March 18, 1947. C. H. LARSON 2,417,764

HERMETICALLY SEALED CONTAINER

Filed June 25, 1943 3 Sheets-Sheet 1

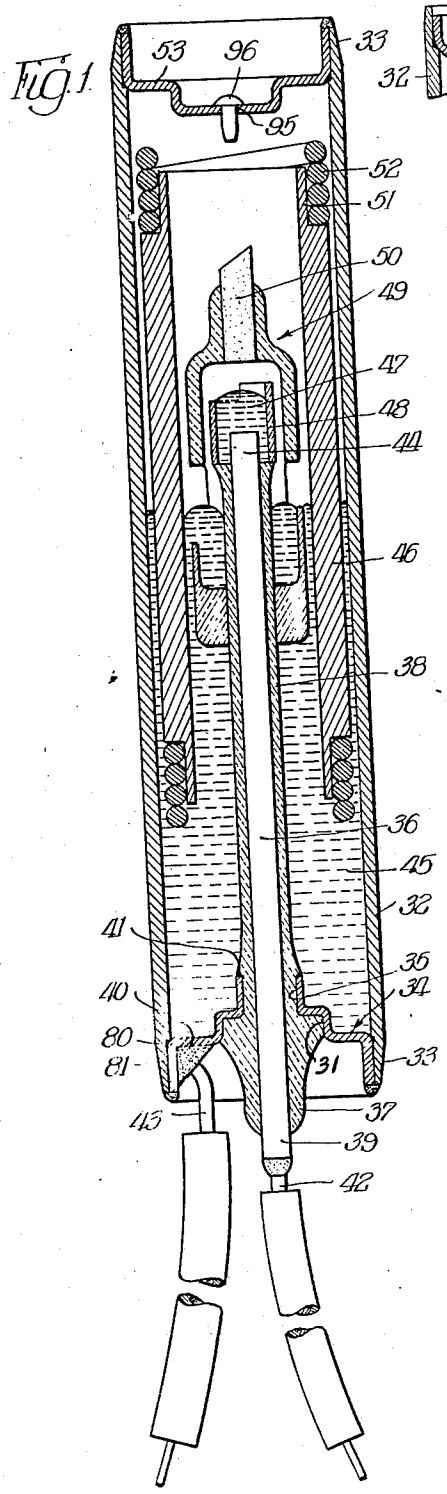



Fig. 1

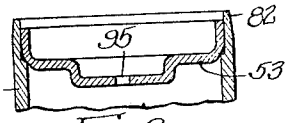



Fig. 2

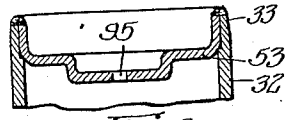



Fig. 3

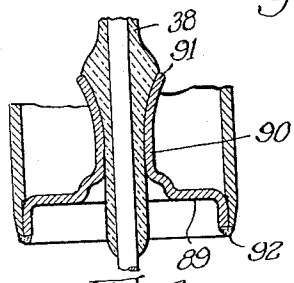



Fig. 4

