

1043.552



PATENT SPECIFICATION

DRAWINGS ATTACHED

1043.552

Date of Application and filing Complete Specification: March 19, 1963.

No. 10729/63.

Application made in United States of America (No. 180490) on March 19, 1962.

Application made in United States of America (No. 225448) on Sept. 24, 1962.

Application made in United States of America (No. 210117) on July 16, 1962.

Complete Specification Published: Sept. 21, 1966.

© Crown Copyright 1966.

Index at acceptance: —H1 D(4A4, 4A7, 4K4, 4X1, 9A, 9CX, 9CY, 9Y, 34)

Int. Cl.: —H 01 j 29/88

COMPLETE SPECIFICATION

Improvements in or relating to Implosion-Resistant Cathode-Ray Tube Envelopes

We, OWENS-ILLINOIS, INC., (formerly known as Owens-Illinois Glass Company), a Corporation of Ohio, United States of America, of Toledo, Ohio, United States of America, (Assignee of DARYL EUGENE POWELL and BURTON WELLS SPEARS), do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention primarily relates to television and more particularly to the control and prevention of fracture and implosive-explosive effects in sealed and vacuumized cathode-ray image tubes for television reception. The invention more specifically relates to improved types of direct-viewing cathode-ray image tubes as well as other vacuumized tubes having glass envelopes and methods of fabricating such tubes to eliminate breakage and to control devacuation thereof upon accidental or spontaneous breakage either in processing, shipping, installation, or while in service.

In the manufacture of television picture tubes having essentially all-glass envelopes, each tube is evacuated to a high degree of vacuum with the resultant effect of creating high external pressures over extensive surface areas of the tube. Relative dimensions of these vacuumized tubes are such that substantial surface pressures are exerted on the glass sidewalls and particularly on viewing and sealed portions. In a vacuumized 27 diagonal inch rectangular picture tube, the viewing area alone presents a surface area of about 400 sq. in. so that the atmospheric loading places a total pressure of approximately 5800 pounds on the tube viewing portion. Such pressures cause a vacuumized tube

to be highly subject to implosive-explosive effects upon fracture or breakage of the envelope and sudden uncontrolled devacuation thereof. Therefore, the tube envelope and its various sealed areas must be designed to withstand such high pressures with a proper degree of safety without damage or breakage during processing, shipment and installation, as well as during long-term service.

Conventional television picture tube envelopes are subjected to variation in internal-external pressure conditions during initial fabrication of the tube and during reprocessing of certain tubes found to contain malfunctions. Varying the pressure differential during evacuation, devacuation and re-evacuation, for example, may introduce excessive stresses into the tube envelope, particularly at their areas of maximum cross-sectional dimensions as well as in the primary seal area, such as where hollow funnel and face plate members are circumferentially joined either by direct fusion or by an annular band of low-melting sealing composition. Tensile stresses can and do occur in exterior surface portions of major cross-sectional dimensions of the envelope such as at or adjacent the seal line. Such stresses present localized areas subject to damage such as by scratches or abrasion.

Heretofore, in the installation of television picture tubes in various types of receivers, a light-transmitting implosion plate usually consisting of a tempered glass panel is mounted in adjacent spaced relation fully coextensive with the tube viewing portion. Alternatively, a contoured implosion plate is bonded to the tube viewing area as an integral component part of the tube to resist implosion-

explosion effects. However, in both types of tube construction and mounting, whether the tube be un laminated with a separable protection panel or laminated with an implosion plate integrally mounted thereon, the tubes may still be subject to destructive implosion either spontaneously or by thermal or physical shock.

In such implosions the glass of the envelope funnel sidewise may break violently in such manner as to destroy component parts of the receiver by fragments being projected forcefully in random directions. The implosion panel serves to restrain glass fragmentation in a forward direction as well as to absorb front impacts delivered to the tube viewing portion. However, in all cases either the separate or integral implosion plate adds substantially to the cost of the tube *per se* or its mounting in a receiver cabinet. Further, the implosion plate having substantial dimensions and wall thickness adds to the over-all weight and dimensions of the receiver, and in combination with the tube face plate, must provide proper light-transmitting characteristics while protecting viewing areas of the tube against implosion.

Obviously, in conventional types of essentially all-glass cathode-ray picture tubes for television reception, only the viewing area has been previously protected against implosion when the tube is properly installed. The body portion of the tube remains subject to damage either in processing, installation or when the receiver is serviced. The front implosion panel does not serve in any way to minimize or prevent damage to the tube body portion but merely deleterious effects in a forward direction. The implosion panel must have light-transmitting properties of near-optical clarity and no visual defects can be tolerated in either this member or the tube face plate. Near-optical perfection and strength requirements in these several members necessitate special precautions in their fabrication and handling. The present invention obviates the need for the conventional twin-panel system and matching of these component parts.

Accordingly, it is an object of the present invention to provide a direct-viewing cathode-ray tube envelope which is resistant to both fracture and sudden evacuation without serious fragmentation under widely varying adverse conditions.

Another object of this invention is to provide a method of making a glass cathode-ray television picture tube envelope which is more resistant to fracture and implosive-explosive effects on breakage of a tube envelope having substantial dimensions than hitherto, whereby upon breakage the envelope is permitted to controllably devacuate without deleterious fragmentation of its side-walls.

According to the present invention, an implosion-resistant cathode-ray tube envelope comprises a funnel-shaped hollow body portion peripherally joined along the rim of its larger end to a face portion which encloses the larger end of said envelope, said face portion having a transverse light transmitting viewing screen curvingly merging in a transitional zone around its outer periphery with a rearwardly projecting annular flange region which joins said body portion along a circumferential seal line and forms a sidewall region of substantially maximum cross-sectional dimensions of said envelope, a discontinuous, thin, annular reinforcing band of high strength material complementally contoured to snugly conform to said sidewall and closely fitting around the periphery of said flange region closely adjacent said viewing screen, and a thin film of high strength adhesive material between said band and said sidewall strongly adhering said band in tight conformity with said envelope sidewall, with essentially no space therebetween and the inner circumference of said band being essentially the same as the outer circumference of the tube at the point of installation, said band and said adhesive having sufficient yield strength to prevent fracture propagation through the envelope sidewall therebeneath upon breakage of said envelope.

Also according to the present invention, an implosion-resistant cathode-ray tube envelope comprises a funnel-shaped hollow body portion peripherally joined along the rim of its larger end to a face portion which encloses the rim of its larger end to a face portion which encloses the larger end of said envelope, said face portion having a transverse light transmitting viewing screen curvingly merging in a transitional zone around its outer periphery with a rearwardly projecting annular flange region which joins said body portion along a circumferential seal line and forms a sidewall region of maximum cross-sectional dimensions of said envelope, an annular layer of rupture-resistant high-tensile strength material adhered to extensive non-viewing exterior surfaces, of said body portion, a discontinuous thin, annular reinforcing band of high strength material complementally contoured to snugly conform to said side wall and closely fitting around the periphery of said flange region closely adjacent said viewing screen, a tension band overlying at least an annular portion of said reinforcing band to press said band into intimate and closely conforming relation with said envelope sidewall and also overlying at least an annular circumferential zone on said layer of rupture-resistant material wholly to engage and restrain at least said circumferential zone of said layer of rupture-resistant material, and a thin film of high strength adhesive material between said band and said sidewall

strongly adhering said band in tight conformity with said envelope sidewall with essentially no space therebetween and the inner circumference of said reinforcing band being

essentially the same as the outer circumference of the tube at the point of installation, said reinforcing band and said adhesive having sufficient yield strength to prevent fracture propagation through the envelope sidewall therebeneath upon breakage of said envelope.

