Dec. 31, 1940. J. H. STALEY 2,227,040

METAL MERCURY TUBE SWITCH

Filed April 24, 1933

Fig. 1.

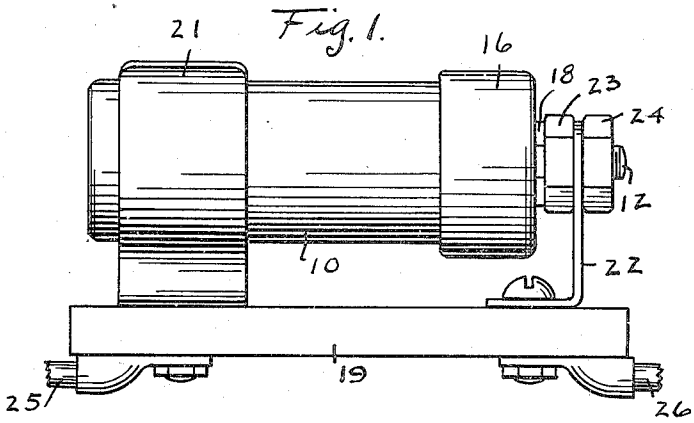
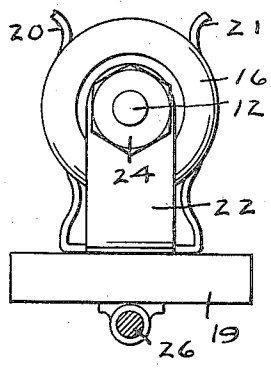


Fig. 2.



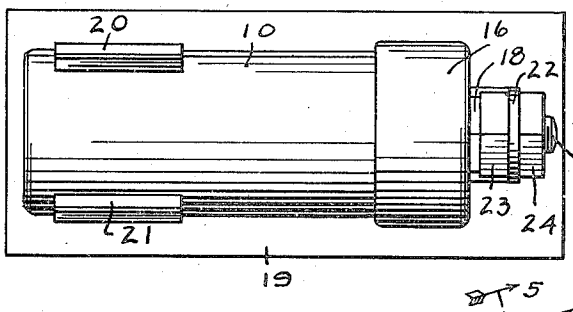
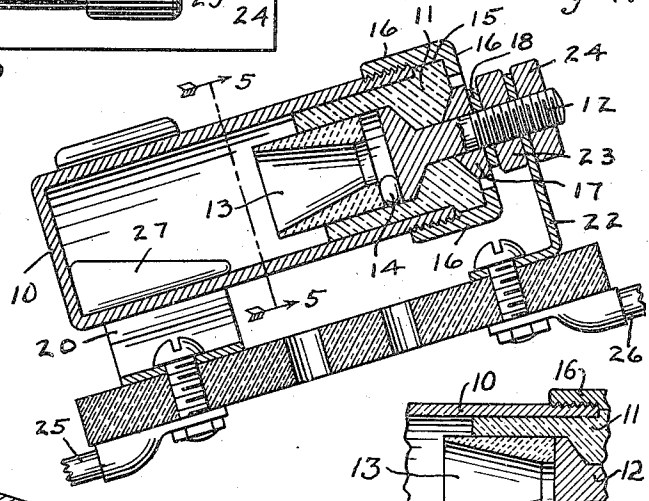


Fig. 3.

Fig. 4.



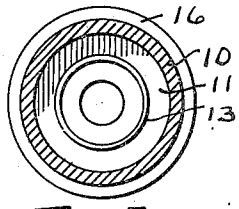


Fig. 5.

