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METHOD OF MAKING MERCURY SWITCHES

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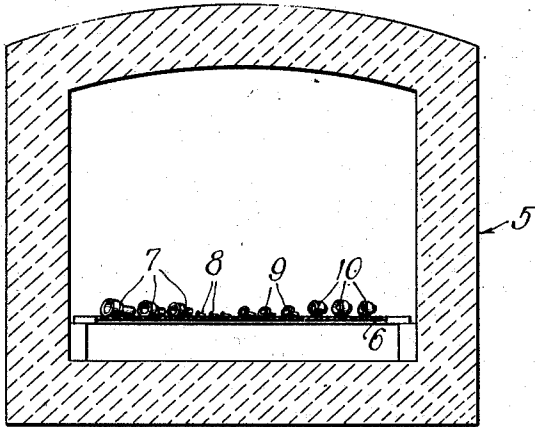


Fig. 1.

Fig. 3.

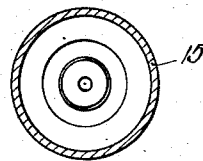


Fig. 2.

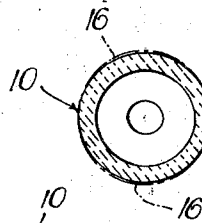
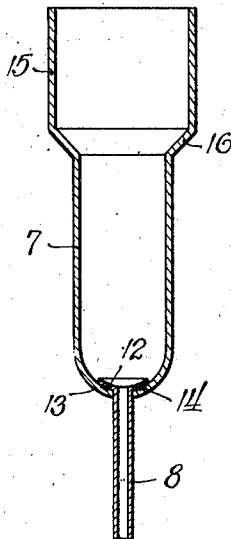


Fig. 4.

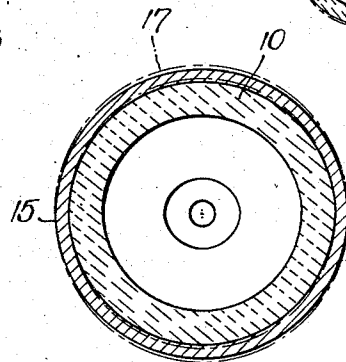
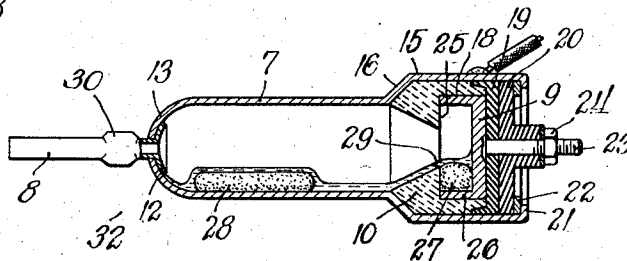


Fig. 5.

Fig. 6.



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METHOD OF MAKING MERCURY SWITCHES

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10 Claims. (Cl. 29—155.5)

This invention relates to a method of making mercury switches, and more particularly is concerned with the method of assembling and treating the parts of a metal envelope switch, such as the type shown in the patent to Paul S. Bear, No. 2,132,921, issued October 11, 1938.

In the manufacture of switches of this type in which hydrogen is employed as the atmosphere within the switch envelope in which the mercury operates, I have found that the iron shell or envelope forming the switch body contains impurities and occluded gases. These gases, as well as water vapor which may be present in connection with the oxides in the iron, render the mercury impure after the switch has been operated for any appreciable period of time, resulting in the changing of its operating angle, and in some cases being such as to render the switch inaccurate in operation, or even entirely inoperative.

The present invention is directed particularly to a switch of the type in which a drawn metal shell of cup shape is provided with an open end in which is inserted a ceramic or refractory insert having a bore therethrough, this bore forming a communicating passageway between mercury carried within the metal shell and a body of mercury retained in contact with an electrode carried by the insert. It is to be understood, of course, that the switch may be of the direct metal to mercury contact type in which the mercury in the shell is movable through the bore in the insert into and out of contact with a metal electrode or the like.

I have found that the ceramic inserts which are prepared by molding and firing do not come out as perfectly cylindrical bodies, but may be of slightly elliptical shape. The metal shell, on the other hand, when drawn properly, has its open end in the form of a true cylinder adapted to receive the ceramic. Consequently, the ceramic does not fit the interior of the shell in a positive manner. This is undesirable since mercury may run between the outer surface of the ceramic and the inner surface of the end of the shell, and in such case, may contact the rubber sealing means producing a deleterious effect on the rubber.

Another disadvantage found in connection with such switches is that the iron shell is susceptible to the hydrogen gas, and if not properly treated, provides an absorptive body which tends to absorb the hydrogen within the envelope, reducing the internal pressure of the

hydrogen and thus reducing its effect upon the mercury and impurities within the envelope.