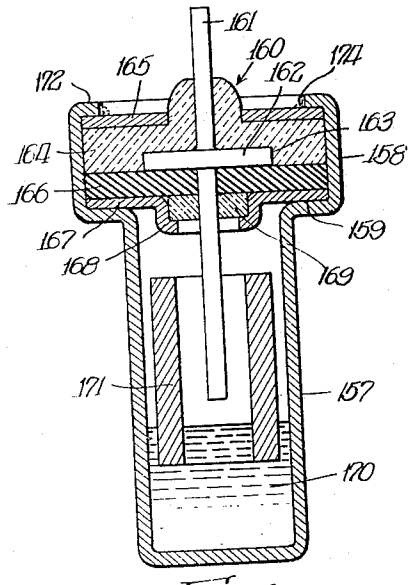



Fig. 5

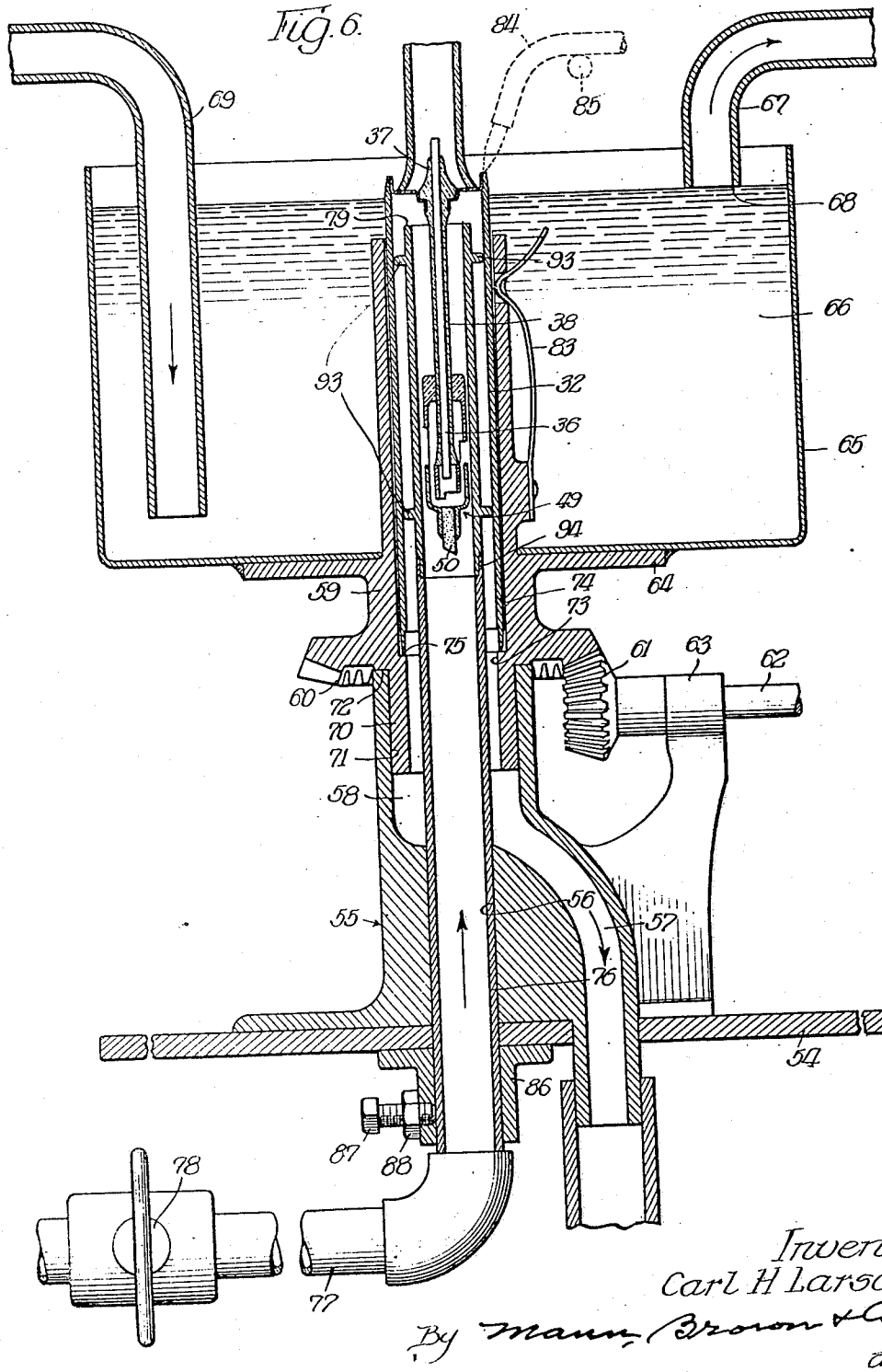
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HERMETICALLY SEALED CONTAINER

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Fig. 6.




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HERMETICALLY SEALED CONTAINER