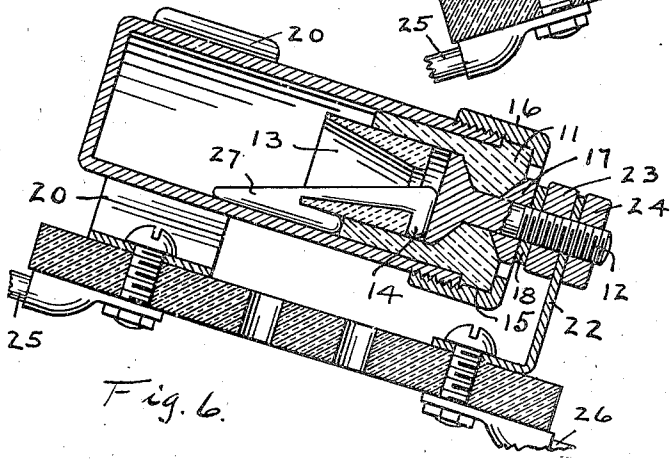


Fig. 6.

Fig. 7.

Inventor,
Joseph H. Staley,
By
Minturn & Minturn,
Attorneys.

Patented Dec. 31, 1940

2,227,040

UNITED STATES PATENT OFFICE

2,227,040

METAL MERCURY TUBE SWITCH

Joseph H. Staley, Columbus, Ind.

Application April 24, 1933, Serial No. 667,536

8 Claims. (Cl. 200—152)

This invention relates to the art of mercury tube switches for making and breaking electrical circuits. While the structure embodying the invention is adapted to be used in handling currents of low voltage, it is particularly adapted to higher voltages of comparatively heavy current flows.

A primary object of the invention is to provide a non-fragile structure capable of being manufactured at an extremely low cost and which will be durable and reliable over a long period of time even though subjected to occasional over-loads.

An important object of the invention is to provide a structure which will permit the mercury to remain in a pure state uncontaminated with a clean surface so that the mercury will remain "frisky."

A further important object of the invention is to provide means for sealing the mercury container against the entrance of atmospheric gases and against the escape of a gas which may be employed within the container. In this regard the sealing means is employed not only to perform the office of sealing against the flow of gases but also to serve as an insulator separating one electrode from another.

A still further important object of the invention is to provide means for definitely locating the position of the arc which occurs upon the separation of the mercury at the time of interrupting the electrical circuit.

These and other objects and advantages of the invention will become apparent to those skilled in the art in the following description of the invention as illustrated in one particular form, in which

Fig. 1 is a side elevation of a structure embodying my invention;

Fig. 2, an end elevation;

Fig. 3, a top plan view;

Fig. 4, a longitudinal vertical section through the structure in a position rocked to the "off" position;

Fig. 5, a transverse section on the line 5—5 in Fig. 4;

Fig. 6, a central longitudinal section similar to Fig. 4 but rocked to the "on" position; and

Fig. 7, a detail in vertical section of a modified structure.

Like characters of reference indicate like parts throughout the several views in the drawing.

My invention contemplates the use of a metallic walled member within which mercury may be caused to flow from one end to the other upon longitudinal rocking of the member. I employ the metal walled member primarily on account of the fact that it does not become broken under the ordinary usage as is often the case with the glass walled members heretofore employed. In the form of my invention as illustrated by the accompanying drawing, I form a metallic tube 10 closed at one end and open at the other. Around the outer side of the tube at its open end are formed screw-threads. An insulating plug or bushing 11 is formed to fit tightly within the open end of the tube, preferably by a forced fit so as to make a sealing connection circumferentially around it against the inner wall of the tube.

This plug 11 has an axial bore therethrough of two diameters, and a stud 12 is initially pressed through the smaller bore to have its major length projecting outwardly beyond the outer face of the plug. The under side of the head of the stud is preferably formed to be conical and the end of the larger bore is likewise conically formed so that the head may be seated thereagainst with a close fit. The inner or top face of the stud 12 is flat and forms a metallic face across the end of the bore.

