

Sept. 21, 1948.

H. O. BARSCHDORF

2,449,759

ELECTRICAL SEAL

Filed May 5, 1944

2 Sheets-Sheet 1

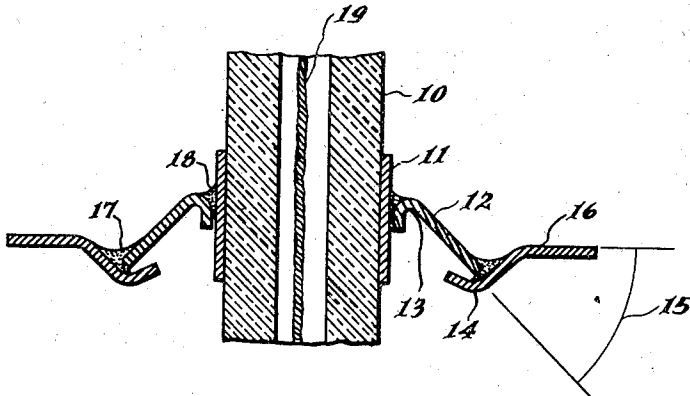


Fig: 1

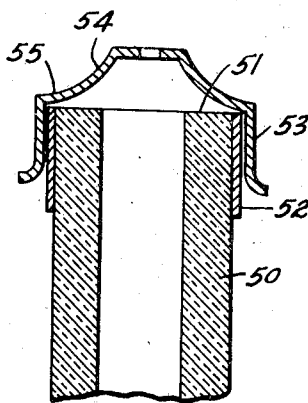


Fig: 3

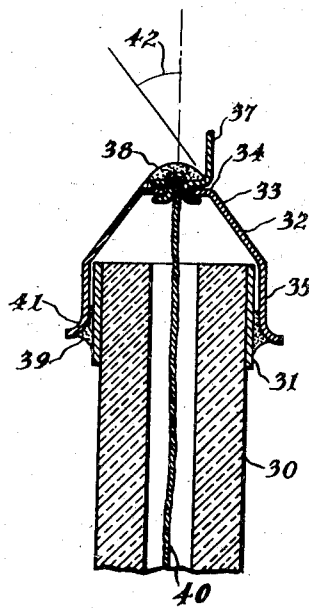


Fig: 2

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2 Sheets-Sheet 2

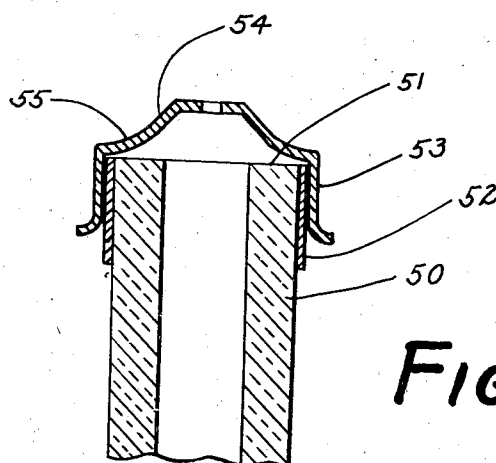


FIG. 3

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UNITED STATES PATENT OFFICE

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ELECTRICAL SEAL

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10 Claims. (Cl. 189—36.5)

1 This invention relates to improved electrical seals, and more particularly refers to improved hermetic glass-to-metal seals.

Broadly speaking, the art of making seals between glass and metal members has been practiced for some time. Unfortunately, however, the efforts in the prior art to produce permanent, hermetic glass-to-metal seals for assemblies likely to undergo wide temperature changes, have been, for the most part unsuccessful. One type of seal proposed is described in U. S. Patent No. 189,778, in which a glass tube is placed in a molten bath of solder or other low-melting alloy and the metal allowed to cool and solidify about the outer surfaces of the glass tube. By this method, however, no firm and integral bond is formed between the glass and the metal. Therefore, the permanence of the hermetic seal is limited, at best.

In general, it has been impossible to produce glass-to-metal assemblies which withstand without rupture the effect of temperature changes, due to the vast difference in the temperature coefficients of expansion of the materials, the metal coefficient usually being 4 or more times as great as the glass coefficient.

It is an object of this invention to overcome the foregoing disadvantages. A further object is to produce a permanent, hermetic glass-to-metal seal. A still further object is to produce a permanent hermetic glass-to-metal seal capable of withstanding temperature changes of 160° C. without rupture. A still further object is to produce a permanent hermetic glass-to-metal seal with a strain-absorbing flange incorporated therein. A still further object is to produce a permanently hermetically sealed container for electrical equipment. A still further object is to produce a permanently hermetically sealed container for electrical condensers and related devices. Additional objects will become apparent from a consideration of the following description and claims.