Another disadvantage, which has been noted in connection with the forming of such switches, is that the bond formed beneath the tubulation by which the switch is evacuated and filled with gas and the interior surface of the switch is sometimes not perfectly gas tight due to impurities in the iron, which prevent a positive weld of the tubulation flange within the end of the envelope.

It is therefore a primary object of the present invention to provide a metal envelope mercury switch of this type in which the shell and tubulation parts, as well as the electrodes and ceramics, are first heated to a relatively high temperature in a hydrogen annealing furnace whereby the metal parts are expanded and the oxides and occluded gases are driven off and replaced by the hydrogen. This renders the metal surfaces bright and clean, and the high temperature causes the metal to expand, opening up its pores and forming a water vapor from the oxides in the iron and the hydrogen case present. The impurities are completely burned up and the pores of the metal are filled with pure hydrogen gas. It is well known to those skilled in the art that a perfectly pure iron will not rust, but that impurities in the iron form small elements in the metal, creating electrolysis effects which corrode the metal. The hydrogen annealing process cleans the iron in such a high degree that even the outside of the envelope is practically rust-proof after annealing, and iron lends itself readily to soldering when the copper leads are applied without first being tin plated.

Another feature of the hydrogen annealing process resides in the complete elimination of the acid cleaning to which such parts are normally subjected before being put into the annealing furnace, providing, of course, that the parts are first washed in carbon tetrachloride.

Still another feature of the hydrogen annealing process is that the tubulation tubes and the iron envelopes are perfectly cleaned before being welded together, and consequently a perfect welding joint is formed assuring a perfect leak-proof connection between the tubulation and the closed end of the envelope. In this connection, since the annealing process makes the metal softer, the tubulation tubes can be pinched more readily after evacuation and hydrogen filling of the envelope, and thus form an excellent gas-proof seal.

Another very important advantage obtained

by the present invention is that during the annealing processes, the heat produces expansion of the metal parts, and inasmuch as the iron has a much greater degree of expansion than the ceramic, introduction of the ceramics into the ends of the iron envelope while they are still hot results in shrinkage of the metal about the ceramic parts, and if the ceramic is slightly out of round, the metal tube shrinks thereabout and takes the shape of the ceramic, forming a very satisfactory seal preventing the mercury from running down between the ceramic and the iron body. At the same time the metal parts are being cooled in a chamber in which they are still subjected to a hydrogen atmosphere, contraction of the metal closes up the pores, trapping hydrogen gas therein in place of the impure occluded gases. It is to be understood that once the parts are placed in the hydrogen annealing furnace, they are not again touched by hand until after the ceramics have been inserted in the ends thereof and the desired shrinkage has been obtained to produce the tight fit of the end of the envelope about the periphery of the ceramic.

Other objects and advantages of the present invention will appear more fully from the following detailed description which, taken in conjunction with the accompanying drawing, will disclose to those skilled in the art the particular construction and operation of a preferred form of the present invention.

In the drawing:

Figure 1 is a diagrammatic view showing the shells and tubulation electrodes and ceramics disposed within the hydrogen annealing furnace;

Figure 2 illustrates the manner in which the tubulations are secured in the inner ends of the shells;

Figure 3 is an end sectional view through the enlarged end of the envelope;

Figure 4 is a corresponding sectional view of the end of the ceramic;

Figure 5 illustrates the manner in which the shell shrinks about the periphery of the ceramic; and

Figure 6 is a transverse sectional view through an assembled switch structure embodying the present process.

Considering the drawing in detail, a hydrogen annealing furnace is indicated generally at 5 and has disposed therein the conventional tray 6 upon which are mounted the shells 7, tubulations 8, electrodes 9, and ceramics 10. These parts are subjected in the furnace to an intense heat in the presence of a hydrogen atmosphere being annealed at a temperature of approximately 2000° F. The iron shells are preferably formed of a material identified as SAE-1315, and when subjected to the annealing temperature of 2000° F. in a hydrogen atmosphere, the pores of the metal are expanded, forcing out the occluded gases and the impurities, such as the oxides, and these gases are completely burned up and the pores filled with pure hydrogen gas.

After the iron shells 7 and tubulations 8 have thus been annealed, and while still hot, they are taken from the furnace and the tubulations are inserted through the small end of the envelope 7 with the flange portion 12 of the tubulations engaging the internal rounded surface of the ends 13 of the envelopes. These are then welded in position, as indicated at 14, substantially in the manner described in the copending application of Paul S. Bear, Serial No. 293,690, filed September 7, 1939. The shells with the tubulation welded

in place are then returned to the furnace. It is apparent that by completely burning up all the impurities, the metal parts have been cleaned to such a high degree that a perfect welding joint is provided and a positive leak-proof seal is effected between the tubulation and the envelope end.