Also according to the present invention an implosion-resistant cathode-ray tube envelope comprises a funnel-shaped hollow body portion peripherally joined along the rim of its larger end to a face portion which encloses the larger end of said envelope, said face portion having a transverse light transmitting viewing screen curvingly merging in a transitional zone around its outer periphery with a rearwardly projecting annular flange region which joins said body portion along a circumferential seal line and forms a sidewall region of substantially maximum cross-sectional dimensions of said envelope, a discontinuous, thin, annular reinforcing band of high strength material complementally contoured to snugly conform to said sidewall and closely fitting around the periphery of said flange region closely adjacent said viewing screen, said reinforcing band being located forwardly of said seal line, and a thin film of high strength adhesive material between said band and said sidewall strongly adhering said band in tight conformity with said envelope sidewall with essentially no space therebetween and the inner circumference of said band being essentially the same as the outer circumference of the tube at the point of installation, said band and said adhesive having sufficient yield strength to prevent fracture propagation through the envelope sidewall therebeneath upon breakage of said envelope.

Furthermore, according to the present invention there is provided a method of fabricating an implosion-resistant cathode-ray tube envelope from a bulb having a funnel-shaped hollow body portion peripherally joined along the rim of its large end to a face portion which encloses the larger end of said envelope, said face portion having a transverse light transmitting viewing screen which curvingly merges in a transitional zone around its outer periphery with a rearwardly projecting annular flange region which joins said body portion along a circumferential seal line and forms a sidewall region of substantially maximum cross-sectional dimensions of said envelope, which comprises disposing a discontinuous, thin annular reinforcing band of high strength material around the periphery of said envelope sidewall to have the front portion closely adjacent said viewing screen with a film of high strength adhesive material between said band and

sidewall, said band being contoured to have its inner surface complemental to that of the underlying sidewall region, pressing said band in an untensioned condition into snug conformity with and peripherally encompassing said sidewall to leave on substantial space between said band and sidewall such that the inner circumference of said band and the outer circumference of said tube are essentially the same at the point of installation, and setting said adhesive to establish a strong bond between said band and sidewall with said band and adhesive having sufficient yield strength to prevent fracture propagation through the sidewall region beneath said band upon breakage of said envelope.

The invention will now be further described by way of examples with reference to the accompanying drawings, in which:—

Fig. 1 is a perspective view of a cathode-ray television picture tube fabricated in accordance with one embodiment of the present invention;

Fig. 2 is an enlarged fragmentary vertical sectional view of one portion of the tube envelope taken along the line 2—2 of Fig. 1;

Fig. 3 is a view similar to Fig. 2 illustrating a modification of the invention shown in Figs. 1 and 2;

Fig. 4 is a view similar to Figs. 2 and 3 illustrating another modification of the invention;

Fig. 5 is a perspective view illustrating another embodiment of the present invention;

Fig. 6 is an enlarged fragmentary vertical sectional view of one portion of the tube envelope taken along the line 6—6 of Figs. 5;

Fig. 7 is a view similar to Fig. 6 showing another modification of the invention;

Fig. 8 is a perspective view of another embodiment of the present invention wherein additional major exterior surfaces of the envelope body portion are covered with reinforcing elements;

Fig. 9 is an enlarged fragmentary vertical sectional view taken along the line 9—9 of Fig. 8;

Fig. 10 is a view similar to Fig. 9 showing still another modification of the invention;

Fig. 11 is an exploded view illustrating the individual components utilized to form the tube shown in Figs. 8 and 9;

Fig. 12 is a view similar to Figs. 9 and 10 showing another modification of the invention;

Fig. 13 is a view similar to Figs. 9 and 10 illustrating still another modification of the invention;

Fig. 14 is an enlarged fragmentary view of the circled portion of Fig. 13;

Figs. 15, 16, 17, 18 and 19 are views

similar to Figs. 3 and 4 illustrating further modifications of the invention; and

5 Fig. 20 is a schematic drawing of one method of fabricating the tube illustrated in Figs. 8, 9, and 11.

Similar reference numerals used in the various embodiments indicate similar parts or substantially similar parts.

10 The present invention is described hereinbelow as specifically applied to the manufacture of a hollow glass television cathode-ray image tube. However, it will be apparent to those skilled in the art that the invention is equally applicable to the manufacture of many
15 different types of glass envelopes particularly those having substantial dimensions which are subject to implosion and concomitant explosion on sudden devacuation.

20 The term "devacuation" as used herein is intended to mean the converse of evacuation as in the case where a vacuumized vessel experiences an internal pressure change toward atmospheric pressure upon loss of vacuum. The rate of change may occur rapidly or
25 over a prolonged period of time.

The term "cave-in" as used herein is intended to mean breakage of the envelope viewing area wherein about 90% or more of the sidewalls of the face plate viewing area cave
30 inwardly upon breakage of the tube envelope, the glass comprising the viewing area being retained partially internally and being partially expelled forwardly in random directions.

35 It has been known to minimize the implosion effects of tubes by tightening an annular tension band around the exterior of the tube envelope around its seal line area, the band applying compressive stresses to the exterior surface portions of the tube sidewalls
40 adjacent and underlying the band. Picture tubes having such a tension band are capable of resisting implosion to some degree; however, such tubes are not intended to be direct-viewing or utilized without an implosion
45 plate or panel. Such tubes are fully capable of minimizing implosion-explosion effects caused by certain types of external forces such as those of lesser severity; however, they do not provide the same degree of
50 fracture resistance to major non-viewing surfaces of the tube nor the prevention and containment of implosion effects caused by virtually all forms of breakage regardless of character such as achievable by the present
55 invention.

60 The present invention provides an implosion-resistant system which is capable of being incorporated into existing types and shapes of conventional cathode-ray picture tubes without serious alteration or modification of present tube fabricating procedures. The invention may be incorporated in any selected type of tube envelope to provide a required level of reinforcement using materials and

65 methods which are capable of supplementing normal tube production.

The invention involves the application of reinforcing elements including at least one annular band firmly adhered to the non-viewing
70 perimetrical region of the tube face plate surrounding its exterior surfaces of substantially maximum exterior cross-sectional dimensions. The band is applied at a region closely adjacent the periphery of the viewing
75 panel and preferably substantially forward of its seal line area. Either a single annular band or a plurality of annular bands is placed around the tube envelope surrounding and encompassing the aforesaid perimetrical region wherein the selected bands are mounted substantially
80 forwardly of the tube seal line. An annular layer of bonding material comprised of organic or inorganic adhesive materials fills the space intermediate at least the next adjacent annular band and exterior glass surfaces
85 therebeneath. The one or more annular bands which are disposed around the perimetrical region have proper physical characteristics such as high-tensile strength and a contoured configuration to provide sufficient yield
90 strength to maintain the surrounded perimetrical region of glass sidewalls essentially intact upon breakage of remaining sidewalls of the envelope. As stated supra, a single circumferential annular band can be employed
95 to perform the functions of the several individual bands as desired or required. Also an enveloping covering of high-tensile strength rupture-resistant material such as glass fibre cloth may be adhered to major non-viewing
100 external surfaces of the tube body portion extending substantially between its larger and smaller ends in a virtually continuous annular pattern.