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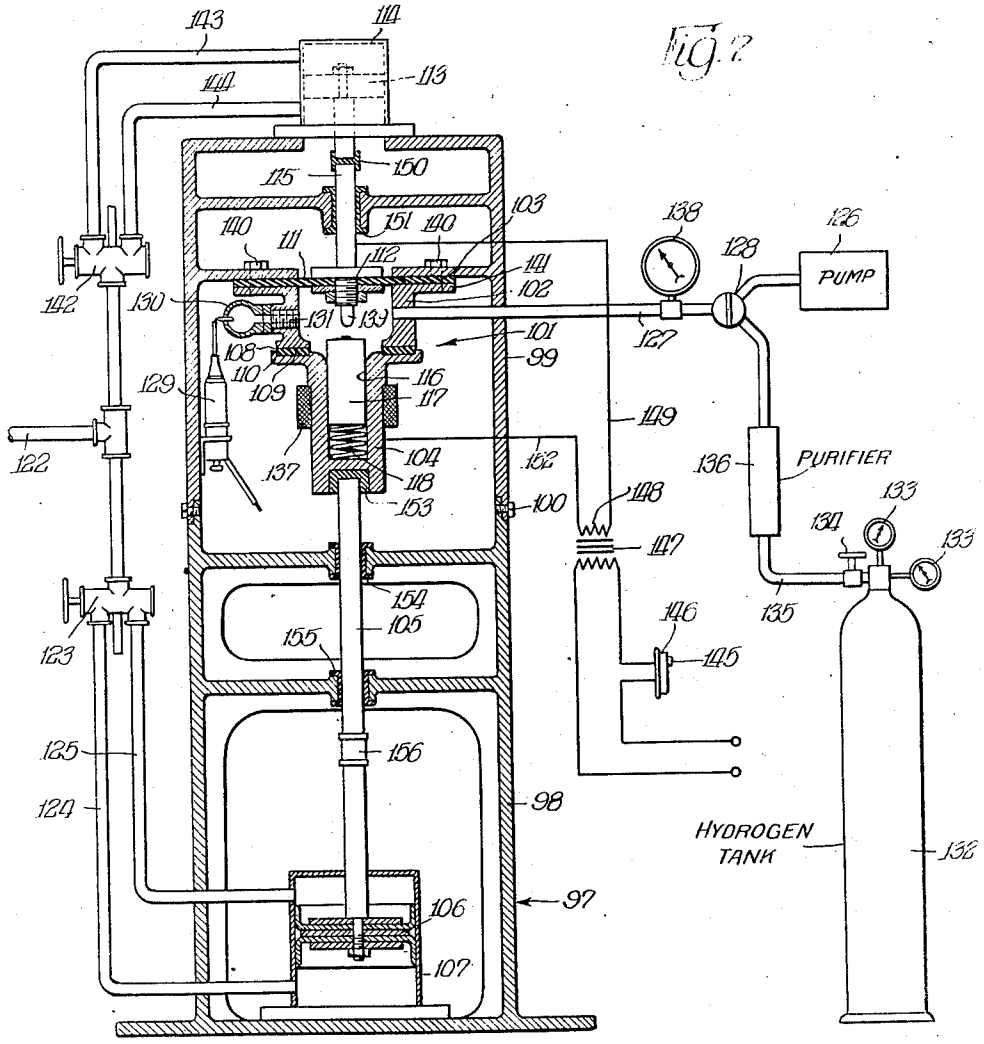



Fig. 7.

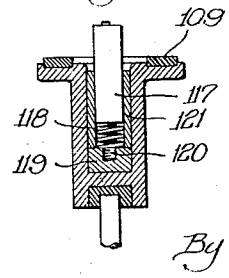


Fig. 8.

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2,417,764

# UNITED STATES PATENT OFFICE

2,417,764

## HERMETICALLY SEALED CONTAINER

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Application June 25, 1943, Serial No. 492,331

5 Claims. (Cl. 200—152)

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Metal envelope mercury switches have some advantages over glass switches, particularly because of their ruggedness of construction and their ability to stand mechanical abuse. Under proper conditions, they may also be gas filled to relatively high pressures which has the effect of increasing the current carrying capacity of the switch and prolonging its life.

There are some problems, however, which arise in the manufacture of switches of this type, chief among which is the problem of obtaining a perfect hermetic seal. Various means have been employed in the past for effecting such a seal, including the use of rubber gaskets, crimping devices, etc., but none have satisfactorily filled the need for an all-metal, pressure-filled switch, particularly of the mercury displacement type.

The principal object of this invention, therefore is to provide a switch which will meet all the requirements of the trade in respect to ruggedness, current carrying capacity, absence of materials which may contaminate the mercury in the switch, high pressure gas fill, and economy of manufacture. These and other objects and advantages of the invention will be disclosed fully in the appended specification and drawings in which

Fig. 1 is a vertical cross sectional view through a metal switch made in accordance with this invention;

Fig. 2 is a fragmentary view showing the top end closure in place prior to being welded to the switch envelope;

Fig. 3 is a view corresponding to Fig. 2 but showing the top closure cap welded to the switch envelope;

Fig. 4 is a view showing a preferred way of sealing the electrode through the base cap;

Fig. 5 is a view showing another way of hermetically sealing the electrode assembly within the switch envelope;

Fig. 6 is a vertical cross sectional view of apparatus which is advantageously used in heat-joining the end closures to the switch envelope; and,

Fig. 7 is a schematic drawing of a machine which evacuates and pressure fills the switch envelope to the desired pressure and then automatically seals the envelope.

Fig. 8 is a fragmentary view showing the manner in which adapters may be used to accommodate containers and envelopes of different sizes.

It is to be understood that the invention is not limited to the specific details disclosed since various substitutions and modifications under my concept will occur to those skilled in the art.

