July 20, 1943. C. E. POLLARD, JR 2,324,595

MANUFACTURE OF SEALED APPARATUS

Filed June 4, 1942

FIG. 1

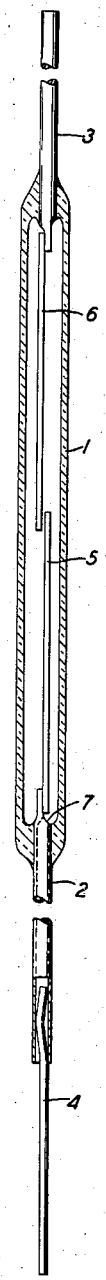
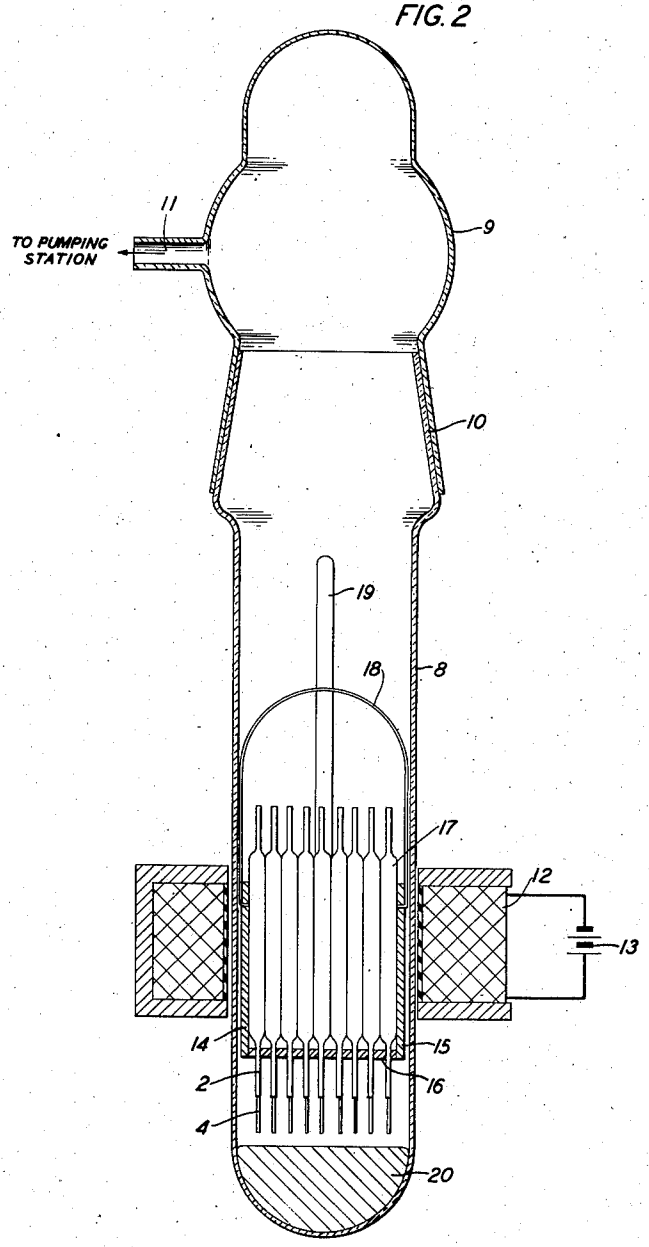



FIG. 2

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## MANUFACTURE OF SEALED APPARATUS

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10 Claims. (Cl. 226—20)

The present invention relates to methods and apparatus for the sealing of gas-tight envelopes, particularly those adapted to contain electrical apparatus which it is necessary to maintain in an evacuated or gas-filled atmosphere.

The present invention is particularly adapted to the evacuation, gas filling and sealing of glass-enclosed magnetic reed switches which are provided with one terminal in the form of a metal tube through which the switches are evacuated and filled with gas. Prior to the present invention, switches of this type were evacuated and filled with gas by individually coupling the metal tube ports of each switch to the pumping station and gas source. They were then sealed by squeezing the ends of the tubes flat and welding the flat sections together.

