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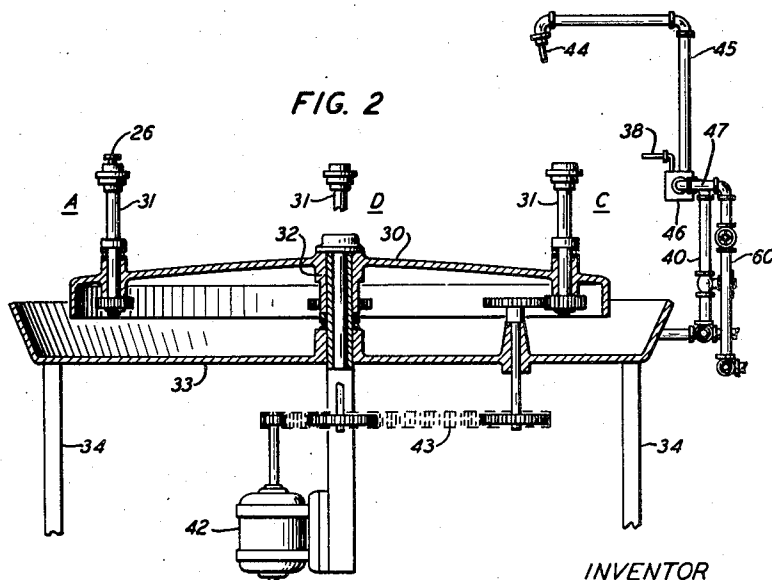
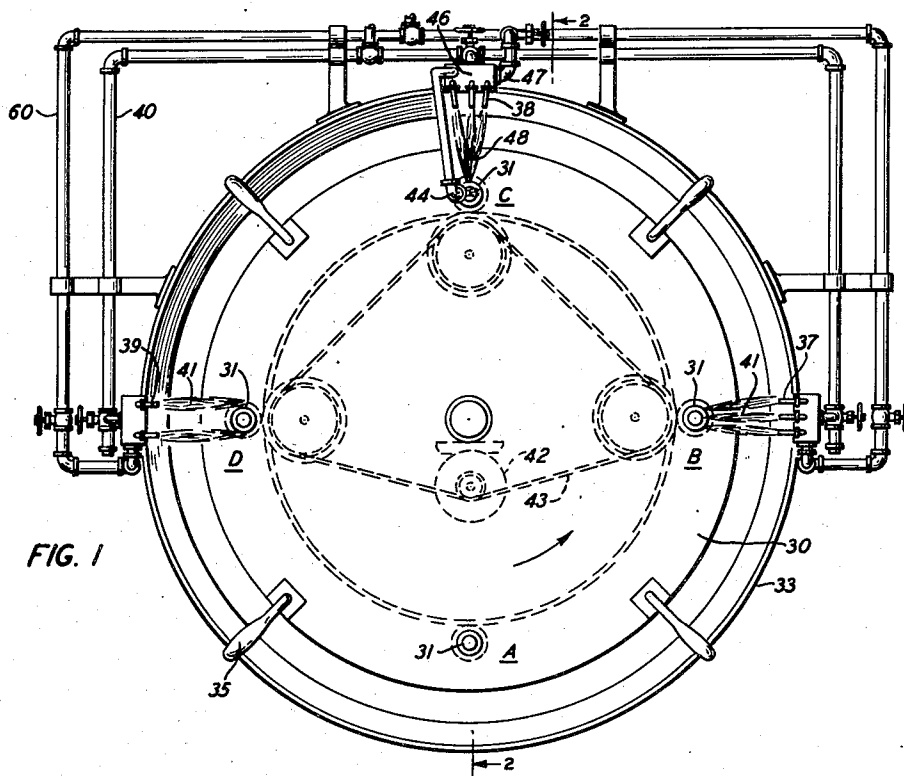
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METHOD OF SEALING GLASS TO METAL