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In the form of switch shown in Fig. 1, it will be seen that the switch comprises a tubular envelope or cylindrical shell 32 of non-magnetic material, preferably of 18–8 stainless steel, and having both ends of the envelope beveled off as indicated at 33. A base or cap 34, preferably made of a material known as Kovar manufactured by the Stupakoff Ceramic and Manufacturing Company, Latrobe, Pennsylvania, is formed, by stamping, into a cup-shaped cap as shown and it has a central aperture through which an electrode 36 is sealed by a heat sensitive plastic material, preferably either 733A or 704 glass made by the Corning Glass Works of Corning, New York. This material is found most advantageous because it has a coefficient of expansion substantially the same as the Kovar material of which the base 34 is preferably formed and substantially the same also as that of molybdenum which is the material preferably used for the electrode 36. However, other combinations of material may be used for the sealing of an electrode through a base but in any case, the sealing material is likely to be heat sensitive and must be protected when the base 34 is heat joined, as for example by torch welding, to the reduced end 33 of the switch envelope.

A feature of the present form of the invention, as will be made apparent, is that the likelihood of the heat-sensitive sealing material being melted by the welding operation is reduced by so shaping the base 34 as to provide a relatively long path to the sealing material for heat conduction from the region at which the welding heat is applied. To this end the base 34 is cup-shaped, and the central portion of the base is offset inwardly around the aperture through which the electrode extends. As shown in Fig. 1, the inward offsetting of the central portion of the base 34 may be provided by forming an annular recess 31 around the aperture in the base, and may be further provided by forming an inward flange 35 around the aperture.

A glass sleeve 38 is telescoped over and fused to the electrode 36, and since the electrode material and glass are chosen with like coefficients of expansion, the glass will adhere to the electrode without cracking even under severe temperature changes. The glass sleeve 38 is enlarged near the lower end 39 of the electrode to form a bead 37 which, with the proper application of heat, may be firmly fused to the seat 40 of the base 34, with a portion of the glass over-

laying and interlocked with the top margin 41 thereof, thus forming a strong and secure insulated bond for the electrode and the base 34.

Lead wires 42 and 43 are soldered to the electrode 36 and base 34, respectively, so that the switch envelope itself forms one side of an electrical circuit and the exposed end 44 of the electrode 36 forms the other side of the circuit. A ceramic cup 48 is fused to the top of the sleeve 38 and contains a body of mercury 47 which is in constant contact with the exposed end 44 of the electrode 36. A magnetically controlled displacer 46 is moved vertically within the envelope to shift the level of the main body of mercury 45, and when the mercury level rises sufficiently to cause mercury to flow over the top of the cup 48, the electrical circuit is closed, and when that condition does not exist, the circuit is open.

A time delay thimble, generally designated 49, is telescoped over the upper portion of the electrode 36 to delay the movement of mercury to and/or away from the mercury 47 in the cup 48 in proportion to the time required for gas to pass through the ceramic plug 50 mounted in the top of the thimble 49 to equalize the gas pressure differential caused by shifting of the mercury level by the displacer. Since the present invention is not concerned with the particular details of the time delay means, it will be sufficient to refer to Larson Patent No. 2,232,874 for a fuller disclosure of this structure.

The plunger or displacer 46 is preferably made of high grade magnetic iron and it is provided at both ends with a reduced portion 51 adapted to receive a non-magnetic steel spring 52 which is frictionally held on the reduced portion 51 of the displacer. The springs 52 may be made of the same material as the switch envelope 32; namely, 18–8 stainless steel in the austenitic form and the use of this material prevents the displacer 46 from adhering to the top closure 53 when it is made of cold rolled steel or other magnetic material.

In making up a metal switch of the type shown in Fig. 1, the electrode 36 is first fused to the insulating sleeve 38 and then the mercury cup 48 and time delay thimble are applied to the upper end of the electrode. The cap 34 is then slipped over the lower end of the insulated electrode and a bead is formed adjacent to the lower end 39. The electrode assembly is then inverted and the base 34 is drawn upwardly toward the end 39 of the electrode to be fused with and bonded to the bead formed at that end of the electrode. The complete sub-assembly consisting of the base 34 and the electrode bonded therethrough with the time delay structure mounted on the upper end of the electrode is then ready for being heat joined to the tubular envelope 32.