These objects are attained in accordance with the present invention wherein a strain-absorbing flange is introduced between the metal assembly and the glass assembly. In a more restricted sense, this invention is concerned with a glass-to-metal seal comprising a metal surface, a conical metal flange whose radial elements are at an angle with respect to the plane of the metal surface, and a glass member, whose surface is provided at least in part with an integrally bonded, thin metal layer, said metal surface being soldered to said flange and said flange being soldered to said integrally bonded metal layer on

2 said glass member. The invention is further concerned with a glass terminal cap seal comprising a glass member, on the outer surfaces of which is provided at least in part a thin, integrally bonded metal layer, a metal cap member comprising a conical section and a cylindrical section, the edges of which, not adjacent to the conical section, are provided with a radially extending lip, the cylindrical portion of said cap being positioned about the metal surfaces of the glass member and being intersoldered therewith. The invention is further concerned with novel strain-absorbing members useful in producing glass-to-metal seals.

15 In its broadest aspect, the invention disclosed herein is applicable in producing hermetic seals between metal surfaces and glass, porcelain or other high-temperature inorganic insulators by use of strain-absorbing flanges or members therebetween, to be hereinafter described. A consideration of the physical or structural conditions, as well as the electrical and chemical conditions, has indicated that a permanent seal between insulators and metals can be achieved only by interpositioning some device therebetween, to eliminate extreme forces, tensile and/or compressive in nature, on the relatively fragile glass or other ceramic surface. This, however, cannot be realized simply by utilizing a relatively thick interlayer of solder, inorganic cement, etc., between the members. According to the invention, there is introduced a carefully and particularly designed metal member whose function is to absorb the stresses and strains due to unequal expansion and contraction without affecting the more delicate constituents of the assembly.

The types of inorganic insulators which may be employed with good results in producing the seals of the invention are many. Outstanding hermetic seals have been obtained using thin or thick walled tubes of electrical "Pyrex," a borosilicate glass. Also satisfactory are ceramic materials generally, such as non-porous steatites, porcelains, etc.

45 The metals to which the seals are joined, and the insulators thereby attached, are not limited, except that it is preferable that they may be readily soldered. "Monel" metal, tinned metals, copper, aluminum, zinc, lead, silver, terneplate and other metal surfaces may be employed. In general, the metal surfaces to which the seals are joined are part of a container of some type for equipment requiring hermetic sealing from the effects of corrosive atmospheres, humidity, etc. For example, they may be the ends of glass tube

enclosed condensers and resistors, or the tops of can-type containers for condensers, networks, etc.

The first step in the production of the seals described herein is the preparation of a thin metal layer on a part of the surface of the glass or other insulating non-metallic member. This thin metal layer is preferably bonded to the glass by a minute interlayer of lead oxide or other common medium, which may chemically react with the glass to produce a lead glass. Such a layer and interlayer and the formation thereof is described in detail in co-pending application Serial No. 445,609, filed on June 3, 1942, by M. Nazzewski, now Patent No. 2,386,628, patented October 9, 1945. Briefly, the process comprises heating the glass member to a temperature approximating the melting point of the metal or alloy to be deposited thereon and spraying the molten metal or alloy (preferably 97.5% lead and 2.5% silver) onto the glass surface, causing formation of lead oxide to some degree in transit. The lead oxide apparently inter-fuses with the glass to form an integral chemical bond therewith and with the unoxidized portion of the sprayed metal. The thin metal layer thus formed is readily soldered to, and acts to some degree as a strain-absorbing layer and permanently maintains its bond to the glass.

However, it is to be understood that other means for producing on the glass a bonded metal layer may be used, if so desired. For example, cathode sublimation of a metal on a heated glass surface may be employed.

Reference is made to the appended drawings in which:

Figure 1 represents the cross-section of a terminal-to-container seal.

Figure 2 represents the cross-section of a terminal end seal, and

Figure 3 represents the cross-section of another terminal end seal.

Referring more specifically to Figure 1, a thick-walled glass insulator is shown passing through a metal surface and sealed thereto in accordance with the invention. Such a terminal device is useful in high-voltage electrical equipment, where a conductor is led through the insulating tube as one terminal.