Filed March 15, 1946

2 Sheets-Sheet 1



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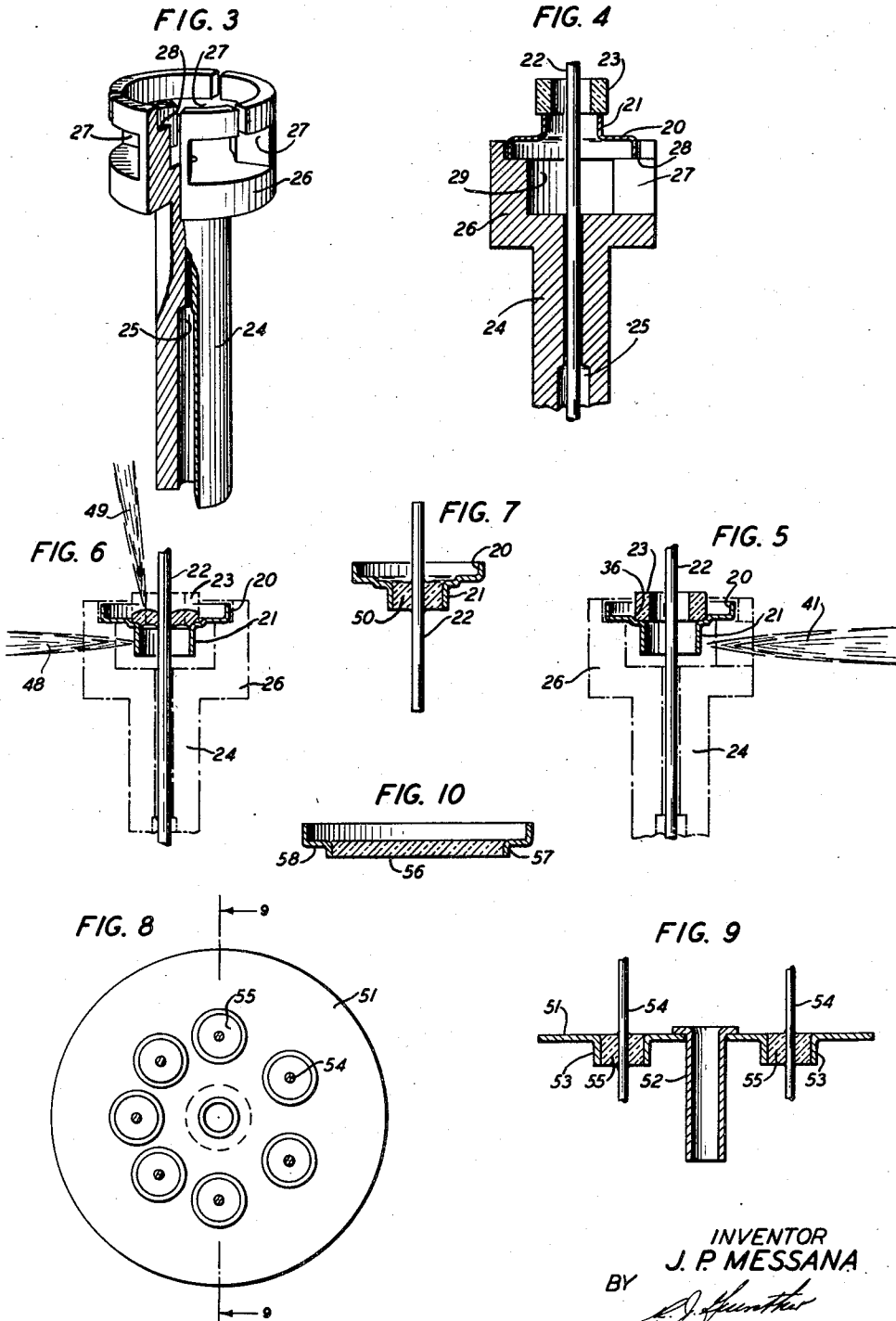
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METHOD OF SEALING GLASS TO METAL

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2 Sheets-Sheet 2



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METHOD OF SEALING GLASS TO METAL

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8 Claims. (Cl. 49—81)

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This invention relates to glass-to-metal seals, and more particularly to hermetic seals of the type employed in envelopes or containers for electron discharge devices, ionic devices, and other types of electrical devices.

The fabrication of a hermetic seal between a coaxial conductor and metallic sleeve shell, heretofore has usually been performed by beading the conductor with glass or pressing the glass by suitable dies in contact with the conductor and shell. In the beading procedure the glass is uncontrolled and where a glass bead having a large ratio of diameter to length is required, this method cannot be used conveniently since it produces a bead having approximately a 1 to 1 ratio of diameter to length. Also this method results in the formation of fragile glass tails where the beads "wets" the central conductor, which increases the longitudinal dimensions of the seal and renders the seal liable to cracking at the fragile joint of the tail. In the pressing procedure various difficulties, particularly with respect to the glass adhering to the dies, and molten glass extruding into the clearances between the dies and wire or eyelet occur which render this method time-consuming, highly expensive and unsatisfactory from a production standpoint.

