

SUBSTITUTE FOR MISSING XR

June 22, 1965

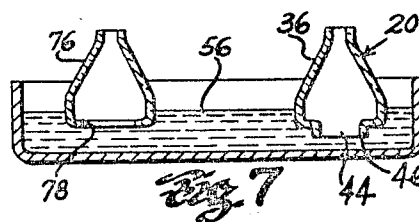
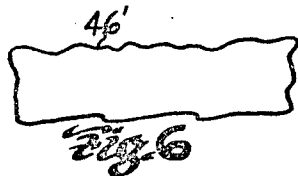
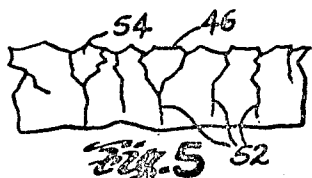
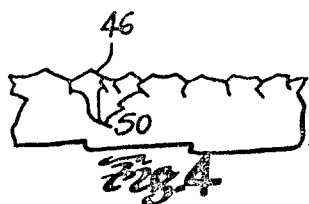
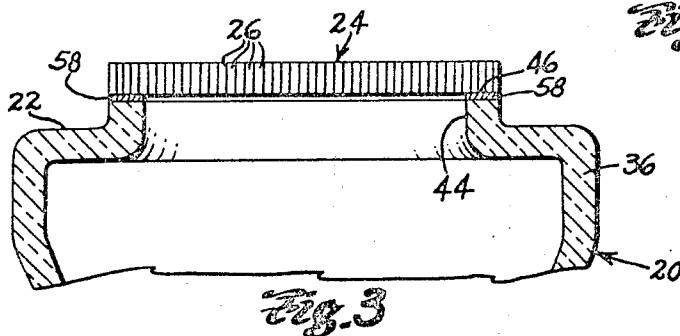
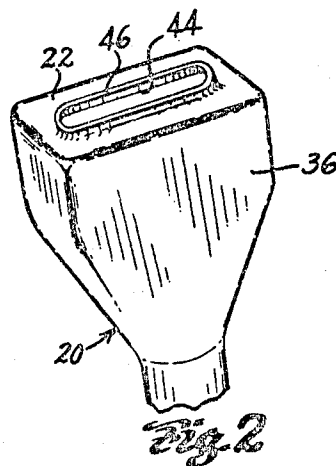
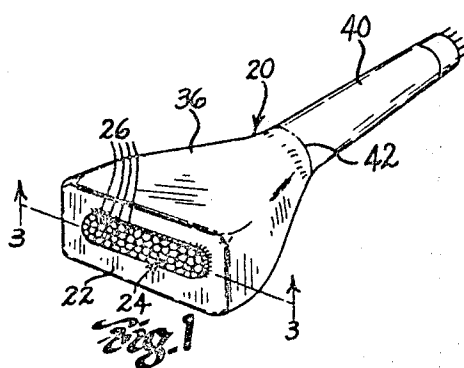
L. O. UPTON