105 In one embodiment of the present invention, as shown in Fig. 1, a glass cathode-ray picture tube envelope 10 is normally comprised of a funnel member 11, face plate 12, and neck tubulation 13 which are joined to form a unitary hollow glass article. Such hollow glass article is normally referred to as
110 a bulb prior to the introduction of various screen and conductive coatings applied interiorly of the envelope and installation of an electron beam-emitting gun. The terminating end of neck 13 is normally sealed by one or more electron-beam emitting guns 14 retained by an end cap member. Body or funnel member 11 is usually funnel-shaped being
115 either frusto-conical or frusto-pyramidal in contour with its small end 11a sealed to neck 13 and its large end 11b sealed to face plate 12. Electron-beam deflecting coils (not shown) are normally mounted exteriorly at the yoke area where neck 13 and funnel small
120 end 11a are joined to provide proper electron beam deflection and scanning of the tube screen.

The face portion 12, commonly known as

the face plate, consists of a light transmitting concave-convex or curvilinear viewing screen 12a (Fig. 2) which moves rearwardly along its outer periphery to merge into a rearwardly projecting cylindrical flange 12b. Face plate flange 12b and large end 11b of the funnel member comprise annular sidewalls of the envelope extending generally parallel to the tube axis and both terminate in annular sealing surfaces of generally complementary contour. As shown in Figs. 1 and 2 the sealing surfaces are joined at a seal line 15 either by direct fusion of the glass as illustrated or by an interposed annular layer of solidified low-melting glass sealing composition which is selected as being compatible with the thermal and physical characteristics of the parent glass parts. The peripheral shape of viewing screen 12a may be either circular or rectangular in plan as conventionally known in the art with the sealing surfaces being substantially planar for forming a vacuum-type durable joint. The present invention is particularly applicable to all conventional types of cathode-ray tube envelopes regardless of their contours and dimensions having sufficient strength and durability to permit retention of a high level vacuum of the order of 10^{-5} mm. of mercury.

Both completed picture tubes and envelopes fabricated in accordance with the present invention have been devacuated by various test procedures including those most frequently used by Underwriters' Laboratories. These procedures include standard test face impacts with a 1-1/4 pound steel ball striking at various impact levels, the thermal shock method and guillotine method.

Impact tests consist of striking various pre-selected regions of the tube viewing area with wide-varying levels of force expressed in terms of foot-pounds ranging from 5 to 40 foot-pounds. In the impact tests the tube is stationarily mounted in horizontal relation in a conventional receiver cabinet with its viewing area exposed.

In the thermal shock or hot-rod method, a 1/4 in glass rod is heated at its end until this portion is in molten condition. A diamond point is used to form an inscribed cross at the edge of the optical area of the face plate at the twelve o'clock position. The end of the glass rod in heated molten condition is applied to the centre of the inscribed cross by physical content. If breakage of the envelope does not occur within a few seconds, as by cracks radiating along the inscribed lines, the rod is removed and cold water is applied exteriorly to the area to obtain a further thermal shock.

In the guillotine test a one inch diameter steel pin is mounted immediately behind the seal line of the tube which is mounted in a horizontal plane. The pin is disposed with its axis in a vertical plane and travel of the

pin is limited to about 1/8 to 1/4 inch. The pin is then impacted downwardly with a force of fifty (50) foot pounds to strike the envelope in its seal line region.

The present invention consists of applying selected reinforcing elements to exterior non-viewing surfaces of the tube envelope either after the tube is fully fabricated or prior to subjecting the envelope or bulb to a tube fabricating process. In the former case, the tube is fully completed and assembled with all its required internal and external electrical working components properly installed in operative alignment and after its subjection to bake-out temperatures and evacuation. In the latter case, the tube envelope consists of a so-called glass bulb having none of its internal electrical working components installed. The envelope or bulb is subjected to the application of the required elements in accordance with this invention with ambient conditions existing both internally and externally thereof. The bulb, after being fabricated into a form where its devacuation is controllable, is then subjected to a tube fabricating process. However, in this case the components of the present implosion-resistant system must be capable of withstanding required bake-out cycling temperatures and pressures of the tube-making process.

A completed cathode-ray picture tube capable of recreating transmitted electronic images is taken for reinforcement of its essentially all-glass envelope as shown in Figs. 1 and 2. The non-viewing annular skirt region or cylindrical flange 12b of the face plate 12 is coated over a major portion of its exterior surfaces closely adjacent viewing screen 12a with a continuous annular layer of bonding material. The bonding material consists of either synthetic resinous material such as epoxy resin, or polyester resin or other bonding material such as silicon-containing solder glasses having relatively low-melting temperatures. An enveloping annular band 21 is mounted around annular layer 20 and face plate skirt portion or cylindrical flange 12b disposed either entirely or substantially forward of the bulb seal line 15 and parallel thereto. Band 21 is mounted to surround a region of substantially maximum exterior dimensions of the envelope with its medial region coincidental with the mold match line 12c of the face flange 12b. Although not necessary, the annular band 21 is preferably placed in tension by drawing its ends together by an air-operated wrench, for example, and applying a crimped clip member 22 to its end to maintain the band in permanent tension. Annular reinforcing band 21 consists of a flexible strap of metallic material such as annealed steel strapping having a substantially uniform cross-sectional configuration. If tensioned, the band tension for a 23 inch tube ranges from 1200 to 1600 pounds ten-

sion. Good adherence of layer 20 to juxtaposed glass and metal surfaces is important. Layer 20 can be applied to range in thickness from .001 to .020 inch although it may not be detrimental for the layer to be thicker in certain applications.

A preferred bonding material consists of Union Carbide Epoxy Resin, EBLA No. 2875, the resin being a thixotropic paste having a relatively high viscosity when previously mixed with two parts Union Carbide Hardener No. ZBLA 0655 per one part of resin. The subject resin is a viscous resin system manufactured by Union Carbide Company for sealing glass-to-metal surfaces. This resin is comprised of liquid epoxide resin which can be cross-linked by a liquid hardener into a thermoset, tough, rupture-resistant solid having excellent dimensional stability and strength. The prescribed resin system has an elongation at rupture of 30 per cent, a tensile strength of 1300 psi and will cure at room temperature in 1/2 to 1 hour. The reacted resin system forms a stable firmly adhesive permanent bond between glass and metal surfaces. Thus the opposing exterior surfaces of face plate flange 12b and annular band 21 are united into an integral unitary structure. Other liquid resins such as Dow Epoxy Resin No. 741-A utilized with suitable hardeners and curing agents can also be employed. This epoxy resin consists of a thermosetting synthetic resin having the ability to bond chemically to the glass and metal surfaces upon reaction, the final coating having some resiliency, considerable strength and rupture-resistance against sudden loading in tension. Other organic and inorganic bonding agents are similarly utilizable to coat further annular external surfaces of the face plate flange just beyond the viewing area, the coating having a slightly greater width than annular band 21.