In this figure, 10 represents a thick-walled cylindrical tube of electrical "Pyrex" through which passes a conductor 18, and upon the surface of which is deposited or otherwise applied a thin metal band 11, preferably in an integral chemically bonded relationship therewith. The thickness of this metal layer is greatly enlarged for the sake of clarity. 16 represents aterneplate metal sheet, which has been punched to form a hole for the glass tube and then the edges crimped into a position 14, which may be represented as a groove into which the outer edge of a flange 12 fits, therefore being concave with respect to the flange.

The strain-absorbing flange 12, according to one of the preferred embodiments of the invention comprises a conical section, whose inner lip 13 is radially turned inwardly until parallel with the axis of the cone, thus forming a cylinder.

The angle between the elements of the cone 12 and the plane of the metal sheet 16 is represented by 15 and is advisably at least 45 degrees, and preferably 50 degrees or somewhat greater. The axis of the tube 10 is preferably perpendicular to the plane of the metal sheet 16.

The flange 12 may be produced from deep drawing steel. In the device illustrated its thickness is from .010" to about .012", although, for larger

or smaller glass tubes and terminals, this range of values may be varied to fit the physical requirements of the flange. Other metals or alloys may be used for the flange.

The flange 12 is soldered to sheet 16 by solder 17; and it is soldered to layer 11 by solder 18. It is advisable that the layer 11, flange 12 and metal 16 be readily solderable. If they are not readily solderable, a layer of metal which is may be applied thereto. For example, they may be tinned, either by the electro-tinning or dip-tinning methods, with excellent results.

According to another preferred embodiment of the invention, the various components of the assembly are first affixed into their ultimate positions by suitable blocks, clamps, etc. Following this, a gas torch flame is applied to the portions of the flange 12 and metal sheet 16 to be soldered. Solder is then applied and fills the concavity between the outer conical edge of the flange 12 and the crimped portion 14. The torch is then applied to the upper and inwardly curved lip of the flange 13, without heating the metal layer 11 to any great extent. Solder is then applied and flows into the channel between the flange and the metal layer. Often the first heating of the divergent end of the flange is sufficient to cause enough heat transmission to the convergent end to permit soldering without additional heating.

The so-formed hermetic seal may then be used as a terminal for an electrical condenser or network, as indicated by 19 which represents an electrical lead.

In soldering the extremity of the flange to the metal layer 11, most satisfactory results have been obtained by restricting the flow of the solder so that it does not extend to the edges of the metal layer 11. It is advisable for the minimum distance between the solder and the metal layer edge to be at least $\frac{1}{16}$ " in the case of tubes of $\frac{1}{2}$ " outside diameter or less and correspondingly greater in the case of tubes of larger outside diameter. This figure applies for both thin and thick-walled tubes, although with the former, the minimum distance is somewhat more critical.

Referring now to Figure 2, an end cap seal for a glass terminal is illustrated in cross-section. The glass tube might be the end of the tube shown in Figure 1, for example, in a condenser assembly.

The glass tube 30 is composed of electrical "Pyrex" or a similar inorganic insulating material, the end thereof being preferably ground to a plane perpendicular to the axis of the tube. A thin metal layer 31 is positioned upon the outer cylindrical surface of the extremity of the tube. This layer preferably adheres to the glass by an integral chemical bonding, as heretofore described.

The metal cap 32 is a preferred embodiment of the invention and is hermetically sealed to the tube end as hereinafter described. Geometrically, the cap 32 comprises a cylindrical section 35, slightly larger in diameter than the glass tube, the lower edges of which are turned or pressed into a radially extending lip 41, a conical frustum 33, and a plane surface 34 defining the outer extremity of the cone frustum. A hole is provided in the center of the plane surface 34, through which terminal lug 37 is riveted, and electrical lead 40 is extended. The angle 42 between the cone elements and the axis of the tube should generally be no more than 45 degrees and preferably about 30 degrees. The riveted lug 37, the wire lead 40 and the cap 32 may be inter-soldered by solder 38 at any time convenient to the assem-

bly of the apparatus. For example, the soldering may take place following impregnation of an electrical condenser whose terminals are produced in accordance with the invention.

The cap 32 and the metal layer 31 may be intersoldered by solder 39. It is preferable to rapidly heat the portion of the cap to be soldered to the metal layer, as for example, by use of a torch flame. The heating should be uniform about the circumference of the cap and need not be appreciably higher than the solder melting point.

As in the case of the seal illustrated in Figure 1, the solder 39 should be limited in its flow so as not to reach any edges of the metal layer 31. The minimum distance between the solder 39 and the edge of the metal layer 31 is preferably at least $\frac{1}{16}$ " when the outside diameter of the tube 30 is $\frac{1}{2}$ " or less, and correspondingly greater when the outside diameter of the tube is greater than $\frac{1}{2}$ ".