3,190,738

METHOD FOR UNITING AN ABRADED ELEMENT TO AN ENVELOPE

Filed Nov. 28, 1960

2 Sheets-Sheet 1



INVENTOR
LEE O. UPTON
BY *Louis L. Sagnor*
ATTORNEY

June 22, 1965

L. O. UPTON

3,190,738

METHOD FOR UNITING AN ABRADED ELEMENT TO AN ENVELOPE

Filed Nov. 28, 1960

2 Sheets-Sheet 2

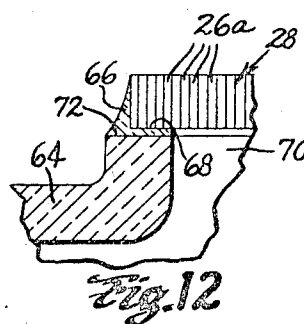
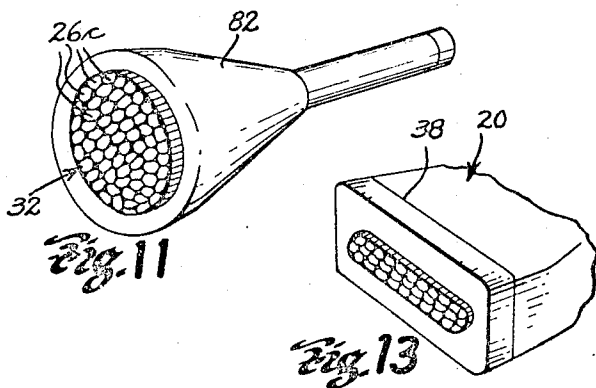
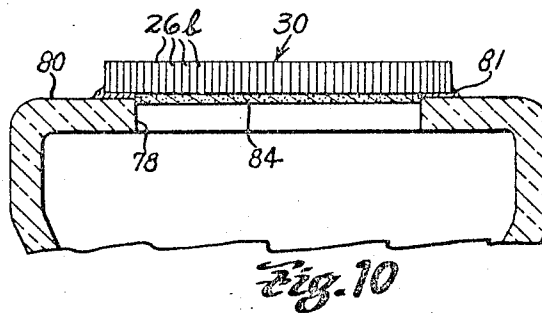
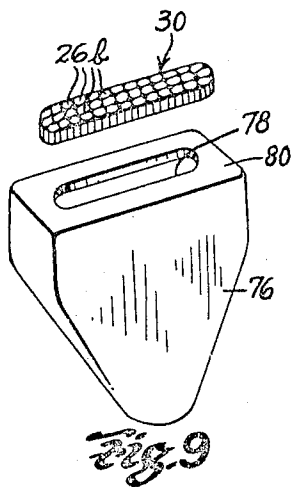
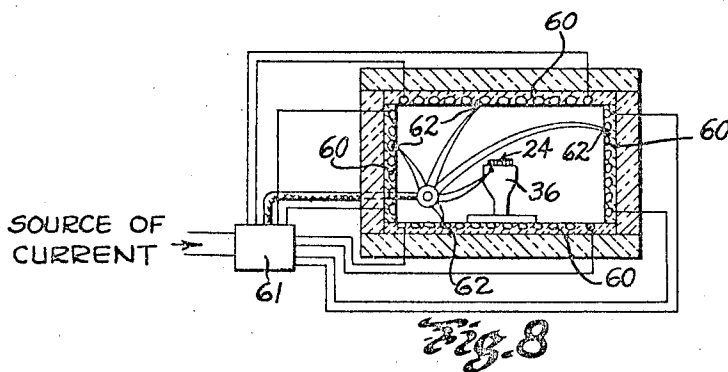


Fig. 13

INVENTOR
LEE O. UPTON

BY

Louis L. Lagon
ATTORNEY

1

3,190,738

METHOD FOR UNITING AN ABRADED ELEMENT TO AN ENVELOPE

Lee O. Upton, Sturbridge, Mass., assignor to American Optical Company, Southbridge, Mass., a voluntary association of Massachusetts

Filed Nov. 28, 1960, Ser. No. 72,182

10 Claims. (Cl. 65—31)

This invention relates to devices embodying fiber-like energy-conducting elements and more particularly to glass structures such as are used in the fabrication of cathode ray tubes or the like having fiber-like energy-conducting face sections and method of making the same.

Cathode ray tubes and other similar vacuumized or pressurized articles having face sections for transferring light or other forms of energy inwardly or outwardly thereof in accordance with their intended function usually comprise a glass envelope in which the electrical components of the tube are contained and a face section which is either hermetically edge-sealed by fusion to one end of the envelope or formed as an integral part thereof.

This invention relates to either the two-part or the one-piece envelope structure and has particular reference to an envelope having an air-tight energy-conducting section formed of fiber-like elements which is glass-fused to and forms a part of the envelope face section in such manner as to receive and transfer energy into or out of the tube envelope.

Envelope faces of the type embodying a section formed of a plurality of individually light-insulated all glass fibers or other types of fibers embodying glass outer claddings which are joined and hermetically sealed in side-by-side relation with each other have proven to be superior to conventional solid glass faces when used as energy-transmitting means in articles such as cathode ray tubes or the like. However, previous to this invention, the use of fiber-type face plates in cathode ray tube assemblies has rendered the assembly processes more complicated, difficult and costly.

With regard to the fabrication of fiber-type envelope faces, it has been relatively difficult to produce a secure vacuum-tight seal between the tube envelope and the fibers of a fiber-type face section without causing a fracturing of the portion of the envelope to which the fiber section is attached and/or distortion and fracturing in the fiber structure itself.

Distortions have resulted primarily from the application of relatively high fusing temperatures which have been required heretofore in forming the joinder between the glass parts wherein the fusing temperatures are usually within the range of the softening points of the materials of said parts. Fracturing, however, is generally caused, in part, by strain and stresses which are set up in bringing about fusion of parts having different coefficients of expansion and also by surface irregularities and the inherent incipient cracks which result from abrading while shaping or otherwise preparing the surfaces of glass parts which are to be heat-joined or glass-fused. Diamond tools, for example, or other abrading devices or media, while from all appearances tend to produce smooth regular surfaces, actually produce minute irregularities along a glass surface and microscopic fractures between these irregularities which tend to grow when the glass is heated and extend deep into the glass structure to the extent of causing a shattering in some cases or deeply seated fractures which render the end product unsuitable for use. Fracturing in articles particularly of the type which are to be vacuumized or pressurized obviously cannot be tolerated.