The embodiment illustrated in Figs. 1 and 2, wherein the band is tensioned, is fully capable of resisting face impacts of the order of 5 to 10 foot-pounds in virtually all cases where properly applied, and passing the thermal shock test. However, this construction will only occasionally pass the guillotine test when applied just behind the band. Face impacts of the order of 15 foot-pounds sometimes will produce cave-in of the envelope face plate, although the single cemented band maintained in tension is capable of resisting external impacts of lesser severity wherever applied. The results provided by this construction, however, are vastly superior to a construction wherein the annular band is placed over the seal line region at the transition zone between face plate and funnel members.

In the embodiment of the invention shown in Fig. 3, a peripheral reinforcing rim band 23 preferably comprised of two similar U-

shaped half-sections is taken for joining to the face plate skirt area or flange 12b. Peripheral rim band 23 is contoured as at 23a to have internal surfaces which are closely complementary to the geometry of the external corner surfaces where face plate flange 12b and the periphery of viewing area 12a intersect. Reinforcing rim band 23 is comprised of a pair of symmetrical half-sections as stated, each being applicable to peripherally surrounding one-half of the face plate annular corner area. The pair of similar half-sections preferably overlap in telescoping arrangement on opposing sides of a rectangular face plate such as on its short axis sides as shown in Fig. 5. An annular layer 22 of bonding material such as epoxy resin is interposed between the juxtaposed surfaces of the untensioned rim band 23 and the exterior surfaces of face plate flange portion 12b, preferably being applied to the inner surface of the rim band before being applied to the tube. Annular layer 22 is capable of bonding the rim band into an integral structure with the exterior glass surfaces so that band 23 surrounds both the intersecting corner region of the face plate and the mold match line 12c of essentially maximum exterior dimensions. Band 23 has an arcuate contour on both the long and short axis sides of the curvilinear face plate to contour precisely to the non-viewing periphery of viewing panel 12a. Rim band 23 has a relative cross-sectional width capable of extending longitudinally throughout the frontal non-viewing area of the face plate surrounding its corner radius and encompassing the mold match line 12c.

With reinforcing elements applied around the tube exterior consisting of rim band 23 and intermediate layer 22 of bonding material as shown in Fig. 3, a 23 diagonal inch cathode-ray tube envelope is capable of resisting impacts of 7-1/2 foot-pounds delivered anywhere over the tube face. The tubes so protected are fully capable of controlled devacuation on breakage of the tube envelope at minimal or low-impact loads. However, in the case of high-impact loads of the order of 15 foot-pounds or greater, excessive glass throw in a forward direction may occasionally occur. The prescribed structure is capable of controlling devacuation without deleterious effects on breakage due to impacts of lesser severity.

In the embodiment shown in Fig. 4 wherein rim band 25 has sufficient cross-sectional width to encompass and surround the entire face plate skirt 12b and seal line 15, slightly improved results are obtainable over the structure of Fig. 3. In this case the annular layer 24 of bonding material similarly extends entirely over the exterior surfaces of face plate flange 12b and seal line 15. Rim band 25 has an inwardly tuned lip portion 25a which closely

70

75

80

85

90

95

100

105

110

115

120

125

130

surrounds the intersecting corner region of the face plate flange and viewing panel portions. The band is preferably comprised of a pair of similar U-shaped half-sections as described above with reacted intermediate layer 24 of bonding material therebetween. Where rim band 25 is comprised of similar contoured metallic half-sections and the intermediate layer consists of reacted epoxy resin having a film thickness ranging from 0.001 to 0.020 inch or greater, a 23 diagonal inch picture tube envelope is capable of withstanding all impact tests below 15 foot-pounds as well as the thermal shock and guillotine tests. It has been observed that cave-ins will sometimes occur on impacts of the order of 15 foot-pounds or greater, although resistance to impact damage is greater than that provided by the construction shown in Fig. 3.

As shown in Figs. 5 and 6, combined rim and tension bands are applied around the skirt portion of the envelope face plate of an image tube designated by the numeral 10A. A reinforcing rim band 23 having a lesser axial extent than that shown in Fig. 3, although sufficiently great to encompass the corner region of the face plate flange 12b and mold match line 12c is adhered to the exterior glass surfaces by an annular layer 26 of suitable bonding material such as described hereinabove. The rim band consists of pressed sheet metal having two symmetrical U-shaped half-sections 23a and 23b which are capable of fully surrounding and encompassing the prescribed envelope corner region as shown in Figs. 5 and 6. The band has a cross-sectional thickness of about 0.020 inch, although it may range from 0.005 to 0.030 inch in thickness depending upon the thickness and properties of the prescribed bonding material. Rim band 23 extends peripherally over and around the major non-viewing exterior surfaces of the face plate rim portion at its frontal region with annular layer 26 of bonding material extending fully coextensively therewith. A second annular tension band or collar 21 with crimped clip member 22 is applied exteriorly over a rearward portion of rim band 23 in parallel relation transversely of the tube axis, the tension band or collar having an appreciable width and being disposed coincidently over the mold match line 12c. The rim band is overlapped to approximately one-half the width of the tension band or slightly greater with annular intermediate layer 26 of bonding material extending only coextensively with rim band 23. Thus, as shown in Fig. 6, the rim band 23 is integrally bonded to the glass exterior surfaces of the face plate flange. Tension band 21 is applied over the rim band and glass surfaces slightly rearwardly thereof but forward of the seal line 15 without the bonding material being applied therebeneath. With

the band applied intension of the order of 1200 to 1600 pounds tension, it has been found that in the case of 23 diagonal inch tube envelopes, cave-ins will sometimes occur on frontal impacts of the order of 15 foot-pounds delivered at corner regions of the face plate viewing panel. Otherwise, this structure is fracture-resistant and controls devacuation of all other face impacts delivered at the same level and below.

In the modification shown in Fig. 7 a construction similar to that shown in Fig. 6 is employed with the addition of a second annular layer 28 of bonding material being interposed between tension band 21 and adhered rim band 23 and rearward envelope surfaces therebeneath. The bonding material may be comprised of a synthetic resin containing adhesive epoxy resin similar to layer 26 with both bands 21 and 23 being fully cemented around the tube non-viewing funnel region. The construction shown in Fig. 7 provides further resistances to impact damage greater than that achieved by the construction shown in Fig. 6, wherein band 21 is similarly maintained in tension of the same magnitude.

A completed picture tube 10B as shown in Fig. 8 capable of recreating transmitted images is taken for further fabrication and reinforcement of its envelope in accordance with the following method. This method of processing the tube is schematically outlined in Fig. 20 of the drawings and Figs. 8, 9 and 11 illustrate various components of the envelope for controlling its devacuation in accordance with this prescribed embodiment.

Tube 10B is placed on a suitable conveyor with its face plate 12 facing downwardly, the tube axis being vertically disposed. The external surfaces of the envelope funnel 11 and face plate skirt or flange portion 12b are wiped clean or treated with a suitable solvent to ensure their cleanliness. A mask (not shown) is mounted around the viewing area 12a of the tube face plate to prevent bonding materials from being accidentally applied to the optical area. A peripheral band of masking tape is effectively applied to surround the viewing area or, alternatively, a reusable mask is utilized to surround the periphery of this area. After masking the periphery of the viewing area 12a the tube is moved into a spray chamber.