In fabricating a switch of this kind, it is convenient to employ a machine of the kind shown in Fig. 6 for heat joining the end closures of the switch envelope to the envelope. As shown in Fig. 6, the apparatus is mounted on a platform 54 and consists of a base casting 55 having a vertical bore 56 and a side bore 57. The two bores merge at the top to form an enlarged chamber 58 adapted to receive the rotatable hollow hub 59 having downwardly facing gear teeth 60 adapted to mesh with a pinion 61 driven in a suitable manner at a relatively slow and controllable speed through the shaft 62 which is journalled in an arm 63 of the base casting 55.

The hub 59 is laterally extended at 64 to provide a seat for the tank 65 which is circular in



form and rests upon and is secured to the seat 64. The tank is adapted to contain a cooling fluid 66 such as water, the level of which is maintained by an outlet tube 67 to which suction is applied to draw off any water above the bottom edge 68 of the tube. Water is admitted to the tank through an inlet pipe 69 which projects downwardly into the cooling fluid a substantial distance and which serves as a stirrer to maintain circulation of the water when the hub 59 and tank 65 are rotated.

Preferably, the base 55, hub 59 and tank 65, as well as all other parts of the apparatus which come in contact with the water, are made of brass to avoid corrosion.

The hub 59 has a vertical bearing 70 which fits into the machined bearing surface 71 provided at the upper portion of the base 55 and the weight of the hub and the tank structure is carried on a horizontal bearing 72.

The bore 73 of the hub 59 is enlarged above the bearing as shown at 74 to provide a seat 75 adapted to receive and support the tubular member which is to be heat joined to a base. The shoulder or ledge 75 may be raised to accommodate shorter switches by inserting spacer sleeves which rest upon the ledge 75 and provide an upper surface to receive the shorter switch envelope. When switch envelopes of smaller outside diameters are to be used in the apparatus, shim sleeves, (not shown) preferably of metal to provide good heat conduction, are fitted into the bore 74 to provide an opening of the right size for the tubular member being worked upon. Hence, by the use of spacer sleeves to effectively raise the ledge 75 and by the use of shim sleeves to effectively reduce the inside diameter of the hub, switch envelopes or tubular members of varying size may be accommodated. Also, it is possible to provide different sized hubs 59 which can be interchangeably mounted on the base 55 to accommodate the switches of different sizes.

In operation, the tank 65 is first filled with water and it will overflow through the hub 59 into the drain outlet 57 in the base 55. Upon inserting a switch envelope blank 32 into the bore 74 of the hub, the water level will rise from the top of the hub 59 to the level determined by the position of the bottom edge 68 of the outlet tube 67, this level being designed to be slightly below the beveled end 33 of the envelope 32 and placing the exposed portion of the switch envelope immediately below the bevel in contact with the water in the tank. A tube 76 connected through a flexible hose 77 to a source of water supply, the volume of which is controlled by a valve 78, is then inserted through the bore 56 of the base 55 until its upper edge 79 is in the approximate position shown in Fig. 6 and then a small volume of water is permitted to flow through the tube 76 to provide a fountain effect at the top which will adequately bathe the lower portion of the electrode seal when the base assembly is slipped into place.

It will be seen in Fig. 1 that the ends of the switch envelope are counterbored, as shown at 80, to provide a seat which receives the base 34 and supports it in position. The outside diameter of the portion 81 of the base is made such that it has a light drive fit with the reduced ends of the envelope 32 so that when the base assembly is slipped into place for being welded to the envelope, it will securely hold its position. It will also be observed that the reduced end of the envelope 32 extends slightly above the top

of the portion 81 of the base as shown at 82 to facilitate the flow of metal from the envelope to the base for a strong and satisfactory weld.

The switch envelope is held in place within the hub 59 by a Phosphor bronze spring 83 and with the base assembly in place, as shown in Fig. 6, a welding torch, shown in dotted lines at 84 and which may be conveniently supported upon a rest 85, is applied to the upstanding mating edges of the envelope and the base while the tank, the hub, the switch envelope and the base are rotated slowly through the shaft 62. By holding the torch steady and by rotating the work an even weld can be consistently obtained while the heat of the weld is being held locally to the point of application. The water in the tank 65 effectively cools the exterior of the switch envelope while the water being passed upwardly through the tube 76 is directed against the glass seal and keeps it sufficiently cool so that heat travelling through the base from the weld will not fracture or disrupt the electrode seal. The cup-shaped configuration of the base 34 reduces the heating of the insulating glass by the welding operation since the heat must travel by conduction the dimension of the flanged portion of the base in addition to the radial distance to the insulating glass. The inward offsetting of the central portion of the base 34, moreover, increases the remoteness of the glass seal from the welding region. It has been found sufficient in protecting the external portion of the seal to provide a metal or ceramic wide mouthed shield which telescopes over the projecting end 39 of the electrode 36 and protects it from the direct flame of the torch.