The effect of incipient fracturing caused by abrading glass surfaces is analogous to that of drawing a diamond

2

across a piece of glass so as to hardly leave a mark thereon. But, as it is commonly known, such a marked piece of glass will chip or fracture along the mark and with very little shock either caused by cooling or heating or by tapping the glass, the fracture will extend completely through the glass or large visible cracks will appear which weaken the structure and grow with age.

This invention takes the above into consideration and provides a solution to the problems relating thereto with the net result of producing a superior end product by the practice of a method which is simple, highly efficient and economical.

Accordingly, it is a principal object to provide an improved secure, substantially strain-free and distortionless energy-conducting structure intended primarily for use as the face section of a cathode ray tube envelope or the like and novel method of making the same.

Another object is to provide a face structure of the above character embodying a fused assembly of fiber elements in glass-sealed air or vacuum-tight attached relation to a solid glass-supporting part.

Another object is to provide an improved method of fabricating such a structure substantially without introducing distortion in the major component parts thereof and without experiencing difficulties of fracturing.

Another object is to provide a novel method for glass-sealing glass parts of the above character together through the use of an interconnecting glassy material so characterized as to be of relatively low viscosity at temperatures required for its fusion to said parts while the materials of said parts will be of relatively high viscosity at said same fusing temperature.

Another object is to glass-seal glass pieces together which have been formed at least in part by abrading operations and which have the abraded areas thereof treated in accordance with this invention so as to avoid the initiation of fractures resulting from incipient cracks produced by said abrading operations.

Another object is to remove said incipient cracks resulting from abrasion at said areas by effecting a so-called "acid polishing" or acid-etching of said areas.

Another object is to provide a novel face structure for a cathode ray type of tube envelope embodying a glass-connected section of fiber-like energy-conducting elements which projects outwardly and away from other portions of said envelope thereby permitting final finishing of the exposed portion of said section to a desired thickness, surface texture and shape without interference from adjacent parts of said envelope.

Another object is to provide a two-part face structure of the above character and novel method of making the same which obviates the requirement for time-consuming and costly fitting tolerances such as have been required heretofore in preparing the parts thereof for assembly with each other.

Other objects and advantages of the invention will become apparent from the following description when taken in conjunction with the accompanying drawings in which:

FIG. 1 is a perspective view of a preferred embodiment of the invention;

FIG. 2 is a perspective view of one of the major components of said embodiment;

FIG. 3 is an enlarged cross-sectional view taken substantially along line 3—3 of FIG. 1 looking in the direction indicated by the arrows;

FIG. 4 is a highly magnified diagrammatic illustration of a cross-section through an abraded glass surface of the character resulting from the practice of a step in the method of this invention wherein section lines have been omitted for purposes of clarity;

FIG. 5 is a similar diagrammatic illustration of said

same surface and which illustrates the results of heating the same to a relative high temperature;

FIG. 6 is a further illustration of the glass surface shown in FIG. 4 after having been treated in accordance with this invention to avoid the condition shown in FIG. 5 when relatively high temperatures are subsequently applied thereto;

FIG. 7 is a diagrammatic illustration of means and method for so treating abraded glass surfaces;

FIG. 8 is a diagrammatic illustration of furnace means for carrying out another step in the method of the invention;

FIG. 9 is an exploded perspective view of a further embodiment of the invention;

FIG. 10 is an enlarged cross-sectional view of the embodiment shown in FIG. 9 when in its finished state;

FIG. 11 is a perspective view of a modification of the invention;

FIG. 12 is an enlarged fragmentary cross-sectional view of a further modification of the invention; and

FIG. 13 is a fragmentary perspective view showing another modification of the invention.

In referring more particularly to the drawings, it will be seen that the invention relates to cathode ray tube envelopes and their manufacture with particular reference to tube envelopes of the type embodying face sections formed at least in part of fiber-like energy-conducting elements for receiving and transferring energy into or out of the envelope in accordance with the intended function of the tube.

For purposes of illustration, a cathode ray tube 20 has been shown in FIG. 1 as embodying a face part 22 having a section 24 joined thereto and which comprises an integral assembly of energy-conducting fiber-like elements 26 adapted to receive electrical or light-energy produced within the tube and to conduct said energy outwardly thereof through the exposed area of the section 24.

It is pointed out that while this invention relates to the construction of glass tube faces of the type embodying a fiber section which is joined by glass-fusion to the solid glass forward portion of a tube envelope or the like, it is in no way limited to use with tube envelopes of the particular shapes which have been shown by way of illustration in the drawings. While cathode ray tubes have been illustrated, tube envelopes of other energy-producing articles such as X-ray devices or couplers for use between tubes which receive and transfer energy may employ the arrangement of the invention to considerable advantage. Furthermore, it should be understood that the face part 22 of FIG. 1 and other similar structures which will be described in detail hereinafter may be used separately and without the adjoining envelope sections of their particular tubes as energy-transmitting components in optical systems wherein the solid glass portion surrounding the fiber element section 24 may be used, for example, as supporting and mounting means to position and hold the section 24 in a desired aligned relationship with other components in the optical system.