In the spray chamber the tube is placed on turntable or rotary jig. A cinch plug with a rubber cap or shield is snapped onto the exteriorly-facing anode button 16 which is normally mounted within an intermediate area of the funnel sidewall between its large and small ends. The yoke portion of a tube envelope at the small end 11a of the funnel member is also masked such as by a paper-board cylinder positioned over the tube neck with its lower end in contact with the glass surfaces. The tube is rotated and sprayed or

- brush-coated with a continuous enveloping coating 30 of synthetic resinous material such as epoxy or polyester resin. A preferred material consists of Union Carbide Resin No. 5 ERLA 2300, the resin having a relatively low-viscosity when previously mixed with two parts of Union Carbide Hardener No. ZZLA 0750 per one part of resin. The subject resin is an epoxy resin containing system 10 manufactured by Union Carbide Company developed for sealing glass-to-glass and glass-to-metal members. The epoxy system is comprised of liquid epoxide resin which can be cross-linked by a liquid hardener into a thermoset, tough, resilient solid having excellent 15 dimensional stability and strength. The reacted resin system forms stable adhesive somewhat flexible bond between glass fibres and the exterior glass surfaces of the funnel member. The prescribed resin has a viscosity of about 300 centipoises at 77° F., an elongation at rupture of 168 per cent and a tensile strength of 565 psi. Other resins such as Dow Epoxy Resin No. 741-A utilized with 25 suitable hardeners and curing agents can also be employed. Also inorganic bonding agents can be utilized to coat the major external surfaces of the funnel member.
- After the funnel is fully coated and while 30 the bonding material remains in liquid workable condition, a piece of glass fibre cloth 31 having a central opening 31a (Fig. 11) is placed downwardly over and around the tube neck portion. A second opening 31b is provided in an intermediate area of glass fibre 35 cloth 31 for its alignment with the masked anode button 16. The piece of glass fibre cloth or other high-tensile strength rupture-resistant material is pulled downwardly into final position and, alternatively, another supplemental portion of synthetic resin is sprayed 40 over the glass cloth to impregnate and fill its openings between individual strands and bundles of glass fibre.
- Upon removal of the tube from the spray 45 chamber the resin-impregnated glass cloth 31 is pulled further downwardly and outwardly to smoothly conform the same to the normally convex outwardly-flaring surfaces of the funnel member to adjacent the face plate flange. 50 The lower extremity of glass fibre cloth 31 is pulled down and pressed tightly against the glass surfaces either to or adjacent mold match line 12c of the face plate flange 12b. The anode button and neck masks are removed 55 from the tube. The epoxy resin-glass fibre coating applied to the tube funnel is then either permitted to cure in air or pass through a heating chamber in which the synthetic resin is thermally cured at an accelerated rate, 60 such as by heating to a temperature of up to 250° F. over a period of approximately 8 minutes.
- After curing the thermosetting synthetic 65 resin to chemically bond the glass fibre sheet to the funnel and optionally the face plate flange areas, the tube is placed on a turntable and the lower periphery of the glass fibre cloth is trimmed in an annular pattern normal to the tube axis. Glass cloth 31 is severed at 70 an area adjacent to or about 1/4 inch above mold match line 12c and preferably covers the circumferential extent of seal line 15.
- If desired a preformed or molded sheet of high-tensile strength material having an internal contour complementary to the exterior 75 of the major external surfaces of the funnel member may be substituted for the sheet of glass fibre cloth to eliminate lower edge trimming and to provide better contouring of the funnel covering to the tube exterior surfaces. 80
- Prior to affixing peripheral rim band 23 to the envelope, the exterior surfaces of face plate flange portion 12b are coated with an application of bonding material such as an epoxy resin either similar to those described 85 hereinabove and preferably Union Carbide Resin No. EBLA 2875. This resin is combined with Union Carbide Hardener No. ZBLA 0655 in the ratio of two parts hardener per one part of resin. The properties of this resin system are set forth hereinabove. The resin is applied to the frontal region of flange 90 portion 12b in the form of an annular layer 32 as shown in Fig. 9. Peripheral rim band 23 formed in two halves 23a and 23b is contoured to have internal surfaces closely complementary to the frontal- non-viewing exterior surfaces and is mounted thereover. Rim band 23 has a width relative to face plate flange 12b suitable to extend longitudinally with respect to the tube axis around the face corner radius and encompass mold match line 12c 100 extending so that its rearward edge 23c (Fig. 11) is in close proximity with the terminating forward edge 31c of glass cloth element 31. Termination of the respective edges 23c and 31c of rim band 23 and glass cloth 31 is variable over the exterior surfaces of face plate flange 12b and for certain conditions, 110 Their adjacent termination is preferably located intermediate mold match line 12c and seal line 15.
- Tension band 21 consisting of high-tensile strength material such as annealed steel 115 strapping is then placed around the tube envelope exteriorly overlapping the rearward portion of rim band 23. Tension band 21 is mounted substantially forward of seal line 15. Rim band 23 is overlapped to approximately 120 1/2 the width of the tension band. A tensioning device such as an air-operated wrench is employed to draw annular band 21 into tension over a range of from about 100 to 2000 pounds or more depending upon the 125 particular size and configuration of the tube envelope. The ends of band 21 are passed through connecting clip 22 and are then drawn tight and then crimped by means of the clip member to form a permanent con- 130

section of the band ends. If necessary, the ends of the bands are severed where any portion extends exteriorly of the connecting device. The tube is then inverted with its viewing area facing upwardly for cleaning the optical area in the event that any bonding material may have inadvertently been applied thereto either during spraying or in any other of the afore-mentioned operations. When an epoxy resin-containing bonding material similar to that described for the rim band attachment is utilized intermediate these elements, a final curing treatment may or may not be required depending upon the characteristics of the bonding material. Alternatively, silicone resins as well as other organic resins and lead-borate-containing solder glasses are utilizable intermediate the rim band and the face plate flange.

With regard to tensioning effects, the permanent tension introduced into annular band 21 is a significant factor in obtaining improved control over devacuation of the tube envelope on breakage. It has been found that by creating tensile force in the band of approximately 1500 to 2000 pounds, satisfactory results have been obtained in 23 diagonal inch wide-angle picture tubes having beam deflection angles of 110° and 114°. Such tension level imparts a considerable safety factor to the tube.

Tests have been conducted on a series of bulbs fabricated in accordance with the embodiment shown in Figs. 8 and 9. All bulbs passed the thermal shock and guillotine tests. In the impact tests all bulbs were capable of withstanding 12-1/2 to 15 foot-pounds impact delivered to the bulb center in either scribed or unscribed condition. Also full acceptable results in the form of aperture-forming devacuation occurred on center impact as well as impacts delivered at any location on the face. The structure illustrated in Figs. 8, 9 and 11 provides improved results over any of the previous single or two-component band systems disposed above.

In Fig. 10 a slight advantage over the construction shown in Fig. 9 is obtained where tension band 21 is applied with an annular layer 33 of bonding material therebeneath. This annular layer of adhesive material serves to more fully interlock the several metallic bands and funnel cloth into an integral structure which serves to further minimize and prevent crack propagation in contiguous envelope sidewalls of the face plate flange.

In the modification of the invention shown in Fig. 12 the enveloping covering of glass fibre cloth 35 is brought forwardly to a region adjacent but out of contact with the rearward edge of tension band 21. Implosion results achieved on impacting the tube face compare favorably with the results obtained with the construction shown in Fig. 9 wherein the funnel cloth is encompassed and retained by

the tension band. The annular layer 30 of resinous material is continued forwardly of seal line 15 essentially without interruption, to provide an adhesive layer beneath both the sheet of fibrous material 35 and the rearward portion of tension band 21, and becomes contiguous with resinous layer 32.

