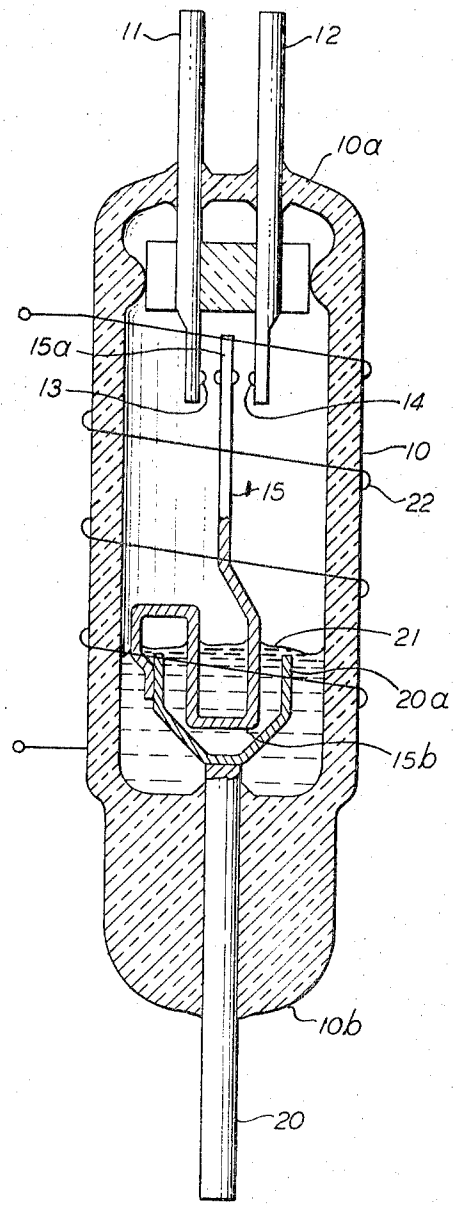

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MERCURY CONTACT SWITCH HAVING AN ALLOY CONTACT

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ABSTRACT OF THE DISCLOSURE

A mercury switch is disclosed in which the contact surfaces contain copper, platinum and nickel in various proportions.

This invention relates to electric switches and particularly to those in which mercury is used on the contacting surfaces to improve switching performance.

It is broadly an object of this invention to improve the construction and operation of switches in which the contacts are wetted.

Switches of the kind under consideration are generally referred to as mercury switches. They take several forms and the ones disclosed in Patent 2,609,464, issued to J. T. L. Brown et al. and Patent 2,868,926, issued to C. E. Pollard, Jr., are typical.

Heretofore, the interacting contact surfaces in mercury switches have generally been made of a precious metal. For example, contacts surfaced with pure platinum have been widely used. Similarly, contacts surfaced with an alloy of platinum and nickel are also commonplace.

Contacts surfaced with either platinum alone or with an alloy of platinum and nickel, however, tend to stick within a short time after switching action begins. Specifically, it has been found that when mercury and platinum meet in the switch, an amalgam forms at the interface. The amalgam disrupts the smoothness of the contact surfaces, and the resulting roughness causes mechanical interlocking or sticking. Thus, amalgamation, the mechanism by which the desired wetting of the contact surfaces is produced, works too well and thereby creates other problems.

The addition of nickel to the platinum tends to inhibit amalgamation. However, if enough nickel is added to completely inhibit amalgamation, the contacts become so magnetic that switch operation is adversely affected. Consequently, while less severe where the contact surface is made of a platinum-nickel alloy, sticking nevertheless continues to be troublesome.

According to this invention, copper is added to the material used on the contact surfaces in order to inhibit sticking. For example, it has been found that when copper is added to platinum, the resulting alloy readily wets but amalgamates only slightly. Similarly, it has been found that by mixing copper with a platinum-nickel alloy, the new alloy readily wets but does not readily amalgamate. Furthermore, in the platinum-nickel-copper alloy, more nickel can be used than before without significantly affecting the magnetic characteristics of the contacts. Finally, it has been discovered that copper can be mixed with nickel alone to form a copper-nickel alloy which, when used as a contact surface, readily wets but neither amalgamates significantly nor exhibits adverse magnetic characteristics.

When taken with the drawing, the following detailed description will help one to a better understanding of this invention. The drawing shows a partial section view of an electromagnetically responsive switch made in accordance with this invention.

The illustrated switch comprises an envelope or housing **10** which may be made of glass and which has two ends **10***a* and **10***b*. Two spaced pole-piece terminals **11** and **12** are sealed in the end **10***a*. Both terminals are made from a magnetic material such as 52 alloy. 52 alloy is a composition consisting essentially of 52 percent nickel and 48 percent iron. Further, the facing inner ends of each terminal **11** and **12** are provided with a contact **13** and **14**, respectively. The composition of the contacts **13** and **14** is described below in detail.