In all of the embodiments shown throughout the drawings, the fiber sections (24 in FIGS. 1 and 3, 28 in FIG. 8, 30 in FIGS. 9 and 10 and 32 in FIG. 11) each embody a plurality of fiber-like elements prefused together in side-by-side relation in the form of a solid vacuum-tight part which is cut, ground or otherwise shaped and finished to a desired peripheral contour and to an initial desired front to back thickness.

The fiber-like elements (26 in FIGS. 1 and 3, 26a in FIG. 8, 26b in FIGS. 9 and 10 and 26c in FIG. 11), in one form, might each embody a core structure formed of optical glass with an outer relatively thin coating or cladding of glass which is intended primarily to function as light-insulating means as will be explained shortly. In another form, the fiber-like elements might each embody a metallic core section adapted to receive and conduct electrical energy and having a relatively thin electrical

insulating glass outer cladding therearound by means of which the latter type of fiber elements may be connected together by fusion in the form of a vacuum-tight integral assembly.

The former case relating to the all-glass fibers will be set forth herein by way of example in the following description of the process of the invention.

The fiber-like elements 26, 26a, 26b, and 26c, in this case, being of the well-known clad or individually light-insulated type, would preferably each embody a core part of material such as glass of the optical flint type or the like having a relatively high index of refraction surrounded by a relatively thin cladding of crown-type glass or the like having an index of refraction lower than that of said core glass. In the usual manner of fabricating such fiber elements, materials which are to comprise the core and cladding parts thereof are selected to have indices of refraction of such relative values as to provide the above-mentioned fiber elements with a maximum light aperture or acceptance angle within which light entering one end thereof will be substantially totally internally reflected adjacent the interface between the said core and cladding parts and thereby transferred through the elements from end-to-end with a minimum loss in intensity. In this way, the cladding parts function to light-insulate one adjacent fiber element of the particular assembly from another adjacent fiber element thereof so as to substantially obviate the effects of "cross-talk" (the passing of light from one fiber element to another). As it is well-known in the field of fiber optics, "cross-talk" is extremely detrimental particularly in instances where a structure formed of many optical fibers is intended for use as means to receive and transfer optical images from one location to another by conducting adjacent elements of an image each through a particular fiber. "Cross-talk" intermixes these image elements and thereby deteriorates the overall transferred image.

The fiber parts 24, 28, 30 and 32 are intended for use as means for transferring optical images with high definition. However, they may be employed in the construction of devices which are used simply to conduct non-image forming light from one location to another or, as stated above, if formed of elements having metallic core parts, they would be used to transfer electrical energy.

A typical fiber element 26, for example might embody a core part of optical flint glass having an index of refraction of approximately 1.62 with a cladding of crown type or similarly characterized glass having an index of refraction of approximately 1.52. A suitable cladding thickness might be in the neighborhood of one-tenth the overall diameter of the fiber itself and the overall fiber diameter might range from a fraction of a thousandth of an inch to several thousandths of an inch. The selection of fiber element sizes would be made in accordance with the degree of image-resolving power desired of the fused fiber part 24. Reasonably good image resolution has been achieved with fiber elements each having a cross-sectional diameter of approximately .003 inch. However, fiber elements having a diametrical size as small as to approach 5 to 10 microns might be used for special applications. A fiber element such as 26, for example, might be formed by placing a relatively large rod of the higher index glass within a relatively close fitting tube of the lower index glass with said rod and tube each having a thickness proportionate to that desired of the respective core and cladding parts of the finally formed element. The rod and tube assembly is heated and drawn down to the ultimate size desired of the element 26.

The fabrication of the particular embodiment of the invention which is shown in FIGS. 1, 2 and 3 will first be described in detail and it will become apparent hereinafter that the other structures shown in the drawings are fabricated generally in the same manner.

Once having formed the fiber part 24, it is applied to

the tube face part 22 which is prepared to receive the same as follows:

The face part 22 may be initially formed integral with the enlarged portion 36 of the tube envelope 20, as shown in FIGS. 1, 3, 9 and 10, or formed separately and edge-fused thereto, as shown by the full line 38 (FIG. 13) in the usual manner well-known to tube manufacturers. In either case, the invention relates to the method of applying the fiber part 24 to the face of the portion 36 of the tube envelope preferably prior to attaching the neck portion 40 of the tube envelope to the enlarged portion 36 with a fused joinder at 42. It should be understood, however, that the tube envelope 20 may be completely assembled prior to the application of the fiber section 24 or partially assembled, it being immaterial to this invention.