When it is desired to reduce the length of apparatus provided with sealed conductors or terminals at either or both ends of the device, it is evident that the beaded seal is unsatisfactory in view of the added length imparted to the seal and the dependent tails extending along the conductor of the seal. While the molded or pressed seal produced by dies overcomes this objectionable feature to some extent, the elements of cost, quality and manufacturing technique render this type of seal deficient in certain applications.

One object of this invention is to produce and facilitate the production of seals that are gas and vacuum-tight, mechanically strong, compact in dimensional length and having excellent insulating properties.

A further object of the invention is to produce a hermetic seal without dies or other pressing molds yet achieving a compact, uniform joint between coaxial metal elements or solely between a glass mass and a surrounding metal member in which the diameter of the vitreous mass is greater than its thickness and in which opposite surfaces of the mass are substantially parallel.

In accordance with features of this invention, these objects are attained in one aspect by mounting a metallic eyelet or cap member and a coaxial conductor on a suitable fixture in a

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sealing machine and locating a vitreous ring or sleeve of larger diameter than the eyelet opening on the eyelet in concentric relation with the eyelet and conductor. In the preliminary step of the sealing process, the eyelet is heated to red heat to conductively heat the glass in contact with the eyelet to such a temperature that the glass sleeve is "tacked" to the eyelet. This procedure assures accurate concentricity of the glass with respect to the conductor and eyelet and prepares the metal for the sealing operation.

In the sealing step, the whole assembly in the fixture is rotated in an intense flame directed at the eyelet and simultaneously a similar flame is directed toward the glass sleeve in a downwardly directed angle to render the glass plastic. During this period, the glass collapses inwardly toward the conductor and by gravitational and surface tension forces and the controllable impact force of the overhead flame the soft glass sags or collapses into the neck opening of the eyelet and fuses to the conductor and eyelet in a solid tablet formation having parallel plane surfaces coincident with the extremities of the eyelet neck portion. The completed seal is finally normalized in an annealing flame to reduce strains and stresses in the glass mass.

A feature of the invention relates to the preliminary "tacking" of the glass sleeve to the metal eyelet prior to sealing the glass to the conductor to insure constant symmetry between the elemental parts of the assembly. This is accomplished by providing a glass ring or sleeve section of larger diameter than the neck opening of the metal eyelet and adjusting the pressure, intensity and direction of the flames so that the proper collapsing effect is secured in the sealing operation.

A further feature relates to the final seal formation of large diameter to length ratio without the use of dies or other pressing tools. The uniform thickness of the glass seal is attained by the surface tension forces and the controlled impact and intensity of the flames acting on the plastic glass mass adhering to the conductor and the neck portion of the eyelet. This results in a compact pill, button or tablet form of glass seal which is consistently uniform in thickness with absolutely uniform parallel surfaces coincident with the extremities of the neck portion of the eyelet. The seal, therefore, is within the limit of the exterior end of the eyelet and has the properties and physical characteristics of a pressed seal without the disadvantages incident to such type seals which are made with dies.

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Another feature of the invention relates to the formation of a window seal with a metallic ring member, the seal being vacuum-tight and permitting visual observation of internal components in devices in which the seal is employed.

These and other features and advantages of the invention will be more clearly set forth in the following detailed description which together with the accompanying drawings sets forth the various aspects of the invention.

Fig. 1 is a plan view of a sealing machine with various operating positions employed in fabricating the seal of this invention indicated;

Fig. 2 is a view in cross-section of the machine of Fig. 1 taken along line 2—2 and showing the sealing position on the right-hand side;

Fig. 3 is an enlarged view of a holding jig or fixture employed in mounting the various elements of the seal in the head of the sealing machine;

Fig. 4 shows in cross-section view one method of mounting the metal and glass components of the seal in the fixture prior to performing the sealing process;

Fig. 5 shows the seal elements in cross-section and their relation in the fixture according to another method of mounting, and also illustrates the preliminary heating step in accordance with a feature of this invention;

Fig. 6 illustrates the sealing step to join the conductor to the other metal member;

Fig. 7 shows the completed seal in cross-section;

Fig. 8 is a plan view of a metallic header with multiple sealed conductors;

Fig. 9 is a cross-sectional view of the header taken along line 9—9 of Fig. 8; and

Fig. 10 is a view in cross-section of a modified form of seal constructed in accordance with the invention, in which the conductor is omitted and the glass mass sealed in the eyelet member to form a viewing window for examining internal components in a vacuum chamber.