A metal tube **20** is sealed in the end **10***b* so as to extend into the housing **10**. One part of the tube **20** is located within the envelope and has a flared or cup-like portion **20***a* for holding an electrically conducting contact wetting liquid; viz, mercury **21**. As illustrated, the mercury **21** may be present in a quantity sufficient to fill part of the housing **10** and cover the cup-like portion **20***a*. Furthermore, the mercury **21** can be initially pure or it can contain additives such as copper or the like.

A reed or swinger **15** is secured to the cup **20***a*. It is made of a magnetic material such as 78.5 Permalloy. 78.5 Permalloy is a composition consisting essentially of 21.2 percent iron, 78.5 percent nickel and .3 percent manganese. One end of the swinger **15** terminates in a contacting portion **15***a* and the other end terminates in a looped portion **15***b*. The central portion of the swinger **15** is adapted to transport the mercury **21** readily between the portions **15***a* and **15***b*. The looped portion **15***b* contacts the mercury **21** in the cup **20***a* and the contacting portions **15***a* is wetted by the mercury **21** transported by the central portion of the swinger **15**. Finally, the contact portion **15***a* is disposed between the terminals **11** and **12** in a position to readily engage the contacts **13** and **14**.

An energizing coil **22**, shown schematically in the drawing, surrounds the housing **10**.

The theory of operation of mercury contact switches is well known to those skilled in the art and, accordingly, it is not discussed. For further information regarding the particular type of switch chosen to illustrate this invention, reference is made to the previously noted Patents 2,609,464 and 2,868,926. Generally, however, the swinger **15** reciprocates between the contacts **13** and **14** in response to energization of the coil **22**. Switching occurs when the swinger **15** engages one of the contacts through the mercury **21**.

The contact **13**, the contact **14**, and, if desired, the portion of the swinger **15** which engages the contacts **13** and **14**, are preformed of an alloy before assembly in the switch. Specifically, they are preformed from an alloy which is substantially non-magnetic; which will not amalgamate in bulk with the wetting agent (viz, the mercury **21**) and only slightly, if at all, on the surface; and which will form an advancing contact angle with the wetting agent of 20 degrees or less. For the purposes of this description, an advancing contact angle is defined as the angle lying between a surface being wetted and a plane lying tangent to the leading edge of the medium which is wetting the surface.

In the particular embodiment described herein, the mercury **21** contains a small amount of copper, and the contacts **13** and **14** are preformed from an alloy consist-

ing of copper and platinum. More specifically, the alloy in the described embodiment consists of platinum and copper mixed in the atomic proportions $PtCu_3$.

Switches having preformed contacts made of $PtCu_3$ have been tested for sticking and the results demonstrate that the problem of sticking has been drastically reduced. For example, four sample lots, each containing 10 relays equipped with contacts surfaced with $PtCu_3$, were subjected to heating tests. The purpose of these heating tests was to force amalgamation between the mercury and the contact surfaces so as to intensify any sticking propensity. Specifically, three of the four lots were subjected to heat at 90 degrees centigrade for 16 hours. In two of the three lots, no sticking occurred whatsoever. In the third lot, only one of the 10 relays stuck. The stuck relay, however, was found to be defective for other reasons; i.e., its swinger was partially dry. The fourth lot was subjected to heat at 90 degrees centigrade for 92 hours and not a single relay stuck.

Next, two of the four lots were subjected to further tests. One was aged for 108 hours at 90 degrees centigrade with observations for sticking made at 32, 48 and 108 hours. This lot was then stored for six months at room temperature. No sticking of any kind occurred.

The remaining lot was heated for 92 hours at 90 degrees centigrade with no sticking observed at 32 and 92 hours. Thereafter, the relays were operated 60 times a second at about 200 percent normal power for 264 hours and then heated for 64 hours at 90 degrees centigrade. None of the relays stuck. The operating point for one relay, however, was substantially increased. By comparison, mercury switches having contacts made of platinum alone or an alloy of platinum and nickel exhibit a high incidence of sticking when subjected to tests of this kind.

At each observation point in the foregoing tests, the contacts were visually inspected for wetting. With the exception of those instances specified above, all of the contact surfaces were covered by the mercury.

In the relay described and in the relays tested, the contacts **13** and **14** were preformed from a combination consisting of a fused alloy of $PtCu_3$ and a base metal. With a fused alloy such as $PtCu_3$, the contacts **13** and **14** are readily made by bonding a sheet of the fused alloy over the base metal and then stamping or cutting out contacts from the composite structure. The resulting contacts will have a base material adapted for joining to one of the terminals **11** or **12**, and a contact surface adapted to engage the swinger **15** and be wetted by the mercury **21**.