This process was similar to that ordinarily used in the manufacture of vacuum tubes and lamps. This method of individual handling could be carried out at low cost in the manufacture of vacuum tubes and lamps, but this low cost was arrived at to a large extent by providing complicated machinery to perform a sequence of individual operations on identical parts being fed continuously to it. Where it is not desired to produce glass-enclosed apparatus of a standardized design in extremely large quantities, the cost of such individual handling may be excessive.

According to the present invention a method and apparatus are provided whereby such articles may be evacuated, filled with gas and sealed in batches, thus avoiding the necessity for individual handling. This batch method is especially adapted to the manufacture of articles of small cross section, such as the glass-enclosed reed switches referred to above. The structure and operation of the apparatus and method of the present invention can best be explained by reference to the accompanying drawing, in which:

Fig. 1 is a view, partly in section, of the type of glass-sealed reed switches adapted to be evacuated, filled with gas and sealed by the method and apparatus of the present invention; and

Fig. 2 is a front sectional elevation of a form of the apparatus of the present invention.

The switch shown in Fig. 1 is made up of a glass envelope 1 having a metal tube 2 sealed in one end and a solid wire lead 3 sealed in the opposite end. The metal tube 2 and the lead 3 are made of a metal having a coefficient of expansion approximating that of glass, such as an alloy of 52 per cent nickel and 48 per cent iron. The metal tube is preferably copper plated to facilitate subsequent sealing with solder. This tube is open at both ends, thus forming a port through which the interior of the envelope communicates with the outside atmosphere. In order to provide a convenient terminal for soldering, a bent piece of tinned copper wire 4 or other suitable metal wire may be inserted in the metal tube leaving a substantial portion of the wire protruding. This wire is subsequently sealed in the metal tube by solder at the time the glass envelope is sealed off. The portion of the tube 2 and the lead 3 within the envelope are flattened and have welded to their flattened portions two reeds 5 and 6 formed of magnetic material. The flattened end of the tube 2 has an opening 7 in its side, furnishing means through which the interior of the envelope communicates with the outside atmosphere as stated above. The construction and operation of this type of switch are more particularly described and claimed in the copending application of W. B. Ellwood, Serial No. 198,629, filed March 29, 1938, which has matured into Patent No. 2,289,830, issued July 14, 1942.

The apparatus shown in Fig. 2 consists of a cylindrical glass evacuation chamber 8 having a removable cover 9 fitted to the body of the evacuation chamber by means of a ground joint 10. A port 11 in the cover furnishes a means whereby the chamber can be evacuated and filled with gas. Surrounding the chamber is a solenoid 12 which is freely movable in a vertical direction along the outside of the chamber. The solenoid is energized by any suitable source of electrical current 13. A cylindrical holder 14 made up of a cylindrical iron wall 15 and a perforated bottom 16, is located within the chamber and maintained in a position in registry with the external solenoid by means of the magnetic field generated by the solenoid. The perforations in the bottom 16 of the cylindrical holder are slightly larger in size than the tubular metal ports 2 of the glass-enclosed reed switches. These perforations are uniformly spaced so that, when the tubular metal ports are inserted therethrough, the switches 17 are regularly and snugly positioned within the cylindrical holder. The tubular metal ports protrude freely through the bottom of the holder. A handle 18 is provided for the cylindrical holder to permit its easy insertion into and removal from the evacuation chamber. A thermometer 19 is inserted in the middle of the batch of switches supported by the cylindrical holder. A body of solder 20, to be used for sealing the metal ports, is located in the bottom of the chamber.

In the operation of the method of the present

invention, a plurality of switches, similar to that shown in Fig. 1, are placed within the cylindrical holder 14 so that their hollow metal tubular ports 2 are downwardly disposed and protrude from the bottom of the holder through the perforations, the metal tube openings forming substantially a horizontal plane. The solenoid 12 is then energized and moved to a vertical position such that the holder 14, after insertion, will be sufficiently high so that the metal ports 2 are out of contact with the body of solder 20. The cylindrical holder, together with the glass-enclosed switches, is then inserted within the chamber in such a manner that it is supported by the magnetic field generated by the solenoid. The cover 9 is then lowered into place on the top of the evacuation chamber and a tight seal is established at the ground joint 10.