In the preparation of metal-to-glass seals various iron-base alloys readily seal to glass provided the coefficient of the glass is compatible with the metal. For example, certain nickel-iron alloys, commercially known as "Kovar" alloys, may be hermetically sealed to some of the hard borosilicate glasses having a coefficient of expansion substantially equal to 47×10^{-7} centimeters per centimeter length per degree centigrade. Similarly soft lead glasses may be equally sealed to iron-base alloys if the expansivity of both are substantially the same. The borosilicate glasses particularly suitable for sealing to nickel-cobalt-iron alloys having the general composition of 29 per cent nickel, 17 per cent cobalt, 0.3 per cent manganese and the balance iron, are commercially known as No. 7052 and 704 glass manufactured by Corning Glass Company and have expansion coefficients compatible with the above-mentioned alloy in a temperature range between 0 and 500° C. Corning glass 7052 is composed of the following approximate parts: Silica 68.0, alumina 8.1, sodium oxide 1.9, barium oxide 2.4, lithium oxide 8.5, and boron oxide 15.2. Corning glass 704 is of similar composition.

In accordance with this invention, the methods of fabrication of such glass-to-metal seals achieve efficient hermetic joints between the metal and glass which are compact and expeditiously made without complicated procedure or pressing dies. A feature of the process in-

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volves utilizing the gravitational and surface tension forces of the plastic glass during the seal formation together with the controllable impact forces and flame intensity of the heating sources to level out the mass within a short tubular portion of the metal member. Thus, there is produced a flat surfaced button-shaped or tablet seal which does not extend beyond the extremities of the tubular portion, thereby producing a sealed mass having surfaces perpendicular to the metal member to which it is joined so that a mechanically strong joint is attained. This type of seal, therefore, avoids relatively large volume extensions of glass and weak glass pedicle or tail extensions which are apt to form on the usual beaded type seal especially where a central conductor is coaxially sealed through the metal member.

Referring to the drawing and particularly to Figs. 3 and 4, the improved glass-to-metal seal made in accordance with this invention includes, in one form, a shallow metallic member or eyelet 20, preferably formed of "Kovar" alloy, and provided with a coaxial dependent neck portion 21 having a much larger diameter than depth to provide a short, compact seal when the peripheral flange of the metallic eyelet is secured to one end of the casing or apparatus which it is desired to seal hermetically. The seal also includes a central conductor 22, which preferably is also formed of the "Kovar" alloy, the seal between the eyelet and conductor being produced from a vitreous sleeve or ring 23, preferably formed of a hard borosilicate glass having a thermal coefficient of expansion equal or substantially equal to the metal eyelet and the conductor.

In one method of assembly, the eyelet 20 is inverted in a holding jig or fixture, shown more clearly in Fig. 3. This fixture includes a cylindrical shank portion 24 provided with a central bore 25 and an enlarged cylindrical head portion 26 having a plurality of side cut-out portions 27 and an internal recessed ridge 28 leading into a central cavity 29. The assembly of the elemental parts of the seal, as shown in Fig. 4, has the inverted eyelet 20 seated on the ridge 28 of the fixture, the short neck portion 21 extending above the top surface of the fixture with the central conductor 22 extending through the bore 25 of the fixture and the glass sleeve 23 seated on the edge of the neck portion, the glass sleeve being of larger diameter than the neck portion.

The glass-to-metal seal produced in accordance with this invention is made without the use of pressing or molding dies in forming the glass in the neck portion of the eyelet, yet a compact and efficient hermetic joint is produced between the central conductor and the neck portion of the eyelet member. This is accomplished by a series of steps performed on a rotatable sealing machine, as shown in Figs. 1 and 2, in which a rotatable drum or carrier 30, supports a plurality of heads 31, adjacent the periphery at equidistant positions, the drum being rotatable on a hub 32 located at the center of a dished circular base or bench 33 supported on legs 34. The drum is shown hand operated by means of the spaced handles 35 for simplicity although the heads and drum may be indexed to their respective operating positions automatically in accordance with well recognized practice in glass working machines.