Considering Figure 3, it will be noted that the enlarged end 15 of the shell which is joined to the main body portion of the shell by the shoulder 16 is a true cylinder that the ceramics 10, due to the fact that they are never perfectly round when molded or fired, since they are heated in a kiln at approximately 2600° F. when made, may be out of round, as indicated by the dotted lines 16 in Figure 4. As a consequence, after the annealing has been completed and the pores of the iron shell filled with hydrogen, the ceramics are placed in the ends 15 thereof while still hot and the parts are then allowed to cool in a hydrogen atmosphere which causes the shell ends 15 to shrink down from their original contour, indicated by the dotted lines 17, to the contour of the ceramic, forming a substantially perfect mechanical engagement about the periphery of the ceramic such that no gaps or voids are provided therebetween which might allow mercury to leak therepast. Since the ceramics have relatively little or no coefficient of expansion when heated, while the iron has an appreciable expansion upon heating, it is apparent that upon shrinking, the iron will decrease in size to shrink about the contour of the ceramic.

At the same time, this cooling produces a closing of the pores of the metal envelope, trapping hydrogen therein in place of impurities and thus providing a clean rust-proof iron shell. It is to be understood that the ceramic is placed in the end of the envelope immediately upon removal from the furnace 5. This is preferably accomplished mechanically so that the ceramics are never touched by hand after having once been placed in the annealing furnace. After cooling in the hydrogen atmosphere to shrink the end 15 of the envelope about the ceramic, the electrode 9 is placed in the recess 18 of the ceramic and is engaged by the resilient sealing gasket 19 and the compression member 20, which may be formed of Bakelite or a ceramic. Suitable axial pressure is placed upon the assembly and a retaining ring 22 engages the compression member 20 to hold the same under compression while the end 21 of the envelope is spun over to lock the parts in sealed position. The particular manner of effecting this end seal is disclosed in the copending application of Paul S. Bear, Serial No. 211,420, filed June 2, 1938.

The shank 23 of the electrode projects outwardly through a cylindrical extension on the compression member, and at its outer end, is threaded to receive the nut 24 by means of which a suitable conductor can be connected to the electrode.

It will be noted that the ceramic 10 is provided with a radial shoulder portion 25 at the inner end of the cup-shaped electrode head 26, which forms an annular groove for retaining a body of mercury 27 in contact with the electrode. A second body of mercury 28 is introduced into the envelope through the tubulation 8, and upon tilting of the envelope, it will be apparent that a circuit is made and broken between the envelope 7 and the electrode 9 at the sharp cutting edge 29 between the retained body of mercury 27 and the moving body of mercury 28. If desired, a suit-

able liquid fill may also be incorporated within the envelope, this fill comprising a material, such as triethanolamine or the like.

When the terminal assembly has been locked in position by spinning over the end 23 of the envelope, the switch is connected through the tubulation 8 to a source of mercury, and the mercury comprising the bodies 27 and 28 is introduced into the envelope, the volume of such mercury being accurately controlled to determine the operating angle of the switch. The interior of the switch is then subjected to a vacuum through the tubulation 8, and all gases which may have been trapped therein during the end assembly are withdrawn. After evacuation, the tubulation 8 is connected to a source of hydrogen gas under pressure and this gas is introduced into the interior of the envelope under a pressure ranging from 3 to 4 atmospheres. While still being subjected to the gas under pressure, the tubulation 8 is flattened, as indicated at 30, to seal off the interior of the envelope, and this flattened portion 30 is then welded to form a perfect gas tight seal. The pinching of the tubulation to form the portion 30 is facilitated because the metal has been softened during the annealing process. After welding, a portion 30 is cut as indicated by the line 32, thus completing the formation of the switch. Preferably, the switch is immediately flashed after this operation to fix its operating characteristics.

It will therefore be apparent that the hydrogen annealing performs two important functions in the process of assembling such a switch. In the first place, it removes all impurities in the iron parts of the switch, facilitating welding of the tubulation and also trapping hydrogen gas within the pores of the metal. Secondly, the expansion of the metal during the annealing process drives out the occluded gases, and also provides for shrinkage at the enlarged end of the envelope over the ceramic to seal off any possibility of mercury passing between the ceramic and the shell and coming into contact with the resilient seal 19. This shrinkage allows the end of the envelope to fit around the contour of the ceramic and produce a tight fit therebetween.