The cap, by virtue of its design, will substantially absorb the expansion difference between the metal components and the glass component, when the seal is produced as indicated. It is preferably pressed from deep drawing steel sheets of about .010" to .012" in thickness, although greater or smaller thicknesses may successfully be employed. It may be electro- or dip-tinned to facilitate soldering. This is, of course, also applicable with respect to the lug 37 and lead 40.

The terminal lug 37 may be replaced by a nut and bolt combination, a plug-in assembly or other common type of electrical connector.

Figure 3 represents a cross-section of a modified cap and exemplifies one of the preferred embodiments of the invention. Due to the nature of the production of insulating tubes of electrical "Pyrex," it is not uncommon for the outside diameter to vary by considerable amounts from piece to piece. To compensate for this variation in tube diameter, the cap shown in Figure 2 is produced with a modified cone frustum, the lower section of which is curved inwardly.

In Figure 3, the so modified cap is shown with the cone frustum 54 at an angle of no more than 45° with respect to the axis of insulating tube 50. The cylindrical portion 53 of the cap fits over the end of tube 50, co-axially with metal band 52, to which the cap is eventually soldered or otherwise bonded.

In the case of the modified cap of this figure, the inner diameter of the cylindrical portion 53 may be somewhat greater than that of the cap shown in Figure 2, to permit use on all insulating tubes to which it is to be sealed. The lower portion 55 of the cone frustum is curved inwardly, thus providing a more nearly flat inner surface which will bear on the tube end 51. Thus, if the tube diameter is less than the prescribed value, the end 51 will not extend materially beyond the cylindrical portion 53 of the metal cap. In this way uniform assembly heights may be produced. The inward curvature shown in Figure 3 may be defined, with reference to the cone frustum, as a section of increasing divergence.

Having described illustrative applications of the stress-absorbing flanges or caps of the invention, it is apparent that several structural features are important and should be incorporated therein for optimum results.

In the case of a glass member protruding through a metal piece, these are:

1. The conical flange should be at an angle of at least 45 degrees with respect to the plane of the metal component;

2. The radially turned lip of the inner flange extremity must be substantially parallel to the metal layer and therefore to the glass tube;

3. The solder must not extend to any edge of the metal layer on the glass tube;

4. In producing the seal, the glass tube and metal layer thereon should not be deliberately preheated.

In the case of sealing a metal cap to a glass tube, these are:

1. The conical frustum of the cap should not be at an angle of more than about 45 degrees with respect to the axis of the glass tube;

2. In producing the seal, the glass tube and metal layer thereon should not be deliberately preheated;

3. The solder must not extend to the edges of the metal layer on the glass tube.

The above principles need not all be incorporated in an assembly, as they are optional, but superior results may ordinarily be obtained by following them. By proper application of these principles, outstandingly permanent, hermetic glass-to-metal seals may be produced, a tremendous advancement over the fragile glass-to-metal seals of the prior art.

The strain-absorbing flange and terminal caps are of particular value in producing hermetically sealed electrical condensers, networks, resistors, etc. In the case of a condenser, armatures separated by porous dielectric material may be placed in an open-ended metal container and a top therefor be produced with one or more glass-tube insulated terminals with strain-absorbing flange and cap arrangements therein, the top or metal sheet being soldered to the body of the container. The sealing of the cap end may be accomplished following impregnation and, if desired, polymerization, of the porous dielectric spacer with a liquid or resinous dielectric material.

Likewise, the caps disclosed herein are of great value in sealing resistance elements in glass tubes, with a cap at each end acting as a terminal, a mounting piece and to protect the glass from physical damage. The seals produced between the cap and the glass tube are permanent, and hermetic, protecting the resistor from the effects of corrosive and humid atmospheres and the like.

It is to be understood that the instructions of copending applications Serial Nos. 445,609 and 530,634, filed by Mathew Nazzewski on June 3, 1942, and April 12, 1944, respectively, are applicable hereto in the same manner as though they were incorporated herein. Patent No. 2,386,628 was issued on the former application on October 9, 1945. These instructions are particularly applicable in applying the metal layer to the glass surface, and in soldering this layer to the adjacent metallic material.

As many apparently widely different embodiments of this invention may be made without departing from the spirit and scope hereof, it is to be understood that the invention is not limited to the specific embodiments hereof except as defined in the appended claims.