As shown in Fig. 13 the forward edge of the sheet of glass fibre cloth 36 having an intermediate layer of bonding material 30 may be brought forwardly to adjacent mold match line 12c. Rim band 23 is applied as described with its rearward portion encompassing the mold match region. The adjacent edges of rim band 23 and glass cloth 36 are surrounded and encompassed by a plurality of windings of glass fibre yarn or roving 37. A relatively-hard unflexibilized resin is employed to cement about five turns of yarn around the face plate flange 12b so that it is disposed equally on either side of the mold match line. Each turn of yarn consists of about twelve individual strands of glass fibre and the yarn is wound in tension of about 10 to 15 pounds tension. Utilizing the glass fibre yarn or roving to surround the exterior surfaces of maximum transverse exterior dimensions provides reinforcement of the envelope which is comparable to the structure disclosed in Figs. 8, 9 and 11. This construction is fully capable of passing thermal shock and guillotine tests and is resistant to face impacts up to and including 15 foot-pounds. Such impacts result in crack-type and aperture-forming devacuation. Fig. 14 shows an enlargement of the yarn wound over and around the adjacent edges of rim band 23 and glass cloth 36. The interstices between the multiple strands of the yarn 37 are filled with solidified resinous material. Shrinkage of the resinous material on curing serves to exert circumferential restraint on the envelope sidewalls therebeneath and adjacent thereto. The roving is preferably wound in tension although, depending upon the size and shape of the envelope and number of turns of roving employed, the roving may not be wound in tension. The roving is wound in such manner as to surround and mechanically engage adjacent juxtaposed annular areas of both the rim band and glass cloth members to interconnect these elements into unitary structure. Other types of elements such as lengthy wires or other types of high-temperature-resistant filaments can be used. The bonding agent employed in conjunction with the glass fibre yarn or roving is preferably comprised of epoxy resin, such as those described above.

In a modification of the essentially two-component system shown in Fig. 15 the tube 10E has a rim band 23 adhered to a frontal region of flange 12b by an annular layer 26 of bonding material. Tension band 21 is mounted in direct contact around rim band 23 in accordance with the structure shown in

70

75

80

85

90

95

100

105

110

115

120

125

130

Fig. 6. An annular layer comprised of a plurality of strands of glass fibre yarn or roving 40 is disposed exteriorly around tension band 21 extending throughout its circumferential extent and lateral width. The strands are mounted to provide additional reinforcement to the mold match region of flange 12b. Insofar as reinforcement of flange 12b is concerned the prescribed elements serve to further maintain this region substantially intact upon breakage of the envelope. This structure is capable of passing low-level impacts. However, glass throw may occur as a result of high-impact breakage where the body portion of the envelope is not surrounded by an enveloping layer of rupture-resistant material.

In the embodiment shown in Fig. 16 an extended rim band 25 comparable to that shown in Fig. 4 is mounted over the face flange 12b extending throughout its circumferential and lateral extent. The rim band encompasses both the corner region of the flange and seal line 15 with an annular layer of bonding material 24 therebeneath. The tube 10F has a tension band 21 applied in direct physical contact over and around a medial region of the rim band 25 in alignment with mold match line 12c. Tension band 21 is mounted forwardly of the seal line and placed in tension to provide further reinforcement of the flange medial region. This construction provides considerable reinforcement of the flange portion which is comparable to or an improvement over that provided by the structure shown in Fig. 9, although the elimination of the rupture-resistant material over the body portion may result in deleterious glass throw at high levels of impact.

Further modifications of the present invention are illustrated in Figs. 17, 18 and 19 wherein essentially four-component systems are disclosed. In Fig. 17 a structure comparable to that disclosed in Fig. 9 is provided with the addition of supplemental glass fibre yarn or roving 41 being applied exteriorly around rim band 21. This additional component serves to further reinforce the envelope 10G. The strands of glass fibre roving 41 are applied annularly fully coextensive with tension band 21 being concentrated in a forward region thereof. The roving is applied subsequent to mounting annular band 21 in tension. The roving serves to augment the reinforcement achieved by tension band 21 applied over rim band 23 and funnel cloth 31, previously mounted in adhered relation. In a modified form band 21 is applied only snugly to encompass the juxtaposed edges of rim band 23 and glass cloth 31 and the roving 41 disposed thereover. The roving is adhered to the tension band with resinous bonding material filling the interstices between individual strands of the roving.

The construction shown in Fig. 17 is capable of providing implosion resistance which is greater than that achievable by the structure shown in Figs. 9, 8 and 11.

In the modification shown in Fig. 18 the enveloping coating which surrounds the envelope body portion is eliminated and except for this feature the structure is comparable to that shown in Fig. 17. The structure 10H is somewhat similar to that shown in Fig. 7 wherein rim band 23 is mounted with an intermediate layer of bonding material 26 and tension band 21 is adhered thereover with an intermediate annular layer of similar or dissimilar bonding material 28. The plurality of reinforcing elements in the form of roving 41 is applied over and around mold match line 12c to provide an effect of further reinforcing this prescribed region. For some types of tests this structure is superior to the utilization of the pair of metallic bands alone in cemented relation. However, if a cave-in occurs the lack of an enveloping coating over funnel member 11 can possibly result in excessive glass throw forwardly which may be objectionable. However, this only occurs in impacts of relatively high magnitude.

In the modification shown in Fig. 19 a structure 10I comparable to that shown in Fig. 10 is provided with the addition of a plurality of strands of glass fibre roving 41 applied over tension band 21. In this case the structure includes the adhered enveloping sheet of glass fibre cloth 31 and the intermediate annular layer of bonding material 33 cementing tension band 21 in place. This construction is capable of providing further improved results over the structure shown in Fig. 10 due to further reinforcement of the mold match region ahead of the seal line.

In the case of both completed tubes and envelopes devacuated by any of the aforementioned test methods while mounted in viewing relation, no more than about an ounce of glass fragments in the form of fine shalc is deposited adjacent and immediately below the viewing area of the tube face plate on breakage.

Tubes fabricated in accordance with the present invention possess significant weight advantages and their installation in a wide range of receiver types can be achieved more economically than with any known tube protection systems. Appreciable cost reduction in both the receiver and certain bonded tubes is obtainable. Redesigning of the tube envelope to light-weight bulb sidewalls, for example, is entirely within the purview of the present invention. The weight-to-length and weight-to-viewing area ratios provided by the present invention offer marked improvements in television and other electronic image-producing fields.

It has been found that the subject tube is

capable of controlled devacuation and can be subjected to nominal impact damage, the results of which may or may not be objectionable depending upon its severity. This damage sometimes results in the formation of so-called checks in the glass exterior surface which are only perceptible upon close examination of the tube face and are imperceptible at normal viewing surfaces. Obviously, when cracks or fissures are formed in the viewing area of the tubes, they then become optically objectionable and are rendered unusable.