A bushing 13 hereinafter termed a breaker, is formed out of some suitable insulating material, preferably refractory in nature so as to resist the effect of an electrical arc. This breaker 13 is formed with an outer cylindrical surface and an inner conical bore merging by the smaller end thereof into a cylindrical bore. The breaker 13 is pressed within the larger bore of the plug 11 to have the breaker end having the cylindrical bore carried back within the plug and spaced a relatively short distance from the face of the head of the stud 12. The spacing between the inner end of the breaker 13 and the face of the stud 12 is critical in that a circumferential pocket is formed therebetween within which a globule of mercury 14 is retained. The longitudinal length of this pocket is made to be such by the spacing of the breaker 13 from the head of the stud 12 that when the assembled parts are rocked to some such position as indicated in Fig. 4, the globule of mercury 14 will remain within the pocket without an additional spilling over as will hereinafter be explained.

As above indicated, the plug 11 with the stud 12 and the breaker 13 assembled therein is pressed into the open end of the tube 10 to have the shoulder presented around the annular flange 15 strike and bear against the end of the tube 10. A retainer ring 16 is formed to extend longitudinally over the flange 15 and screw-threadedly engage the threads on the tube 10. This ring 16

has an inturned flange coming into contact with the outer face of the plug 11 so that when the ring 16 is turned sufficiently about the end of the tube 10, this flange will tend to compress the plug flange 15 longitudinally against the end of the tube 10.

The plug 11 on its outer end about the stud 12 is counter-bored to form a conical depression within which is seated a conical sealing washer 17 which is passed over the end of the stud 12 and compressively forced against the plug 11 by means of a lock nut 18, this nut tending to compress the plug 11 between the head of the stud 12 and the washer 17 and further tending to force the plug 11 laterally against the tube 10 and the retaining ring 16. The diameter of the washer 17 is less than that of the diameter of the opening through the ring 16 so that there is an annular gap therearound between the washer and the ring.

The mercury tube switch assembled as above indicated is carried by some suitable base 19 by having the tube 10 compressively engage between the spring clips 20 and 21 and the stud 12 entered through an eye of an upturned clip 22. A nut 23 screw-threadedly carried on the stud 12 and abutting the nut 18 is brought into contact against the back side of the clip 22 when the nut 24 is screw-threadedly carried on the outer end of the stud 12 and revolved thereon to compressively engage the clip 22 between it and the nut 23. The clips 20 and 21 are united at their lower ends and fixed to the base 19 to be in an electrical circuit with a conductor 25. The clip 22 is in electrical circuit with the conductor 26, the switch assembly being thus interposed between the two conductors 25 and 26 as a means of making and breaking the electrical circuit therebetween. The base 19 is mounted in any suitable manner (not shown) whereby it may be rocked to shift the switch assembly from one position to another as indicated in Figs. 4 and 6.

An important factor contributing to the success of the operation of the switch is that the atmospheric gases within the tube 10 be replaced by some gas inert insofar as mercury is concerned. It is therefore necessary to remove the atmospheric gases at the time the tube 10 is sealed by the plug 11 and furthermore to replace such removed gases by the gas to be employed. Hydrogen gas operates successfully. The quantity of mercury 27 which is placed in the tube 10 prior to the insertion of the plug 11 is such that when the switch assembly is rocked to its extreme position of closing the circuit, there will be sufficient mercury to bridge over the breaker 13 through its axial bore to be in contact both with the face of the head of the stud 12 and over an appreciable area of the inner side of the wall of the tube 10 as indicated in Fig. 6. In practice this quantity of mercury is made to be such that the electrical circuit between the stud 12 and the tube 10 through the mercury is maintained even though the tube be turned completely on its end with the stud 12 pointing downwardly. However, the proportions of the parts entering into the switch assembly are such that when the parts are rocked to the normal position to complete the circuit through the mercury 27 between the stud 12 and the tube 10, the cylindrical bore in the breaker 13 is completely filled by the mercury, but upon reverse rocking, at the instant of the break, the upper portion thereof is open as indicated in Fig. 6, so as to leave a clear passageway leading from that part of the circumferential chamber above the mercury between the breaker and the stud 12. The breaker 13 while being carried within the plug 11 is formed to have sufficient length so as to extend beyond the plug 11 an appreciable distance into the tube 10 with clearance therearound.