In the embodiment shown in FIGS. 1, 2 and 3, the face part 22 is provided with a press-through opening 44 (see FIGS. 2 and 3) having its peripheral edge 46 directed outwardly as shown and of an outer contour size and shape substantially similar to that of the fiber section 24 which is to be placed thereon and glass fused thereto.

The edge 46 of the press-through 44 is preferably abraded with diamond charged tools or other abrasive means to a flat so as to provide a seat for receiving the fiber section 24 and is then acid-etched or, as referred to in the trade, "acid-polished" to remove incipient cracks which inherently result from abrading operations.

Referring more particularly to FIG. 4, wherein a diagrammatic highly magnified cross-section of the edge 46 is shown, it can be seen that incipient cracks 50 extend a minute distance into the glass structure. These are the inherent results of abrading operations as described hereinabove in detail and have been found to initiate destructive fracturing and shattering when heat is applied thereto during the glass-joining of the fiber part 24 to the edge 46.

Without removing the incipient cracks 50 prior to fusing the fiber section 24 to the edge 46, the heating effect will tend to cause said cracks to grow into large and deeply seated fractures such as shown at 52 in FIG. 5 to render the ultimate product unsuitable for use. The deep seated fractures also, in communicating with each other, cause a flaking at the edge 46 wherein glass particles such as 54 become loosened to the point of falling out. In any event, a condition such as illustrated in FIG. 5 is obviously highly undesirable and is avoided by the "acid-polishing" operation of this invention which removes the incipient cracks 50 to leave a smooth surface texture substantially of the character shown diagrammatically in FIG. 6 by the reference numeral 46'.

The "acid-polishing" operation may be performed by painting a suitable acid upon the edge 46 or dipping the same into an acid bath 56, as shown in FIG. 7, for a period of time sufficient to accomplish the results indicated at 46' in FIG. 6.

A suitable acid solution 56 might be a 10% solution of concentrated commercial hydrofluoric acid in distilled water or a mixture of commercial sulphuric acid (H_2SO_4) and commercial hydrofluoric acid (HF) in the respective proportions of from 25% to 75% HF. The time period required to remove incipient cracks such as 50 (FIG. 4) resulting from normal abrading operations by an immersion in the acid bath 56 ranges from approximately five seconds to one minute depending upon the character of the glass used in the construction of the portion 36 of the envelope. Such envelopes are usually formed of a crown-type glass similar in character to that mentioned above as being preferred for claddings of the fiber-like elements 26. In such a case, immersion in an acid bath 56 consisting of 50% H_2SO_4 and 50% HF for a time period of approximately thirty seconds will produce desirable results.

After the edge 46 has been "acid polished," the fiber section 24 is glass-sealed in overlying relation therewith by means of a relatively low melting glass composition which will be referred to hereinafter as the solder glass 58.

This solder glass, in accordance with one aspect of the invention, would embody a granulated silicate glass that contains a high percentage of lead oxide and which is so characterized as to be elastic by nature and absorptive to stresses and strains which might result from existing differences in expansion characteristics between the fiber part 24 and the face part 22 which are to be joined thereby. A silicate glass having a softening temperature of approximately 850° F. and containing approximately 70% lead oxide would be suitable. However, solder glasses having melting temperatures ranging from 700° F. to 1000° F. and containing from 85% to 50% lead oxide may be used. Solder glasses of this type, such as Corning 7570, are commonly known to the trade and are readily available commercially. It is pointed out that the selection of solder glass 58 would be made in accordance with the selection of glasses used in the fiber part 24 and face part 22 so that said solder glass will have a melting temperature of approximately 25° F. to 50° F. below that of the glass of said parts 24 and 22 which have the lowest softening temperature.

Another desirable type of so-called solder glass might consist of a controllably devitrifiable glass which, upon heating, will change in character from a vitreous to a mixed vitreous and crystalline condition. This would be initially in pulverized form as vitreous material mixed with an organic binder such as amyl acetate or ethyl acetate or the like to the consistency of a paste. A commercially available solder glass material of the above character is known as Pyroceram.

With the latter type of solder glass in paste form, a thin layer thereof (as thin as possible, preferably within the neighborhood of .1 of a millimeter) is applied to the "acid-polished" edge 46 of the push-through opening 44 and the fiber section 24 is seated thereupon as shown in FIG. 3. The assembly is then heated to a temperature sufficient to produce the desired glass-fused seal between the fiber section and face part 22 and, at this time, the above-mentioned organic binder is burned away.