Other ways of making the contacts **13** and **14** are also feasible. For instance, they can be formed by sputtering or by electroplating the alloy metal over the base metal. Whichever method is used, however, the alloy metal overlay in the preformed contact should have a thickness on the order of 10 microns or greater.

While the embodiment described in the foregoing had contacts preformed from a copper-platinum alloy, the principles disclosed herein can be extended to other arrangements. For example, nickel is readily substituted for the platinum. In such a case, instead of copper-platinum, the preformed contact alloy consists of copper-nickel. The nickel substitution, moreover, need not be complete. For example, an alloy made of copper, platinum and nickel is particularly advantageous when the proportion of nickel present is 12 to 15 percent by weight. Thus, while an alloy consisting of platinum and copper is especially effective, other alloys containing copper will also create contact surfaces which wet easily and which do not stick.

Furthermore, the proportion of copper in the alloy can be varied. In the particular embodiment specifically described herein, platinum and copper are present in the proportions $PtCu_3$. Other proportions, however, will also provide good results. For example, where absolute freedom from sticking is not of utmost importance, the proportion of copper in the alloy can be as low as 5 percent by weight. Better reliability, however, is obtained when the percentage of copper is increased to the order of 55 percent by weight. Best reliability is obtained when the amount of copper in the alloy is just sufficient to chemically stabilize the interface between the contact and the wetting agent.

Similarly, when the alloy consists of copper and nickel, the amount of nickel can be varied. While the composition of the alloy can go as high as 70 percent nickel by weight before the alloy becomes magnetic in its operating range, best results are obtained when the amount of nickel is kept within 20 to 65 percent by weight.

In summary, a switching device containing contacts wetted by an electrically conducting agent has been disclosed in which the wetted contacts stay wet and sticking is substantially eliminated. It is to be understood, however, that the above described arrangements are merely illustrative of the application of the principles of this invention. Numerous other arrangements may be devised by those skilled in the art without departing from the spirit and scope of the invention.

What is claimed is:

1. In a sealed contact switching device containing a contact wettable by mercury, the combination comprising:
- a first contact having a contact surface preformed from an alloy consisting of copper and a metal selected from the group consisting of nickel, and an alloy of platinum and nickel;
- a second contact for engaging said first contact; and
- mercury wetting the contacting portions of said first and second contacts.

2. A combination in accordance with claim **1** wherein said first contact is a fused alloy consisting of copper and platinum and wherein the percentage of copper in said first contact ranges from 5 percent to 55 percent by weight.

3. A combination in accordance with claim **1** wherein said alloy consists of platinum and copper in the atomic proportions $PtCu_3$.

4. In a switching device containing a contact wettable by an electrically conducting liquid sealed in a vessel, the combination comprising:
- mercury for wetting a first and second contact;
- said first contact having a contact surface wetted by said mercury, said contact surface being preformed from an alloy which is substantially non-magnetic, which is substantially free of amalgamation in said mercury, and which forms an advancing contact angle of less than 20 degrees when wet by said mercury; and
- said second contact having a contact surface wetted by said mercury and arranged to engage the contact surface on said first contact.

5. A combination in accordance with claim **4** wherein said alloy consists of copper and a metal selected from the group consisting of platinum, nickel and an alloy of platinum and nickel.

6. In a sealed contact switching device containing a contact wettable by mercury, the combination comprising:
- a first contact having a contact surface preformed from an alloy of platinum, nickel and copper wherein the percentage of copper in said first contact ranges from 5 percent to 55 percent by weight, and the percentage of nickel ranges from 12 to 15 percent by weight;
- a second contact for engaging said first contact; and
- mercury wetting the contacting portions of said first and second contacts.

7. In a sealed contact switching device containing a contact wettable by mercury, the combination comprising:
- a first contact having a contact surface preformed from an alloy of nickel and copper;
- a second contact for engaging said first contact; and
- mercury wetting the contacting portions of said first and second contacts.

8. A combination in accordance with claim 7 wherein the percentage of nickel in said first contact ranges from 20 percent to 65 percent by weight.

9. In a sealed contact switching device containing a contact wettable by mercury, the combination comprising:

a first contact having a contact surface made of an alloy preformed from copper and at least one metal selected from the group consisting of platinum and nickel, the amount of nickel present being no more than 70 percent and the amount of copper being between 5 percent and 55 percent by weight;

a second contact for engaging said first contact; and

mercury wetting the contacting portions of said first and second contacts.

10. A combination in accordance with claim 9 wherein said copper and said metal are fused to form said alloy.

References Cited

UNITED STATES PATENTS

2,769,875	11/1956	Brown et al.	200—166
3,018,354	1/1962	Pollard	200—166
3,054,873	9/1962	O'Brien et al.	335—58
3,114,811	12/1963	Kohman	335—58
3,146,328	8/1964	Mason et al.	200—166

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