Due to the overhang of the breaker 13 beyond the plug 11 within the tube 10, the mercury 27, Fig. 6, will flow around under the overhanging part of the breaker against the end of the plug 11 to fill up that space while more of the mercury flows through the conical bore of the breaker 13 against the head of the stud 12.

Now when the switch is rocked to the "off" position, Fig. 4, the mercury 27 will tend to flow to the other end of the tube 10 away from the breaker 13. In so doing the globule 14 is left within the pocket formed between the breaker and the head of the stud 12 and as above indicated, this pocket is of a definite size such that when the mercury 27 initially flows away from the globule 14 left behind, the additional rocking of the switch to insure sufficient elevation of the then raised end of the tube to cause the larger mass of mercury to remain at the lower end, will not cause any mercury to break away from the globule 14 and flow through the breaker 13 to momentarily re-establish the circuit. In other words, once the major mass of the mercury 27 leaves the globule 14, there is no additional spill over from the globule 14 which would otherwise cause a "flicker" in the circuit. While the circuit is interrupted principally by elevating the end of the tube within which the plug 11 is fitted so as to cause a mechanical separation of the mercury under the influence of gravity, other factors enter which cause the arc produced at the time of separating these masses of mercury to come at a definite location. In order to have long life, it is necessary that there be no pitting or wearing away of the metallic surfaces of the tube 10 and of the exposed head of the stud 12. Should there be any deterioration of these metallic surfaces, the metal eroded would become amalgamated with or coated over the mercury so that its original inherent high surface tension would be destroyed and there would no longer be a sharp break between the globule 14 and the main mass of the mercury. Therefore it is essential that the arc produced be confined within the breaker 13 which is made of a suitable refractory material to withstand the action of the arc.

In shifting from the position indicated in Fig. 6 to that indicated in Fig. 4, the mercury tends to flow down the bore within the breaker 13 until the thickness of the mercury is reduced to produce an actual severance thereof substantially at the junction of the conical and cylindrical bores within the breaker. Thus the arc occurring between these two adjacent masses of mercury at the time they are severed is initially located at this position. Since the mercury within the cylindrical bore of the breaker 13 represents that section having the smallest cross-sectional area, the natural inherent effect of the current flowing through the mercury is to set up a "pinching" effect tending to automatically pinch this narrow neck of mercury so as to further restrict its cross-sectional area. This action is accentuated by reason of the metallic wall of the tube 10 encircling the breaker causing an intensification of the magnetic field set up thereabout. Thus the flow of current itself tends to quicken the break between the two masses of

mercury in addition to the effect of gravity and the surface tension of the mercury.

Now when the arc does occur, it takes place at the small end of the breaker 13 wherein by reason of the restricted surface, the surface immediately about the arc becomes highly heated and the gases thereabout tend to expand. Since the pocket between the breaker and the head of the stud 12 is limited in size, the expansion must be out through the breaker into the increasingly larger surface and consequently cooler surface so that there is a tendency of the expanded gases to flow inwardly into the tube 10 thereby carrying the ionized gases into a cooler area where the tendency is to cause the gases to become deionized and thereby reduce the possibility of the re-establishment of the current through the space between the globule of mercury 14 and the receding mass 27.

Since the breaker 13 overhangs the plug 11, and since the mercury is coming down and out of the breaker 13 when that end of the tube is being lifted, the mass of mercury 27 covers over the surface of the tube 10 immediately about the overhanging end of the breaker 13 so that even should the arc occur at the outer end of the breaker 13, it will not be in contact with the metallic wall of the tube but will still have to be between two separating masses of mercury. Furthermore as the tube is being rocked to the position indicated in Fig. 4, there is still a mass of mercury back under the overhanging portion of the breaker 13 which rushes along in conjunction with the other mercury coming out of the breaker so as to form in effect a delayed covering over of the tube 10 until all the mercury to come has been emptied from within the breaker, the combined effect being not only to effectively cover over the wall of the tube 10 but to accelerate the flow of mercury to the opposite end of the tube.