The heating is accomplished preferably with a furnace generally of the character shown diagrammatically in FIG. 8 and which embodies top, bottom and side electrical heating elements 60 preferably individually controlled or operated in pairs through a conventional heat control device 61 which functions to increase or decrease the heat in the elements 60. Heat-sensing thermocouples or the like 62 adjacent the elements 60 are operatively coupled to the control device 61 to provide an indication of the temperature produced by their respective adjacent elements and one of said thermocouples is positioned adjacent the glass assembly to give an indication of its temperature. The heat control device 61 and heating elements 60 are conventional and are arranged and operated in conventional fashion to produce a desired controlled uniform heat throughout the area of joinder between the fiber part 24 and face part 22.

The fusion of the parts 24 and 22 is accomplished by applying gradually increasing controlled heat thereto by operation of the heating elements 60.

When the parts 24 and 22 reach a temperature of approximately 1050° F. (for glasses of the above-mentioned character) or within the range of from 700° F. to 1100° F., the devitrifiable solder glass 58 will have become substantially completely converted to its final semi-crystallized form and a rigid vacuum-tight joinder between the parts 24 and 22 will result. The temperature is then gradually lowered to approximately 825° F. where it is held for a period of approximately two hours or from two to ten or more hours to fully anneal the glass of the part 16 and cladding glass of the fiber elements 26 which glasses are initially chosen to be substantially identical in character. A minimum of two hours is usually considered to be needed for proper annealing.

After the above annealing period, the temperature in the furnace, adjacent the fused joinder is dropped to

approximately 690° F. or to within a range of from 500° F. to 750° F. and held there for approximately two hours or from two hours to ten or more hours to fully anneal the solder glass 58 and core glass of the fiber elements 26. Again, a minimum of two hours is usually considered sufficient for this annealing cycle.

Following the two annealing periods, the temperature in the furnace is lowered to completely cool the resultant fused structure which, at this time has a hermetically sealed fused jointer between its parts formed of the solder glass 58 as shown in FIG. 3.

In referring now to the use of the first-mentioned type of solder glass, the same procedure would be followed using substantially the same temperatures and time cycles. The result, however, would be that the high lead content solder glass, not being devitrifiable, would not crystallize but would retain its vitreous character.

In taking advantage of this fact, an alternate method of making the glass-fused connection between the fiber part 24 and the face part 22 would be to mix the high lead content solder glass into paste form with an organic binder of the above-mentioned type and apply a thin film thereof (approximately .1 millimeter in thickness) to the edge 46 of the push-through opening 44. Then, in order to "tin" said edge 46 with the solder glass, the envelope part 36 is placed in the furnace (FIG. 8) without the fiber part 24 and heated to approximately 1000° F. or within the range of from 850° F. to 1100° F. This will melt the solder glass and cause it to fuse securely to the edge 46. The part 46 is then annealed in the manner mentioned above at approximately 825° F. for approximately two hours and thereafter cooled to receive the fiber part 24.

With the fiber part next placed upon the "tinned" edge 46, the temperature is again raised to approximately 1000° F. to remelt the solder glass and fuse the same to the fiber part 24 thereby forming the secure fused connection shown in FIG. 3. The resultant fused assembly is then annealed and cooled by following the above-outlined procedure relating to the devitrifiable solder glass composition.

In FIG. 12, a similar fused jointer between a fiber section 28 and glass tube envelope 64 is made with solder glass 66, which, in addition to being placed between the adjoining parts, is also placed against the outer edge of the fiber section 28 and an adjacent protruding portion of the edge 68 to form a more rigid jointer. This is accomplished by forming the fiber section of a slightly smaller outer contour size than that of the outer size of the edge 68 of the push-through opening 70 so as to provide an exposed ledge 72 therearound when the assembly is made.

FIGS. 9 and 10 illustrate a further modification of the invention wherein the enlarged forward portion 76 of a tube envelope is provided with a cut-in or abraded opening 78 over which a fiber section or part 30 is to be placed and glass sealed as shown more clearly in FIG. 10.

The opening 78, being formed by abrading tools or the like, will inherently bear the usual incipient cracks such as illustrated diagrammatically in FIG. 4 which, in accordance with this invention, are "acid-polished," preferably as shown in FIG. 7 by dipping the end of the envelope portion 76 having the opening 78 therein into an acid bath 56 of the type previously described above.

After having so treated the edges of the abraded opening 78 to remove incipient cracks, the fiber section 30 is glass-fused thereto with the above-mentioned high lead content solder glass either directly or by first "tinning" the area of the portion of the face 80 over which the fiber part 30 is to be seated. The solder glass, in paste form, is painted over this area as illustrated by the reference numeral 81 and "tinning" or direct soldering is accomplished through the use of temperatures and time cycles such as outlined hereinabove.