The provision of means for supplying a copious quantity of cooling fluid to the underside of the base during the welding or other heat joining operation is of considerable importance because there is no convenient way to inspect the bond within the envelope after the base is affixed to the switch envelope.

A skilled operator will soon know how much water to have flow through the tube 76 and where to adjust the top 79 of the tube 76 in order to protect the seal during the heat joining operation. Preferably, the tube 76 passes through a gland 86 where it may be held in any desired vertical position by a set screw 87 locked in place by lock nut 88.

After the base assembly has been welded into place, the switch is removed from the hub and the excess water flows out through the top of the hub 59. The switch is then returned to its normal upright position, filled with mercury, pretested for operating characteristics and then placed back in the apparatus of this invention to have the top 53 welded into place. The method of welding the top 53 to the switch envelope is identical with that already described except that the tube 76 is removed as it must be to accommodate the switch base and the cooling of the switch during the welding operation is done entirely from the outside by the water 66 in the tank 65. Since there is no bond of heat sensitive material in the top, the outside cooling is adequate.

A modified form of seal for the electrode is shown in Fig. 4 and it consists of a base 89 having a neck 90 terminating in an outwardly flared throat 91 so that when a bead is formed on the glass sleeve 38 slightly above the point of application of the base and the base is slipped upwardly with the simultaneous application of heat to form the seal shown in Fig. 4, the actual juncture between the glass and the base 89 is substantially removed from the place where the base is welded to the envelope as shown at 92. Hence, the cooling of this bond during the welding operation by the water being passed upwardly through the tube 76 is more readily and more fully accomplished.



The spacing of the tube 76 from the interior wall of the switch envelope 32 (Fig. 6) may be accomplished in various ways, all that is required being that some form of spacer be employed to centrally locate the tube 76 within the hub so that the central electrode structure cannot be damaged by movement of the tube within the hub. In the form of the apparatus shown, the upper portion of the pipe 76 is formed of hexagonal bar stock and is turned down to leave spacers 93, as shown in Fig. 6. This section of the tube is then brazed to the lower portion of the tube as shown at 94.

There is sufficient room between the time delay thimble 49 and the inner walls of the tube 76 to accommodate the relatively small volume of flow which passes through the tube 76.

It will be observed that the top closure 53 is provided with a central opening 95 adapted to receive a loose fitting welding pin or brad 96 as shown in Fig. 1. When this pin is in place, it is sufficiently loose fitting so that gas may be withdrawn from the otherwise hermetically sealed envelope or introduced into the envelope without substantial delay, but obviously, if desired, the head of the pin could be given a special shape to insure proper ingress and egress of the gas from the envelope during the evacuation and gas filling operation.

After a switch has been completely fabricated, with the exception of inserting the gas fill, it is placed in the machine shown in Fig. 7. This machine, which is shown diagrammatically in the drawings consists of a frame generally designated 97 which may be of any convenient construction, but which is here shown, for the purpose of this disclosure, as consisting of a base member 98 and an upper member 99 which may be conveniently disassembled for access to the interior of the machine and which are normally held together by bolts 100. Access openings are provided wherever necessary or desirable.

Within the frame is a two-part chamber or enclosure generally designated 101 consisting of an upper part 102 which is fixed to a flange 103 of the member 99, and a lower part 104 which is supported through a rod 105 on a piston 106 which travels within an air cylinder 107. Downward movement of the piston 106 opens the chamber 101 at the point 108 just above the rubber gasket 109 which is recessed into the enlarged top face 110 of the part 104.

The upper part 102 of the chamber or enclosure 101 has a diaphragm wall 111 through which a movable head 112 is hermetically sealed and movement of the head 112 is controlled by a piston 113 which travels within a cylinder 114 mounted on the top wall of the frame 97 and is connected to the head 112 through a rod 115.

The lower part 104 of the chamber 101 is recessed, as shown at 116, to provide a pocket or support for the container 117 which is to be hermetically sealed after receiving the appropriate gas fill.

By opening the chamber 101 through the lowering of the piston 106, the switch 117 may be

inserted in the pocket 116 into the base of which a spring 118 may be placed to resiliently support the switch against the pressure exerted by the head 112 when it is lowered to act on the switch. If an extremely short switch is being worked upon, a plug 119 (Fig. 8) may be dropped into the bottom of the pocket 116 and the plug should have a screw threaded opening 120 to facilitate its removal. Also, if the switch has a smaller diameter than the bore of the pocket 116, a spacer sleeve 121 may be inserted into the pocket to accurately accommodate the switch 117.