The subject tube construction provides a single viewing surface to be maintained clean, this surface being readily exposed in such manner as to facilitate easy cleaning. Only one light-reflecting surface is presented in the optical area which may be exteriorly coated or uncoated as desired to reduce reflectivity. Where a rim band is employed to surround the viewing area, it may serve as a bezel to mask the non-viewing periphery of the tube face as well as to function in its devacuation controlling capacity. The subject tube utilizes a safeguard envelope which following evacuation may be handled or processed with fewer precautions than required for conventional commercial tubes.

The basic theory involved in fabricating tube envelopes in a subject manner to be capable of controlling their devacuation on sudden or accidental release of vacuum is not fully understood. However, on cavitation of the face plate from any fracture source, where its perimetrical exterior surfaces are reinforced as described, its fragments, however large or small, are driven forcefully in a rearward direction by atmospheric pressure to strike and impinge internal surfaces of the tube body portion with considerably less force. This is true where the perimetrical region of substantially maximum exterior cross-sectional dimensions of the tube envelope is reinforced by circumferentially firmly adhered elements. This reinforcement must be sufficient to maintain the envelope side walls at this region substantially intact upon breakage of any remaining sidewalls of the tube envelope. Good adhesion between glass and reinforcing elements contacting the glass surfaces is important. Thus, the peripheral flange or side panel of the face plate is retaining substantially united by the surrounding annular band or bands attached to the exterior surfaces in firmly adhered relation. Crack propagation of any severity does not normally extend into this area, although, depending upon the nature of the fracture source, small incidental cracks or fissures of a minor nature may enter or approach this area. The face fragments whether large or small when driven rearwardly may or may not internally impact the tube funnel portion with sufficient force to cause breakage of this

member. Where the funnel is exteriorly coated with extensive firmly-adherent rupture-resistant material such as glass fibre cloth cemented to the funnel exterior surfaces, with the coating preferably having some flexibility or resiliency cracks or fissures may be produced therein by the internal blows registered by the face fragments. However, this coating which extends circumferentially over the funnel exterior absorbs the face blows and prevents immediate funnel collapse on fracture so that air cannot rush into the interior void in a forward direction to cause further fragmentation of both funnel and face components. Where the funnel and rim portion of the envelope are both covered, virtually all non-viewing surfaces are protected against damage due to scratches, abrasion, mechanical or thermal shock. Where breakage originates in the funnel, the fragments of this member are restrained by its external covering. In every case air is prevented from rushing into the vacuumized interior of the funnel area with such force as to cause violent devacuation of the envelope. In most cases breakage of the face plate usually results in aperture or crack-type devacuations in which fragments from the area of the source are drawn inwardly and virtually completely contained within the envelope proper as the envelope interior pressure rises to atmospheric. In many tests where the envelope is struck by a steel ball with sufficient force to form an opening, the ball is retained in place against the opening by air pressure as the envelope interior slowly reverts to atmospheric pressure.

Various modifications may be resorted to within the scope of the appended claims. For example although, for the most part, the rim band (reinforcing band) has been described as being made from metal, it is to be appreciated that the other high strength materials may be used such as glass fibre or yarn, e.g. in the form of roving or, in the case of glass fibre, in the form of individual fibres. If desired, when using glass fibre or yarn, the glass fibre or yarn may be embedded in a coating of a synthetic resinous material.

WHAT WE CLAIM IS:—

1. An implosion-resistant cathode-ray tube envelope comprising a funnel-shaped hollow body portion peripherally joined along the rim of its larger end to a face portion which encloses the larger end of said envelope, said face portion having a transverse light transmitting viewing screen curvingly merging in a transitional zone around its outer periphery with a rearwardly projecting annular flange region which joins said body portion along a circumferential seal line and forms a sidewall region of substantially maximum cross-sectional dimensions of said envelope, a discontinuous, thin, annular reinforcing band of high strength material comple-



capable of controlled devacuation and can be subjected to nominal impact damage, the results of which may or may not be objectionable depending upon its severity. This damage sometimes results in the formation of so-called checks in the glass exterior surface which are only perceptible upon close examination of the tube face and are imperceptible at normal viewing surfaces. Obviously, when cracks or fissures are formed in the viewing area of the tubes, they then become optically objectionable and are rendered unusable.

The subject tube construction provides a single viewing surface to be maintained clean, this surface being readily exposed in such manner as to facilitate easy cleaning. Only one light-reflecting surface is presented in the optical area which may be exteriorly coated or uncoated as desired to reduce reflectivity. Where a rim band is employed to surround the viewing area, it may serve as a bezel to mask the non-viewing periphery of the tube face as well as to function in its devacuation controlling capacity. The subject tube utilizes a safeguard envelope which following evacuation may be handled or processed with fewer precautions than required for conventional commercial tubes.

The basic theory involved in fabricating tube envelopes in a subject manner to be capable of controlling their devacuation on sudden or accidental release of vacuum is not fully understood. However, on cavitation of the face plate from any fracture source, where its perimetrical exterior surfaces are reinforced as described, its fragments, however large or small, are driven forcefully in a rearward direction by atmospheric pressure to strike and impinge internal surfaces of the tube body portion with considerably less force. This is true where the perimetrical region of substantially maximum exterior cross-sectional dimensions of the tube envelope is reinforced by circumferentially firmly adhered elements. This reinforcement must be sufficient to maintain the envelope side walls at this region substantially intact upon breakage of any remaining sidewalls of the tube envelope. Good adhesion between glass and reinforcing elements contacting the glass surfaces is important. Thus, the peripheral flange or side panel of the face plate is retaining substantially united by the surrounding annular band or bands attached to the exterior surfaces in firmly adhered relation. Crack propagation of any severity does not normally extend into this area, although, depending upon the nature of the fracture source, small incidental cracks or fissures of a minor nature may enter or approach this area. The face fragments whether large or small when driven rearwardly may or may not internally impact the tube funnel portion with sufficient force to cause breakage of this

member. Where the funnel is exteriorly coated with extensive firmly-adherent rupture-resistant material such as glass fibre cloth cemented to the funnel exterior surfaces, with the coating preferably having some flexibility or resiliency cracks or fissures may be produced therein by the internal blows registered by the face fragments. However, this coating which extends circumferentially over the funnel exterior absorbs the face blows and prevents immediate funnel collapse on fracture so that air cannot rush into the interior void in a forward direction to cause further fragmentation of both funnel and face components. Where the funnel and rim portion of the envelope are both covered, virtually all non-viewing surfaces are protected against damage due to scratches, abrasion, mechanical or thermal shock. Where breakage originates in the funnel, the fragments of this member are restrained by its external covering. In every case air is prevented from rushing into the vacuumized interior of the funnel area with such force as to cause violent devacuation of the envelope. In most cases breakage of the face plate usually results in aperture or crack-type devacuations in which fragments from the area of the source are drawn inwardly and virtually completely contained within the envelope proper as the envelope interior pressure rises to atmospheric. In many tests where the envelope is struck by a steel ball with sufficient force to form an opening, the ball is retained in place against the opening by air pressure as the envelope interior slowly reverts to atmospheric pressure.

Various modifications may be resorted to within the scope of the appended claims. For example although, for the most part, the rim band (reinforcing band) has been described as being made from metal, it is to be appreciated that the other high strength materials may be used such as glass fibre or yarn, e.g. in the form of roving or, in the case of glass fibre, in the form of individual fibres. If desired, when using glass fibre or yarn, the glass fibre or yarn may be embedded in a coating of a synthetic resinous material.