The machine includes heads in four positions A to D, in which the spindle or head 31 at position A is stationary, to permit the loading of the

head with the jig or fixture and the component parts of the seal, namely, the eyelet, central conductor and glass sleeve. The subsequent sequence of operations in forming the seal may be realized from a description of the seal operations in connection with Figs. 5 to 7, inclusive, showing a different allocation of the metallic eyelet, conductor and glass sleeve suitable for commercial production. In this arrangement, the eyelet is centered in the ridge or shoulder 28 of the fixture and the glass sleeve is seated in a concentric recess 36, shown exaggerated in Fig. 5 of the eyelet, to insure absolute concentricity of the sleeve when a sealing head is shifted from position A to position B where the head is rotated in the initial heating flame. The glass ring 23 may also be centered in the eyelet by the conical sloping wall formed by the inside radius of the upper neck portion 21 where it joins the transverse wall of the eyelet. At positions B to D, inclusive, burner manifolds 37, 38 and 39 are directed toward the heads on the drum and are supplied by a gas main 40 and an air or oxygen main 60 to produce an intense flame 41 at positions B and D, respectively. The heads in the various operating positions are rotated at a uniform speed by a motor 42 connected thereto through driving gears and a chain drive 43.

In position B, the rotating fixture in the head 31 permits the depending neck portion 21 of the eyelet to be heated by the flame 41 which is controlled as to pressure and directed so that it enters the distributed openings 27 in the fixture to apply the flame directly to the neck portion and heat it to a cherry red or dull red color at a temperature which is between 600 and 700° C. This initial heating of the dependent neck portion only of the eyelet prepares the neck portion for the subsequent sealing operation by forming a suitable coating of oxide on the neck portion and at the same time the glass sleeve 23 is sufficiently heated by conduction through the metal, to "tack" or weld the glass in positive position in the eyelet and insure absolute concentricity regardless of the subsequent pressure produced by the fires or flames in later positions in the sealing operation. When the preliminary heating step is completed, the drum is moved so that the head in position B is advanced to position C. In this position, a single overhead burner 44 is connected through piping 45 to the manifold 46 of the multiple burner 38, the manifold being connected through a pipe connection 47 to a supply of compressed air or oxygen at about five pounds pressure, so that the flames issuing from the multiple burner 38 and the overhead burner 44 have a more intense sharp flame of high temperature. The pressure and intensity of the flame are controlled by the valves associated with the gas and air lines.

In position C, the flame from burner 38 is a sharp pointed flame 48 directed toward the metallic eyelet through the openings in the fixture and simultaneously a sharp flame 49 is directed downwardly from the overhead burner 44 toward the remote end of the glass ring 23 to render the glass plastic progressively from the top so that the sleeve collapses inwardly and circumferentially about the conductor 22, as shown in Fig. 6, and the plastic glass gradually sags into the neck portion 21, to form the seal as shown in Fig. 7. The plastic glass is leveled out in the neck portion 21 of the eyelet, in which the mass seals to the conductor and the inner wall, by gravitational and surface tension forces and the con-

trollable impact force of the overhead flame. The plastic glass consequently forms a tablet, pill or button seal 50 wholly within the confines of the neck portion 21 of the eyelet in which the inner and outer surfaces of the glass mass are perpendicular to the conductor and neck portion and are confined within the extremities of the length of the neck portion of the eyelet. The temperatures of the glass and the eyelet during the sealing operation in position C are within the range of 750 to 1000° C., these temperatures being the best for 7052 and 704 type borosilicate glass and the "Kovar" alloy eyelet which constitute one type of sealing combination. It is, of course, understood that these temperatures will vary with different types of alloys and other types of glasses sealed thereto.