It should be understood that the previously-described

devitrifiable solder glass may be used if desired by practicing the same process of application and heating as described hereinabove with relation to the structures of FIGS. 1, 2 and 3.

As referred to herein, the term "solder glass" is intended to include all glass or glass compositions having softening ranges approximately within the range of 25° F. to 100° F. below the temperatures which would normally render the other glasses of the parts 24 and 22 appreciably distortable.

A still further modification of the invention is shown in FIG. 11 wherein an enlarged circular fiber section 32 is shown as applied to a cathode ray tube envelope 82 having a generally circular cross-sectional shape. The fiber section 32 embodying the coated fibers 26c is applied to the envelopes 82 by means of a solder glass and in a manner identical to that described hereinabove with relation to the other arrangements of FIGS. 1, 3 and 10. Tube envelope shapes are obviously no limiting factor in sealing a fiber part over an opening previously provided in their face portions in accordance with the teachings of this invention. By glass-sealing the fiber face part in outwardly projecting overlying relation with the particular opening through the envelope face section, it can be seen that the exposed side of the fiber part can be subsequently abraded, polished and/or otherwise finished to any desired shape and/or surface texture or minimum thickness without engaging or encountering interference from the adjoining tube envelope parts.

It is pointed out that the fiber sections 24, 30 or 32, after having been glass-sealed to the tube envelope face parts, would normally be provided with an inner coating or layer 84 of phosphorescent material, as shown in FIG. 10, in instances where the particular arrangement of the envelope and fiber section is to be used as the image-producing and transmitting section of a cathode ray tube. For other applications of use, however, photosensitive coatings either of the photo-emissive or photoconductive type might be used in place of the coating 84 and it should be understood that a coating such as 84 may be applied to the outer or opposite surfaces of the sections 24, 30 or 32 for special applications with or without the inner coating 84 which is shown in FIG. 10. Also, multi-layer coatings of materials having similar or different characteristics may be used.

It will be seen from the foregoing that simple, efficient and economical means and method have been provided for accomplishing all of the objects and advantages of the invention as expressed in the accompanying claims and the invention is not to be limited to the exact matters shown and described as only the preferred matters have been given by way of illustration.

Having described my invention, I claim:

1. The method of connecting a first member of glass to a second member of glass having one of its surfaces abraded to a precontrolled shape, said method comprising etching said abraded surfaces of said second member to a depth such as to remove sharp irregularities of cracks, caused by the abrasion thereof, placing said members one upon the other with a solder glass disposed between said members throughout areas thereof to be connected, said solder glass being characterized in that its melting temperature is below that of the glasses of said first and second members and heating said glass members and solder glass to a temperature sufficient to render said solder glass fusible to said members.

2. The method of glass-sealing a first member of glass to a second member of glass having a ground portion intended to be joined to said first member comprising etching said ground portion to a depth such as to substantially completely remove sharp irregularities of cracks caused by the grinding of said portion, placing a granulated relatively high lead-containing vitreous glass material upon one of said members throughout areas thereof to be joined to the other of said members, said vitreous

glass material having a softening temperature below that of the glasses of said members, placing said other member upon said vitreous glass material with said vitreous glass material being disposed between said first member and said etched portion of said second member and heating said glass members and vitreous glass material to a temperature such as to render said vitreous glass material fusible to said glass members without introducing appreciable distortion of said members.

3. The method of glass-sealing a first glass member to a second glass member having an abraded portion intended to be joined to said first member comprising etching said abraded portion to a depth such as to substantially completely remove sharp irregularities of cracks caused by the abrasion of said portion, placing a pulverized devitrifiable glass material initially in a vitreous state upon one of said members throughout areas thereof to be joined to the other of said members, said devitrifiable glass material being so characterized as to become devitrified and fusible to said members at a temperature below that which would render said parts appreciably distortable, placing said other member on said devitrifiable glass material with said material being disposed between said first member and said etched portion of said second member and heating said members and glass material to a temperature sufficient to bring about devitrification and fusion of said glass material to said members without causing appreciable distortion of said members.

4. The method of glass-sealing one glass member to another glass member having an abraded portion to which said first-mentioned member is to be joined comprising acid etching said abraded portion to a depth sufficient to remove sharp irregularities of cracks caused by the abrading of said portion, placing upon the portion of a first of said members which is to be joined to the second of said members a glass material characterized to have a melting temperature below that of the glasses of said members, heating said first member and glass material to a temperature sufficient to melt and fuse said glass material to said first member without causing appreciable distortion of said first member, reducing the temperature of said first member and glass material sufficiently to at least solidify said glass material, placing said second member upon said solidified glass material and reheating said glass material sufficiently to render the same fusible to said second member without causing appreciable distortion of said first and second members.