I claim:

1. A ceramic cylinder having a metallic layer circumferentially bonded to the surface thereof, said metallic layer being bonded to and circumferentially enclosed by a strain-absorbing flange comprising a conical frustum, one end of which provides a circular band adjacent the cylinder and the opposite end of which is bonded to a metal surface.

2. A ceramic cylinder having a solderable me-

tallic layer circumferentially and integrally bonded to the surface thereof, said metallic layer being hermetically soldered to and circumferentially enclosed by a strain-absorbing flange comprising a conical frustum of solderable metal, one end of which is shaped to provide a circular band adjacent the cylinder and the opposite end of which is hermetically soldered to a solderable metal surface.

3. A hermetically sealed electrical device comprising a cylinder of heat-resistant glass having a metallic layer predominating in lead circumferentially and integrally bonded to the surface thereof, said metallic layer being hermetically soldered to and circumferentially enclosed by a strain-absorbing flange comprising a conical frustum of solderable metal, the convergent end of which is shaped to provide a circular band adjacent and approximately parallel to the surface of the aforesaid cylinder, and the divergent end of which is hermetically soldered to a solderable metal surface.

4. A hermetically sealed electrical device comprising a cylinder of heat-resistant glass having a metallic layer predominating in lead circumferentially and integrally bonded to the surface thereof, said metallic layer being hermetically soldered to and circumferentially enclosed by a strain-absorbing flange comprising a conical frustum of solderable metal, the convergent end of which is turned inwardly to provide a circular band adjacent and approximately parallel to the surface of the aforesaid cylinder, and the divergent end of which is hermetically soldered to a circumferentially indented portion of a solderable metal surface.

5. A hermetically sealed electrical device comprising a cylinder of heat-resistant glass having a metallic layer predominating in lead circumferentially and integrally bonded to the surface thereof, said metallic layer being hermetically soldered to and circumferentially enclosed by a strain-absorbing flange comprising a conical frustum of solderable metal, the divergent end of which is extended to form a cylinder adjacent and approximately parallel to the surface of the aforesaid cylinder, and the convergent end of which is hermetically soldered to the terminal of an electrical lead.

6. A hermetically sealed electrical device comprising a cylinder of heat-resistant glass having a metallic layer predominating in lead circumferentially and integrally bonded to the surface thereof, said metallic layer being hermetically soldered to and circumferentially enclosed by a strain-absorbing flange comprising a conical frustum of solderable metal, the convergent end of which is turned inwardly to provide a circular band adjacent and approximately parallel to the surface of the aforesaid cylinder, and the divergent end of which is hermetically soldered to a circumferentially indented portion of a solderable metal surface, said metal surface being in a plane approximately perpendicular to the axis of the aforesaid glass cylinder.

7. A hermetically sealed electrical device comprising a cylinder of heat-resistant glass having a solderable metallic layer circumferentially and integrally bonded to the outer cylindrical surface of one extremity of said glass cylinder, said metallic layer being hermetically soldered to and circumferentially enclosed by a strain-absorbing flange comprising a conical frustum of solderable metal, the divergent end of which increases in divergence and is extended to form a cylinder adjacent and approximately parallel to the surface of the aforesaid cylinder, and the convergent end of which is hermetically soldered to an electrical lead.

8. A hermetically sealed electrical device comprising a cylinder of heat-resistant glass having a solderable metallic layer circumferentially and integrally bonded to the surface thereof, said metallic layer being hermetically soldered to and circumferentially enclosed by a strain-absorbing flange comprising a conical frustum of solderable metal, the convergent end of which is shaped to provide a circular band adjacent and approximately parallel to the surface of the aforesaid cylinder, and the divergent end of which is hermetically soldered to a solderable metal surface.

9. A hermetically sealed electrical device comprising a cylinder of heat-resistant glass having a solderable metallic layer circumferentially and integrally bonded to the surface thereof, said metallic layer being hermetically soldered to and circumferentially enclosed by a strain-absorbing flange comprising a conical frustum of solderable metal, the convergent end of which is turned inwardly to provide a circular band adjacent and approximately parallel to the surface of the aforesaid cylinder, and the divergent end of which is hermetically soldered to a circumferentially indented portion of a solderable metal surface.

10. A hermetically sealed electrical device comprising a cylinder of heat-resistant glass having a solderable metallic layer circumferentially and integrally bonded to the surface thereof, said metallic layer being hermetically soldered to and circumferentially enclosed by a strain-absorbing flange comprising a conical frustum of solderable metal, the divergent end of which is extended to form a cylinder adjacent and approximately parallel to the surface of the aforesaid cylinder, and the convergent end of which is hermetically soldered to an electrical lead.

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