I am aware that various changes may be made in certain details of the process as herein described, and I therefore do not intend to be limited except as defined by the scope and spirit of the appended claims.

I claim:

1. In the process of manufacturing a metal envelope mercury switch having a ceramic insert in one end thereof and a tubulation in the opposite end thereof, the novel steps which comprise placing the envelope, insert and tubulation individually into a furnace, heating said parts in a hydrogen atmosphere to expel occluded gases therefrom and simultaneously expand said metal parts to open the pores thereof to hydrogen, inserting said ceramic into the end of said envelope while hot, and cooling said parts in a hydrogen atmosphere to shrink said envelope about said insert and simultaneously close said envelope pores to trap hydrogen therein.

2. In the process of manufacturing a metal envelope mercury switch of the type having a refractory disposed in the open end thereof, the novel steps which comprise placing the unassembled envelope and refractory in a furnace, heating these parts to a temperature of approximately 2000° F. in a hydrogen atmosphere to

expand the envelope and open its pores for removal of oxides and occluded gases therefrom, inserting the refractory into the open end of said envelope while said parts are heated, and cooling said parts in a hydrogen atmosphere to shrink said envelope about the refractory and simultaneously trap hydrogen in the pores of the envelope.

3. The process of claim 2 wherein said last-named step comprises water cooling of said parts to produce rapid contraction of said envelope.

4. In the process of manufacturing a metal envelope mercury switch having a refractory insert adapted to be disposed in the open end thereof, the novel steps which comprise heating said envelope to a temperature sufficient to expand the same and open its pores, inserting said refractory into the open end thereof while expanded, and rapidly cooling said envelope in a hydrogen atmosphere to shrink said end tightly about said refractory whereby said envelope end assumes a shape closely fitting the external contour of said refractory and to trap hydrogen within the pores of the envelope.

5. In the process of manufacturing a metal envelope mercury switch having an enlarged cylindrical end, the novel steps which comprise heating said envelope in a hydrogen atmosphere to expand said end and drive off any gaseous impurities and replace them with hydrogen, inserting a generally cylindrical refractory into said end while heated, and then rapidly cooling said end to shrink said end closely around the external contour of said refractory.

6. In the process of manufacturing a metal envelope mercury switch having an enlarged open end and a closed end provided with a bore, the novel steps which comprise heating said envelope in a hydrogen atmosphere to drive out occluded gases and burn off impurities therein, simultaneously heating a flanged tubulation adapted to project outwardly through said bore, welding the flange of said tubulation to the internal defining edge of said bore while said pieces are hot, reheating said welded assembly in a hydrogen atmosphere, and then rapidly cooling said assembly in a hydrogen atmosphere to trap hydrogen in the pores of said envelope.

7. The process of claim 6 further characterized by the steps of heating a refractory in said hydrogen atmosphere while reheating said welded assembly, and inserting said refractory into the open end of the envelope while hot whereby upon said rapid cooling said open end shrinks about the refractory to closely embrace the external contour thereof.

8. A method of manufacturing a cup-shaped metal envelope type mercury switch which comprises heating said envelope in a hydrogen atmosphere to drive off occluded gases and fill the pores of said envelope with hydrogen, simultaneously heating a metallic tubulation, welding said tubulation to said envelope adjacent the closed end thereof, reheating the welded assembly in a hydrogen atmosphere, inserting a ceramic bushing in the open end of said envelope while hot, and then cooling said assembly to shrink said end about said bushing and to trap hydrogen in the pores of said envelope.

9. In the process of manufacturing a metal envelope mercury switch having a metallic filling tubulation connected therewith, the steps which comprise placing said envelope and said tubulation individually in a furnace and sub-

jecting them to a relatively high heat in a hydrogen atmosphere to drive off occluded gases and impurities present in the metal parts and to open the pores thereof, removing the parts from said furnace, welding said tubulation to said envelope, reheating the assembly in said hydrogen furnace, and quickly cooling said assembly in the presence of hydrogen to trap hydrogen in the pores of the metal.

10. In the process of manufacturing a metal envelope mercury switch having an open end, a refractory insert adapted to be disposed in the open end of said envelope and an evacuating and filling tubulation connected to and communicating with the interior of said envelope, the

steps which comprise heating said assembled envelope and tubulation in a hydrogen atmosphere to a temperature sufficient to drive out occluded gases and burn off impurities therein, simultaneously heating said refractory, inserting said refractory in the open end of said envelope while hot, rapidly cooling said assembly to shrink the end of said envelope tightly about said refractory, additionally sealing the open end of said envelope, evacuating the contents of said envelope and then filling it with hydrogen through said tubulation, and sealing off said tubulation before discontinuing the flow of hydrogen into said envelope.

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