5. The method of forming an integral glass structure embodying a member formed of fused glass fiber elements and a glass envelope comprising forming an opening extending through said envelope, abrading the edge portions of said opening to a desired shape, acid etching said abraded portions to a depth sufficient to remove sharp irregularities of cracks resulting from said abrading, placing a relatively thin layer of a glass material characterized in that its melting temperature is below that of the materials of said member and envelope upon the portion of said envelope to which said member is to be attached, seating said member upon said glass material and heating the resultant assembly to a temperature such as to cause said glass material to melt and fuse to the adjoining areas of said member and envelope.

6. The method of forming an integral glass structure embodying a first glass member formed of fused glass fiber elements and a second solid glass member in the form of an electron tube envelope comprising forming an opening extending through said second glass member, abrading the edge portions of said opening to a desired shape, acid etching said abraded portions to a depth sufficient to remove sharp irregularities of cracks resulting from said abrading, placing a relatively thin layer of a glass material characterized to have a melting temperature below that of the materials of said first and second members upon the portion of said second member to

which said first member is to be attached, heating said second member to a temperature sufficient to melt and fuse said glass material to said second member without appreciably distorting said second member, cooling said heated second member to solidify said glass material, seating said first member upon said solidified glass material and heating the resultant assembly to a temperature sufficient to remelt said glass material and fuse the same to said first member without appreciably distorting said members.

7. The method of forming an integral glass structure embodying a glass member constructed of fused glass fiber elements and a solid glass envelope comprising forming an opening in a portion of said envelope with the edge of said opening being directed outwardly therefrom, abrading said outwardly directed edge substantially flat, acid etching said edge to a depth sufficient to remove existing sharp irregularities of cracks resulting from said abrading, applying to said etched edge a layer of glass material characterized to have a lower melting temperature than that of the materials of said member and envelope, seating said member upon said glass material in overlying relation with said etched edge and heating the resultant assembly to a temperature sufficient to melt and fuse said glass material to said member and etched edge of said envelope without causing appreciable distortion of said member and envelope.

8. The method of forming an integral glass structure embodying a first glass part constructed of fused glass fiber elements and a second part in the form of a solid glass envelope comprising cutting an opening through an end of said second part, grinding the edge of said opening to a desired peripheral contour shape and size, acid etching said ground edge to a depth sufficient to remove existing sharp irregularities of cracks resulting from said grinding, applying a layer of glass material characterized to have a lower melting temperature than that of the materials of said first and second parts to the area of a side of one of said parts which is to be joined to the other of said parts, placing said parts together with said first part in overlying relation with said glass material and heating the resultant assembly to a temperature sufficient to melt and fuse said glass material to said first and second parts without introducing appreciable distortion therein.

9. The method of forming a fused glass structure embodying a first glass part constructed of a plurality of glass fiber-like elements fused in side-by-side relation with each other, and a second solid glass part comprising forming a press-through opening in said second glass part with the edges thereof directed outwardly and away from a side of said part, abrading said edges substantially flat, acid-polishing said abraded edges to a depth such as to remove sharp irregularities of cracks resulting from said abrading, applying a layer of glass material characterized to have a lower melting temperature than that of the materials of said first and second parts between the portions thereof to be joined, and with said first part in overlying relation with said opening and heating the resultant assembly to a temperature sufficient to melt and fuse said glass material to said first and second parts.

10. The method of forming a fused glass structure embodying a first glass member constructed of a plurality of fused glass fiber-like elements which is glass-sealed to a second solid glass member comprising cutting an opening through said second member, abrading the edges of said opening to a desired peripheral contour shape and size, acid etching said abraded edges to a depth such as to remove existing sharp irregularities of cracks resulting from said abrading, applying a layer of glass material characterized to have a lower melting temperature than that of the materials of said first and second members upon the portion of one side of one of said members which is to be attached to the other of said members, placing said members together with said glass material therebetween and with the first of said members over-

11

lying the opening in said second member and heating the resultant assembly to a temperature sufficient to melt and fuse said glass material to said first and second members.

References Cited by the Examiner

UNITED STATES PATENTS

2,264,183	11/41	Nash	65—41
2,275,602	3/42	Beck et al.	156—24 X
2,347,614	4/44	Rudolph	65—47
2,398,708	4/46	Hendrix	156—24 X
2,781,820	2/57	Rogers	161—43

5

10

12

2,794,756	6/57	Leverenz	161—43
2,799,123	7/57	Van Steenis	65—47
2,907,626	10/59	Eisen et al.	65—3
2,919,970	1/60	Russell	65—3
2,979,632	4/61	MacNeille.	
2,992,956	7/61	Bazinet	65—4 X

DONALL H. SYLVESTER, *Primary Examiner.*

ARTHUR P. KENT, EARL M. BERGERT, WILLIAM B. KNIGHT, *Examiners.*