The overhead heating of the glass ring 23 together with a rendering of the remote end of the ring plastic before the end in contact with the eyelet is affected, causes the remote end to collapse or shrink inwardly toward the conductor. The progressive heating of the collapsed ring as exposed to the intense flame from above, eventually renders all the glass plastic and by virtue of the bridging mass of plastic glass in the cavity between the conductor and the eyelet neck portion, the surface tension forces in the glass tend to level out the glass mass into a solid tablet formation in the short neck portion of the eyelet. There are produced thereby substantially perpendicular surfaces on opposite ends of the tablet seal without the aid of any pressing molds or dies which would be apt to stick to the glass and produce imperfections in the seal. Furthermore, the tablet form of seal produced in accordance with this invention achieves a compact glass joint, is devoid of pedicle or tail extensions on the glass in contact with the conductor which would produce weakened portions of the seal and the improved seal reduces the extension of the sealed joint so that it is cut off at the extremity of the neck portion 21 of the eyelet, thereby providing a compact and mechanically strong joint wherein the glass is contiguously sealed to the inner wall of the neck portion and the central conductor is hermetically sealed in the eyelet.

Since rapid cooling of the glass and metal components of the seal which have been subjected to intense heat in position C will cause objectionable strains and stresses to be set up, the drum is advanced to position D where less intense flames, substantially between 400 and 500° centigrade, directed so as to maintain the heat in the periphery of the cylindrical head portion of the fixture 26, gradually normalize the glass seal so that the temperature of the glass is gradually reduced to avoid strains. At the same time, the vitreous mass is cooled in compression by virtue of the constricting band or eyelet which is cooled last. After the seal is normalized the drum is advanced to the loading position A and the completed seal removed and the header reloaded for advancement through the series of sealing positions previously described.

The invention may also be utilized in forming a multiple header seal, as shown in Figs. 8 and 9. Such a metallic header 51 is provided with a central exhaust tubulation 52 and a circular series of formed neck portions 53 and may be mounted in a suitable holder with coaxial conductors 54 supported concentrically within the neck portions and larger diameter sleeves mounted above the neck portions in the same

manner as described in connection with the eyelet form of seal. This assembly may be placed in a suitable holder for forming the tablet or button seal mass 55 in each neck portion, in accordance with the procedure as outlined above, to produce a short, compact sealed joint for the production of multiple headers especially adapted for multielectrode electronic tubes, particularly of the metal type in which a metallic casing is welded to the periphery of the metal header to enclose an electrode assembly in the device.

A further modification of the sealing of glass to a metallic ring or compression band, in accordance with this invention is shown in Fig. 10. This form relates to the provision of a window 56 of larger diameter than thickness hermetically sealed in the wide neck portion 57 of a ring or band 58 of metal compatible with the glass employed in the seal to form an optical viewing surface for vacuum sealed apparatus where it is desired to inspect or observe internal components in the apparatus. The window seal may be produced in accordance with the methods outlined in connection with the eyelet seal wherein surface tension forces and impact forces of the heating flames level out the plastic glass mass in the neck portion 57 of the ring and produce a window seal having parallel surfaces perpendicular to the end boundaries of the neck of the ring or band 58. Thus the window seal may be made by placing a glass sleeve on the rim of the ring 58, tack-welding the lower edge of the glass sleeve to the rim, heating the upper end of the glass sleeve to render it plastic, collapsing that upper end into the center of the ring and around the tack weld as a pivot or hinge, and continuing to apply heat to the sleeve and ring until the plastic glass mass is level in the neck portion 57 of the ring 58.

While the invention has been disclosed in various aspects to achieve the die-less fused seal, in accordance with the methods of this invention, it is, of course, understood that various changes and modifications may be made in the detailed processes without departing from the scope of this invention as defined in the appended claims.

What is claimed is:

1. The method of fabricating a hermetic seal between vitreous material and a metallic member having a neck portion forming an aperture therein and also a conductor extending through said neck portion, which comprises, mounting said conductor in coaxial relation to the neck portion of said metallic member, placing a short ring of vitreous material and of greater diameter than said neck portion concentrically about said conductor in contact with said neck portion, heating said metallic member, tacking said ring to said neck portion by conduction heating from said member, directing an intense heating flame toward said ring from an elevated angle to render the remote end of said ring plastic and collapse said remote end inwardly toward said conductor, and intensely heating said neck portion to soften said vitreous material whereby said vitreous material collapses into the neck portion under the gravitational force and the impact of said first flame, and withdrawing said metallic member and said vitreous material from said flames when said vitreous material has leveled out as a filling mass between said neck portion and said conductor.