After a tight seal has been established the chamber is evacuated through the outlet 11 to an absolute pressure of about $10^{-3}$ millimeters of mercury. The portion of the evacuation chamber containing the switches, and the switches therein, are heated to about 100° C. by any suitable heating means, not shown, to aid in the elimination of the adsorbed gas. The chamber is then flushed with a mixture of hydrogen and helium, reevacuated and filled with a mixture of hydrogen and helium, the hydrogen pressure being about 130 millimeters of mercury and the helium pressure being about 630 millimeters of mercury. Obviously, any other desired inert gas can be employed.

Sufficient heat is then applied to the bottom of the chamber by any suitable means (not shown), such as an open flame, to melt the solder contained therein. The solenoid is then lowered, together with the cylindrical holder and the switches contained therein, until the metal tubes of the switches are immersed in the solder to a depth of about one-eighth inch.

The heat of the solder causes expansion of the gas within the switches, which results in bubbling of the gas from the bottom of the tubes. After the bubbling has stopped the helium pressure within the chamber is increased by about 30 millimeters of mercury in order to force the solder a considerable distance up inside the metal tubes. Within the metal tubes the solder immediately cools and commences to harden. The solenoid is then raised to remove the metal tubes from the pool of solder. The cover can then be removed from the chamber and the holder, together with the finished switches, can be removed.

An eutectic solder made up of 63 per cent tin and 37 per cent lead is suitable for this process because of its low melting point and because of the fact that it changes completely from a liquid to a solid order within a small temperature range. Another suitable solder which, however, has a higher melting point, is made up of 2 per cent tin and 2½ per cent silver and the remainder, lead. Obviously any suitable fusible sealing material may be employed.

The invention has been described in terms of its specific embodiment but certain modifications and equivalents will be apparent to those skilled in the art. Such modifications and equivalents are intended to be included within the scope of the present invention which is to be limited only by the fair and reasonable scope of the appended claims.

What is claimed is.

1. In the manufacture of electrical devices enclosed in gas-filled, sealed glass envelopes which are adapted to be sealed off by closing tubular metal ports sealed therein, the steps which comprise suspending within an enclosed chamber a holder which is formed at least partly of magnetizable material and which supports a plurality of said envelopes with their metal ports in a downwardly disposed position with their openings exposed, said chamber containing in its lower portion a body of solder which is maintained in a molten state at least during the subsequent sealing operation, said chamber being surrounded by an energized vertically movable solenoid which, by means of its magnetic field, maintains said holder in vertical registry with said solenoid and which is maintained at a vertical position sufficiently high so that the said metal ports are out of contact with said solder, evacuating said chamber, filling said chamber with the desired gas under the desired pressure, lowering said solenoid together with said holder and said envelopes contained therein until the openings of said tubular metal ports are immersed in said pool of molten solder in the lower portion of said chamber, increasing the gas pressure within the chamber to force the molten solder part way up in said tubular metal ports, wherein it solidifies, and raising said solenoid together with said holder until the sealed envelopes are out of contact with the pool of molten solder.

2. In the manufacture of electrical devices enclosed in gas-filled, sealed glass envelopes which are adapted to be sealed off by closing tubular metal ports sealed therein, the steps which comprise suspending within an enclosed chamber a holder which is formed at least partly of magnetizable material and which supports at least one of said envelopes with its metal port in a downwardly disposed position with its opening exposed, said chamber containing in its lower portion a body of solder which is maintained in a molten state at least during the subsequent sealing operation, said chamber being surrounded by a vertically movable solenoid which, by means of its magnetic field, maintains said holder in substantially vertical registry with said solenoid and which is maintained at a vertical position sufficiently high so that the metal port is out of contact with said solder, altering the atmosphere within said chamber to correspond with that desired within said envelope and sealing off said envelope by lowering said solenoid until the metal port of said envelope is immersed in said pool of molten solder in the lower portion of said chamber.