As to materials employed, I find that the tube 10 and the stud 12 forming the other electrode may be made out of any metal which does not amalgamate with the mercury. Iron, cold rolled steel, and "stainless" steel have been employed successfully. The plug 11 must be made out of some material which will not shrink, which will not contaminate the mercury and which may be machined or molded. One suitable material which I have employed is a vulcanized paper fiber although care must be exercised to control the moisture content thereof. The material from which the plug 11 is made may preferably have some degree of resilience although it must be non-deteriorating so that the essential feature of forming a gas tight connection between the tube 10 and the stud 12 is maintained at all times. The breaker 13, being fragile, is supported by the plug 11 so that the breaker may expand and contract and may be cushioned from external shocks without liability of breakage.

The foregoing described structure provides for the chamber 15 back of the breaker so that a pool 14 of mercury may be formed in order that the circuit is broken between two masses of mercury. This is preferable when the current flow is such that the interruption thereof between the walls direct would cause pitting of the metal. For circuits having less flow, the chamber 15 may be omitted entirely as shown in Fig. 7 where the breaker is pushed into the plug bore to have the breaker end bear against the larger bore end whereby there is no chamber left therebetween. In this form, it is to be seen that the gas pressure induced by the heat of the arc may be greatly increased in the small bore of the breaker since there is no chamber 15 within which the gas pressure must first be built up to cause a gas flow back through the breaker, and that the flow of gas from the arc position may be only out toward the larger chamber. It is therefore desirable to keep the size of the chamber 15 from the gas pressure standpoint as small as possible under all conditions, the size decreasing to nothing as shown in Fig 7. When the chamber 15 is necessary, the breaker shape provides in effect a Venturi tube between the chamber 15 and the larger chamber in the tube 10.

While I have here shown and described my invention in the one form as now best known to me, it is obvious that structural changes may be made without departing from the spirit of the invention and I therefore do not desire to be limited to that precise form beyond the limitations as may be imposed by the following claims.

I claim:

1. In a mercury tube switch, the combination of a metallic tube closed at one end, an insulating plug sealably fitted in the open end of the tube, an electrode sealably carried by the plug and terminating interiorly thereof to extend across the end of an axial bore in the plug, a breaker axially carried in said bore defining a short cylindrical chamber between the breaker and the electrode, said breaker having a bore therethrough flaring outwardly toward the rear end from a small axial opening leading from said chamber, said breaker overhanging said plug to the rear thereof to extend a short distance into said metallic tube, a quantity of mercury sufficient to bridge over said breaker to complete a circuit thereover between said tube and said electrode upon tilting of the switch to lower the electrode, a retaining ring interengaging said tube and said plug to prevent axial shifting of the plug in the tube, and cooperating means compressively engaging said plug tending to distort the plug and maintain sealing joints between the plug and the electrode and the plug and the tube.

2. In a mercury tube switch, the combination of a metallic tube closed at one end, an insulating plug sealably carried in the open end of the tube, an electrode entering said plug and extending interiorly thereof into a chamber in the plug, from which chamber an axial bore leads to discharge at the rear of the plug, said bore having a diameter at the chamber end less than that of the chamber and a diameter at the rear end exceeding that at the chamber end, a quantity of mercury sufficient to interconnect said tube and said electrode through said bore when the tube is tilted to lower the electrode, a retaining ring inter-engaging said tube and said plug to prevent axial shifting of the plug in the tube, and cooperating means compressively engaging said plug tending to urge the plug into compressive contact with the tube and the electrode.