After the switch 117 is in place within the pocket 116, air, or some other fluid under pressure, is introduced into the lower part of the cylinder 107 from a source 122 through a dual valve 123 and pipe 124, the valve 123, at the same time, placing the pipe 125 leading from the upper part of the cylinder 107 in communication with the atmosphere in the conventional way. The piston thereupon urges the lower part 104 of the chamber against the upper part with a force proportional to the pressure of air within the line 122 and the rubber gasket 109 makes the chamber gastight.

With the switch in place, the chamber is then evacuated by pump 126 which is connected to the chamber through a pipe 127 and two-way valve 128. When the proper vacuum has been drawn, as determined by a Tesla coil 129, which produces a discharge in a small glass side chamber 130 which is in communication with the interior of the chamber 101 through a bore 131, the valve 128 is turned to place the chamber 101 in communication with the gas which is to be used for filling the envelope 117. This gas, which may be hydrogen, helium, argon, or the like, may be stored in a tank 132 equipped with the usual pressure gauges 133 and reducing valve 134 and is connected to the chamber 101 through a pipe 135, a gas purifier 136 of any suitable design, the valve 128 and pipe 127.

While the pump 126 is evacuating the chamber 101, the air within the envelope is being simultaneously withdrawn with the air or gas within the chamber 101 and likewise, when the chamber 101 is subjected to the gas from the tank 104, the envelope immediately fills with such gas and acquires the same pressure as the gas within the chamber 101. During the evacuation stage, the envelope 117 may be heated by a resistance coil 137 or an induction coil may be used, if desired. Ordinarily, it will suffice to heat the envelope with its contents outside of the machine and place it into the machine while hot but resistance coil or induction coil heating in situ may be used, if desired. If a high frequency induction coil is used, it may be located either inside or outside of the part 104 of the chamber 101.

After the switch envelope has been flushed out several times by first evacuating the chamber 101 and then pressure filling it, the final step of introducing gas at the desired pressure is performed with the pressure being shown on a gauge 138. The switch envelope is then ready for being hermetically sealed.

The head 112 carries a welding contact 139 and is hermetically sealed through the diaphragm wall 111, which is preferably made of heavy rubber and is clamped by bolts 140 between the flange or web 103 of the frame and a mating flange 141 on the upper part 102 of the chamber 101. The head is movable up and down by proper



manipulation of a dual valve 142, similar in all respects to the valve 123 and connected on one side to the compressed air supply 122 and on the other side through pipes 143 and 144 with the upper and lower sides, respectively, of the piston head 113. As is the case with the valve 123, when one side of the piston is open to the compressed air supply 122, the other side is placed in communication with atmosphere through the valve and, of course, the valves 123 and 142 have off positions in which both sides of the pistons are shut off from the air supply.

With the proper gas fill supplied to the switch envelope 117, the valve 142 is turned to force the welding contact 139 into direct contact with the pin 96 in the top closure 53 of the envelope and an electrical circuit is then closed by pushing a button 145 to provide a correctly timed welding impulse to the head 139. This causes the pin 96 to be welded to the cap 53 and thereby hermetically seal the envelope. The timing cycle is controlled by a timer 146 and upon closing the primary of the transformer 147 by pushing button 145, an impulse is induced in the secondary 148 of the transformer to produce the weld. As may be seen in Fig. 7, one side 149 of the secondary is connected to the head 112 through the rod 115 which is insulated from the frame by insulating members 150 and 151 and the other side 152 of the secondary is connected to the chamber base 104 which is also preferably insulated from the frame by insulators 153, 154, 155 and 156.

Instead of torch welding the top closure cap 53 to the switch envelope 32 and introducing the gas fill through the central opening 95, it is possible to fit the head 112 with a special welding contact to electrically weld the top cap in place after the envelope has been properly evacuated and gas filled. In such a case, the cap 53 may be supported in some appropriate fashion by the head 112 until the envelope has been gas filled after which the head is lowered to put the cap 53 in place and weld it to the envelope.

Another form of switch which can be evacuated and gas filled in the machine shown in Fig. 7 is illustrated in Fig. 5. The switch comprises a container or envelope 157 preferably made of stainless steel in its austenitic form. The envelope is provided with an enlargement 158 at its open end thus providing a seat 159 upon which the electrode assembly generally designated 160 rests. This assembly consists of an electrode 161 preferably of molybdenum to which a metal disk 162 is welded or otherwise secured and the disk fits within a recess 163 formed in the bottom face of a ceramic or plastic insulator 164 over the top surface of which is placed an annular metal disk 165.