3. In the manufacture of glass envelopes which are adapted to be sealed off by closing protruding tubular ports, the steps which comprise suspending, within an enclosed chamber, a holder which is formed at least partly of magnetizable material and which supports at least one of said envelopes with its tubular port in a downwardly disposed position, maintaining said holder, by means of a vertically movable magnetic element located outside said chamber, at a vertical position sufficiently high so that said tubular port is out of contact with a body of sealing material located in the bottom of said chamber, altering the atmosphere within said chamber to correspond with that desired within said envelope and sealing off said envelope by lowering said magnetic element together with said holder and said envelope until the opening of said tubular port is immersed in a pool of solidifiable liquid sealing material located in the lower portion of said chamber.

4. In the manufacture of enclosed gas-tight envelopes, the steps comprising altering the atmosphere within a chamber containing a body of fusible sealing material in its lower portion and containing at least one of said envelopes having a sealable opening, said envelope being supported with its opening in a downwardly disposed position by a holder, a portion of which at least is formed of magnetizable material, said holder being freely movable vertically within said chamber and being maintained at a sufficiently high position so that the opening in said envelope is out of contact with said fusible material by the influence of a vertically movable magnetic element located outside said chamber, lowering said magnetic element and with it said holder to a position such that the opening in said envelope is immersed in a fused pool of said fusible sealing maerial and raising said magnetic element together with said holder and said envelope which has its opening sealed by a body of said sealing material.

5. In the treatment of glass envelopes having hollow metal tubes sealed in the walls thereof, the steps comprising suspending at least one of said envelopes having its metal tube unsealed, within a chamber with its metal tube in a downwardly disposed direction, altering the atmosphere within said chamber to correspond with that desired within the envelope and sealing off said envelope by lowering said envelope until the open end of said metal tube is immersed in a pool of molten solder located in the lower portion of said chamber.

6. In the manufacture of enclosed gas-tight envelopes, the steps comprising placing within a chamber at least one of said envelopes, said envelope having an unsealed opening, altering the atmosphere within said chamber to correspond with that desired within the envelope and sealing said opening by lowering said envelope until said opening is immersed in a pool of liquid solidifiable sealing material located in the lower portion of said chamber.

7. A device for altering the atmosphere within and sealing glass vessels which are adapted to be sealed off by closing protruding tubular ports, which device comprises an enclosed glass chamber adapted to contain a liquid sealing material in its lower portion, said glass chamber having a cover fitted to an opening therein by means of a gas-tight ground glass joint, said opening being sufficiently large to permit the insertion of a holder for said glass vessels, a holder within said chamber adapted to support a plurality of said glass vessels with their tubular ports in a downwardly disposed direction, said holder being constructed at least in part of magnetizable material, said holder comprising a substantially horizontal plate containing a plurality of spaced openings slightly larger than the size of said tubular ports, said holder being freely movable vertically within said chamber, means for withdrawing and introducing gas into the space defined by said chamber and said cover, and a solenoid the turns of which surround a portion of said chamber, said solenoid being freely movable vertically along the outside of said chamber.

8. A device for altering the atmosphere within and sealing gas-tight vessels having sealable protruding tubular ports, which device comprises an enclosed chamber adapted to contain a liquid sealing material in its lower portion, means for introducing and withdrawing gas from said chamber, supporting means within said chamber adapted to support a plurality of said vessels with their tubular ports disposed in a downward direction and defining substantially a horizontal plane, said supporting means being freely movable in a vertical direction and being so constructed that it is capable of being moved to and held in various vertical positions within the chamber by means of a magnetic element located outside the chamber and a vertically movable magnetic element located outside said chamber so disposed as to be capable of controlling the position of said supporting means within said chamber.

9. A device for altering the atmosphere within and sealing gas-tight vessels having sealable ports, which comprises an enclosed chamber, vertically movable means within said chamber for supporting at least one of said vessels, said supporting means being formed at least in part of magnetizable material, a pool of solidifiable liquid sealing material in the lower portion of said chamber, and magnetic means outside said chamber for moving said supporting means vertically within said enclosed chamber.

10. A device for altering the atmosphere within and sealing gas-tight vessels having sealable ports, which comprises an enclosed chamber adapted to be evacuated, vertically movable means within said chamber for supporting at least one of said vessels, a pool of solidifiable liquid sealing material in the lower portion of said chamber, and means for moving said supporting means vertically within said enclosed chamber.

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