3. In a mercury tube switch, the combination of a metallic tube closed at one end, an insulating plug sealably carried in the open end of the tube, an electrode extending into the plug to enter a chamber therewithin, from which chamber leads an axial bore to discharge from the rear of the plug, said bore having a diameter at its chamber end less than the transverse width of the chamber and having a diameter at its rear end larger than at the chamber end, and a quantity of mercury sufficient to interconnect the tube and the electrode through the bore upon tilting the switch to lower the elec-

trode, and a breaker carried by the plug in which said bore is located, said breaker being axially mounted in the plug to extend rearwardly therefrom a distance and formed to have the external diameter of the extension less than that of the tube so as to leave a clearance therearound.

4. In a mercury tube switch, a metallic tubular member, an insulating plug sealably carried in one end of the member, said plug having an axial bore therethrough having a small diameter in that portion adjacent the outer end and a larger diameter toward the rear end, an electrode inserted through said bore, a head on the electrode within the larger diameter portion of the bore limiting withdrawal of the electrode, a compression member carried externally by the electrode causing the plug to be compressively engaged between the head and the compression member, and a quantity of mercury sufficient to interconnect the tubular member and the electrode head through said bore, said head being spaced forwardly in said bore to leave a chamber as defined by the bore between the head and the rear end of the plug, said head and said compression member having opposing conical faces engaging like faces on the plug, whereby a lateral deformation of the plug is induced to urge the plug against the tubular member.

5. In a mercury tube switch, a metallic tubular member, an insulating plug sealably carried in one end of the member, said plug having an axial bore therethrough having a small diameter in that portion adjacent the outer end and a larger diameter toward the rear end, an electrode inserted through said bore, a head on the electrode within the larger diameter portion of the bore limiting withdrawal of the electrode, a compression member carried externally by the electrode causing the plug to be compressively engaged between the head and the compression member, and a quantity of mercury sufficient to interconnect the tubular member and the electrode head through said bore, said head being spaced forwardly in said bore to leave a chamber as defined by the bore between the head and the rear end of the plug, said head and said compression member having opposing conical faces engaging like faces on the plug, whereby a lateral deformation of the plug is induced to urge the plug against the tubular member, and a retaining ring engaging the plug and secured to the tubular member.

6. In a mercury tube switch, the combination of a metallic tube closed at one end, an insulating plug sealably fitted in the open end of the tube, an electrode sealably carried by the plug and terminating interiorly thereof to extend across the end of an axial bore in the plug, a breaker of refractory material axially carried in said bore defining a short cylindrical chamber between the breaker and the electrode, said breaker having a bore flaring outwardly toward the rear end from a small cylindrical bore of relatively short length leading directly from said chamber, a quantity of mercury sufficient to bridge over said breaker to complete a circuit thereover between said tube and said electrode upon tilting of the switch to lower the electrode and adapted to separate adjacent the cylindrical bore of the breaker when the tube is tilted in the opposite direction.

7. In a mercury tube switch, the combination of a metallic tube closed at one end, a resilient insulating plug sealably fitted in the open end of the tube, an electrode sealably carried by the plug and terminating interiorly thereof to extend across the end of an axial bore in the plug, a breaker of refractory material axially carried in said bore and defining a short cylindrical chamber between the breaker and said electrode, said breaker having a bore flaring outwardly and rearwardly, and a quantity of mercury sufficient to bridge through said breaker bore to complete a circuit between said tube and said electrode upon tilting of the switch.

8. In a mercury tube switch, the combination of a metal tube closed at one end, an insulating plug sealably fitted in the open end of the tube, an electrode sealably carried by the plug and terminating interiorly thereof to extend by a head across the inner end of an axial bore in the plug, a breaker of refractory material within said tube and maintained by said plug in axial end to end abutment with the inner end of said electrode head, said breaker having a bore flaring outwardly toward its rear end, a quantity of mercury sufficient to bridge over said breaker to complete a circuit thereover between said tube and said electrode upon tilting of the switch to lower the electrode and adapt it to separate adjacent the cylindrical bore of the breaker when the tube is tilted in the opposite direction.

JOSEPH H. STALEY.