The lower face of the insulator 164 rests upon a rubber gasket 166 which in turn rests upon a metal plate 167 seated upon the ledge 159 of the envelope 157 and having a dished out portion 168 adapted to receive and support a ceramic plug 169 which tightly fits over the electrode 161 and prevents contamination of the mercury 170 within the envelope by the rubber gasket 166.

The envelope 157 is first filled with the correct amount of mercury 170 after which the plunger or displacer 171 which is made of magnetic material is placed in the envelope. The electrode assembly 160 is then slipped into place and the whole switch is then placed in the sealing machine of Fig. 7. The fit of the assembly

160 in the shell 157 is loose enough so that the envelope can be evacuated and pressure filled with ease while in the chamber 101. After this is done, the upstanding margin of the enlargement 158 is then crimped over as shown at 172 by use of a die having a curved suitable die face specially shaped for this purpose. The crimping over the upstanding margin is accompanied by the application of pressure which forces the rubber gasket outwardly to effectively seal the interior of the envelope from the atmosphere. If desired, hard solder may be applied to the crimped over portion of the enlargement 158 as shown at 174 or the crimped over portion may be welded to the metal disk 165.

Although the switch shown in Fig. 5 can be pressure filled, it is not nearly as satisfactory as the form of switch shown in Fig. 1 because of having a less perfect hermetic seal. In the switch shown in Fig. 1 no organic substances are used in effecting the seal and the all-metal all-welded construction insures lifelong maintenance of the pressure fill without any danger of mercury contamination. This is not true in the case of the switch shown in Fig. 5 although this latter switch does possess certain advantages over prior art switches of this type.

Switches made according to this invention can be produced economically and with uniformity of quality and operating characteristics. Their ability to save and hold gas pressures on the order of one hundred pounds or more gives them a liability of operation and exceedingly long life.

Many modifications will occur to those skilled in the art without departing from the spirit or scope of the appended claims.

I claim:

1. In a mercury switch, a cylindrical metal shell, a metal cap having a central aperture and having its outer edge heat-bonded to said shell to seal one end thereof, a metal electrode extending through said aperture, and heat-sensitive material surrounding said electrode and sealing the electrode to the cap, said cap being flanged in one direction at said aperture to provide a tubular extension surrounding said heat-sensitive material and being flanged in the opposite direction at its periphery to provide a cylindrical extension terminating at said outer edge of the cap whereby said heat-sensitive material at the cap aperture lies at points remote from the region of heat application for bonding the cap to the shell.

2. In a mercury switch, a cylindrical metal shell, a metal cap having a central aperture and having its outer edge heat-bonded to said shell to seal one end thereof, a metal electrode extending through said aperture, and heat-sensitive material surrounding said electrode and uniting the electrode with the cap, said cap being offset in one direction around said aperture and being flanged in the opposite direction at its periphery whereby said heat-sensitive material at the cap aperture lies at points remote from the region of heat application for bonding the cap to the shell.



3. In a mercury switch, a sheet metal cap adapted to be heat-bonded at its outer edge to seal one end of the switch, said cap having a central aperture, a metal electrode extending through said aperture, and heat-sensitive insulating material surrounding said electrode and uniting the electrode with the cap, said cap being cup-shaped and centrally offset to place sealing portions of said heat-sensitive insulating material a substantial axial distance from the region of heat application at said outer edge of the cap.

4. In a sealed switch, a cylindrical metal shell forming a part of the switch casing, said shell being reduced in thickness at the end to form an inwardly spaced inner annular shoulder, a cup-shaped cap backed into said shell into sealing engagement with said shoulder with the rim of the cap heat-bonded to the end of the shell, said cap having an axial aperture, an electrode extending through said aperture, and a mass of heat-sensitive insulating material forming a seal around said electrode in said aperture, said cap being offset inwardly around said aperture to increase the distance that heat must travel by conduction from the heat-bonded rim of the cap to destroy the seal at said aperture.

5. In a sealed switch, a cylindrical metal shell forming a part of the switch casing, said shell being reduced in thickness at the end to form an inwardly spaced inner annular shoulder, a cup-shaped cap backed into said shell into sealing engagement with said shoulder with the rim of the cap heat-bonded to the end of the shell, said cap having an axial aperture, an electrode extending through said aperture, and a mass of heat-sensitive insulating material forming a seal around said electrode at said aperture, said aperture being offset inwardly and having an inwardly extending flange to increase the distance that heat must travel by conduction from the heat-bonded rim of the cap to destroy the seal at said aperture.

CARL H. LARSON.


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