2. The method of fabricating an insulating hermetic seal between a metallic eyelet and a

central conductor comprising, positioning said eyelet coaxial with said conductor, said eyelet having a neck portion of greater diameter than its length, placing a vitreous tubular body in contact with said neck portion and coaxially related to said eyelet and conductor, heating said eyelet to red heat to tack said body thereto, applying heat from above said body to heat said body to a plastic state to soften the uppermost end of said body so that it collapses inwardly towards said conductor, and continuing the heating of said body from above until the neck cavity is filled by a vitreous mass having parallel surfaces coextensive with the terminal edges of said neck portion.

3. The method of fabricating a glass tablet form seal between a conductor and a metallic eyelet without pressing dies which comprises, mounting a glass ring of large diameter coaxially on a metallic eyelet having a dependent neck portion, mounting a conductor coaxially within said neck portion, tack-welding said ring to said eyelet, heating said ring and eyelet from the side and from above, rendering said glass plastic initially to collapse the ring inwardly towards said conductor around the tack weld as a pivot, and continuing said heating to collapse the glass into said neck portion to fill the annular gap between said portion and said conductor with a mass contiguously joined to the wall of said portion and said conductor and having top and bottom flat surfaces in planes at the extremities of said neck portion.

4. The method of fabricating a glass tablet form seal between a conductor and a metallic eyelet without pressing dies, the eyelet having a dependent neck portion and the conductor extending centrally therethrough, which method comprises, mounting a glass ring of large diameter coaxially on the metallic eyelet, tack-welding said ring to said eyelet, directing a downwardly projecting flame towards the free end of said ring to cause said end when plastic to collapse toward said conductor and into said neck portion, and further heating said ring and neck portion to fuse the plastic glass to the inner wall of said neck portion and said conductor within the confines thereof and by surface tension of the glass spread out in said neck portion in the form of a solid glass tablet having parallel surfaces perpendicular to the terminal ends of said neck portion.

5. The method of forming glass button seals in a metallic header having a plurality of tubular extensions and conductors extending through said extensions, which comprises mounting glass sleeves thereon coaxially with respect to said extensions and conductors, tacking said sleeves to said header by heating the latter, heating said sleeves by an overhead flame directed at the top ends of said sleeves to progressively render the glass plastic, causing the plastic glass to collapse inwardly and engage said conductors, continuing the heating of said sleeves and header to collapse the glass into said extensions until by surface tension the glass spreads uniformly and fills said extensions to form a button seal having parallel surfaces at opposite ends of said tubular extensions.

6. The method of hermetically sealing a vitreous mass to a metallic ring member which comprises placing a short vitreous sleeve having a greater diameter than said ring upon the edge of said ring, heating said metallic member to tack weld said vitreous sleeve to said edge,

heating the uppermost end of said sleeve from above to heat said end to a plastic state, collapsing said plastic end toward the axis of said ring around the tack weld as a pivot, progressively softening said sleeve and heating said ring to collapse the vitreous mass into said ring until said mass is level within said ring forming parallel plane surfaces on said mass within the edges of said ring.

7. The method of fabricating a glass tablet form seal between a conductor and a metallic eyelet which comprises mounting a glass ring of larger diameter than said eyelet coaxially on the metallic eyelet, said eyelet having a depend- end neck portion and said conductor extending centrally through said portion, heating said ring to tack-weld it in said eyelet, directing a flame towards the free end of said ring to heat said end to a plastic state, collapsing the plastic portion of said ring towards said conductor around the tack-weld as a pivot, and further heating said ring and said eyelet to cause viscous movement of the glass into said neck portion, said further heating being terminated when the glass has flat surfaces level with the extremities of said neck portion.

8. The method of fabricating a hermetic seal between vitreous material and a metallic member having a neck portion forming an aperture

therein and a conductor extending through said neck portion which comprises mounting said conductor in coaxial relation to the neck portion of said metallic member, placing a short ring of vitreous material and of greater diameter than said neck portion concentrically about said conductor in contact with said neck portion, heating said metallic member, tacking said ring to said neck portion by conduction heating from said member, directing a flame against the remote end of said ring to render said remote end plastic and collapse said remote end inwardly toward said conductor, and intensely heating said neck portion and simultaneously softening said ring to cause viscous movement of said vitreous material into said neck portion, surface tension forces tending to level out said material as a filling mass between said neck portion and said conductor.

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