WHAT WE CLAIM IS:—

1. An implosion-resistant cathode-ray tube envelope comprising a funnel-shaped hollow body portion peripherally joined along the rim of its larger end to a face portion which encloses the larger end of said envelope, said face portion having a transverse light transmitting viewing screen curvingly merging in a transitional zone around its outer periphery with a rearwardly projecting annular flange region which joins said body portion along a circumferential seal line and forms a sidewall region of substantially maximum cross-sectional dimensions of said envelope, a discontinuous, thin, annular reinforcing band of high strength material comple-



- mentally contoured to snugly conform to said sidewall and closely fitting around the periphery of said flange region closely adjacent said viewing screen and a thin film of high strength adhesive material between said band and said sidewall strongly adhering said band in tight conformity with said envelope sidewall with essentially no space therebetween and the inner circumference of said band being essentially the same as the outer circumference of the tube at the point of installation, said band and said adhesive having sufficient yield strength to prevent fracture propagation through the envelope sidewall therebeneath upon breakage of said envelope.
2. A tube envelope as claimed in claim 1 in which an annular front portion of said reinforcing band extends onto and conforms to a portion of said viewing screen curved transitional zone and is adhered thereto.
3. A tube envelope as claimed in Claim 1 or 2 in which said reinforcing band lies entirely forwardly of said seal line and its inner diameter and the outer diameter of said sidewall at all corresponding points are substantially the same.
4. A tube envelope as claimed in any one of claims 1 to 3, in which said reinforcing band comprises multiple metal bands with overlapping ends.
5. A tube envelope as claimed in claim 4, in which said reinforcing band comprises two U-shaped half sections with the ends disposed one within the other.
6. A tube envelope as claimed in any of claims 1 to 5, which comprises constriction means for applying radially-inwardly-directly compressive forces to the reinforcing band and the envelope sidewalls in an annular area circumferentially around the envelope at the point of substantially maximum envelope diameter.
7. A tube envelope as claimed in claim 6, in which said construction means is a band of high-tensile material under tension overlying at least an annular portion of said reinforcing band to press said band into intimate and closely conforming relation with said envelope sidewall and establish a band of compression in said face portion.
8. A tube envelope as claimed in claim 7, in which said tension band is a metal strap of substantially uniform rectangular cross-section and a retention means engaging the strap end portions to maintain it under tension.
9. A tube envelope as claimed in claim 7 or 8, in which said reinforcing band has a concavo-convex cross-sectional contour complementary to said face portion and is disposed in close and conforming relationship thereto, and said tension band has a flat, rectangular cross-section which at least partially overlaps said reinforcing band.
10. A tube envelope as claimed in any one of claims 1 to 9, which comprises an annular layer of rupture-resistant material adhered to extensive non-viewing exterior surface areas of said envelope extending over a major area of said body portion.
11. A tube envelope as claimed in claim 10, in which said rupture-resistant material extends forwardly adjacent to said reinforcing band and said tension band overlies adjacent annular circumferential areas of said reinforcing band and said rupture-resistant layer.
12. A tube envelope as claimed in claim 10 or 11, in which said rupture-resistant material comprises a high tensile strength coating of silicon-containing material and glass fibers.
13. A tube envelope as claimed in any one of claims 7 to 12 in which the inner surface of said tensioned band is bonded to the adjacent underlying surfaces.
14. A tube envelope as claimed in any one of claims 10 to 13 in which said rupture-resistant material adhering to said envelope comprises a coating of epoxy resin-containing material with an integral interwoven sheet of glass fiber cloth bonded thereto.
15. A tube envelope as claimed in any one of claims 1 to 14, in which said adhesive material bonding said reinforcing band and envelope comprises epoxy resin containing material in solidified reacted condition.
16. An implosion-resistant cathode-ray tube envelope comprising a funnel-shaped hollow body portion peripherally joined along the rim of its larger end to a face portion which encloses the large end of said envelope, said face portion having a transverse light transmitting viewing screen curvingly merging in a transitional zone around its outer periphery with a rearwardly projecting annular flange region which joins said body portion along a circumferential seal line and forms a sidewall region of maximum cross-sectional dimensions of said envelope, an annular layer of rupture-resistant high-tensile strength material adhered to extensive non-viewing exterior surfaces of said body portion, a discontinuous thin, annular reinforcing band of high strength material complementally contoured to snugly conform to said sidewall and closely fitting around the periphery of said flange region closely adjacent said viewing screen, a tension band overlying at least an annular portion of said reinforcing band to press said band into intimate and closely conforming relation with said envelope sidewall and also overlying at least an annular circumferential zone of said layer of rupture-resistant material wholly to engage and restrain at least said circumferential zone of said layer of rupture-resistant material, and a thin film of high strength adhesive material between said band and said sidewall strongly adhering said band in tight conformity with said envelope sidewall with essentially no space therebetween and the

inner circumference of said reinforcing band being essentially the same as the outer circumference of the tube at the point of installation, said reinforcing band and said adhesive having sufficient yield strength to prevent fracture propagation through the envelope sidewall therebeneath upon breakage of said envelope.

17. An implosion-resistant cathode-ray tube envelope comprising a funnel-shaped hollow body portion peripherally joined along the rim of its larger end to a face portion which encloses the larger end of said envelope, said face portion having a transverse light transmitting viewing screen curvingly merging in a transitional zone around its outer periphery with a rearwardly projecting annular flange region which joins said body portion along a circumferential seal line and forms a sidewall region of substantially maximum cross-sectional dimensions of said envelope, a discontinuous, thin, annular reinforcing band of high strength material complementally contoured to snugly conform to said sidewall and closely fitting around the periphery of said flange region closely adjacent said viewing screen, said reinforcing band being located forwardly of said seal line, and a thin film of high strength adhesive material between said band and said side-wall strongly adhering said band in tight conformity with said envelope sidewall with essentially no space therebetween and the inner circumference of said band being essentially the same as the outer circumference of the tube at the point of installation, said band and said adhesive having sufficient yield strength to prevent fracture propagation through the envelope sidewall therebeneath upon breakage of said envelope.

18. A tube envelope as claimed in claim 17, in which said reinforcing band comprises two similar U-shaped half-sections and is contoured to have internal surfaces which are closely complemental to the external shape of at least a part of said transitional zone.

19. A tube envelope as claimed in claim 18, in which said U-shaped sections overlap in telescoping arrangement.

20. A tube envelope as claimed in any one of claims 17 to 19, in which a tension band overlies at least a rearward portion of said reinforcing band, approximately half of the width of said tension band overlying said reinforcing band and the whole of said tension band lying forwardly of said seal line.

21. A method of fabricating an implosion-resistant cathode-ray tube envelope from a bulb having a funnel-shaped hollow body portion peripherally joined along the rim of its large end to a face portion which encloses the larger end of said envelope, said face portion having a transverse light transmitting viewing screen which curvingly merges in a transitional zone around its outer periphery

with a rearwardly projecting annular flange region which joins said body portion along a circumferential seal line and forms a sidewall region of substantially maximum cross-sectional dimensions of said envelope, which comprises disposing a discontinuous, thin annular reinforcing band of high strength material around the periphery of said envelope sidewall to have the front portion closely adjacent said viewing screen with a film of high strength adhesive material between said band and sidewall, said band being contoured to have its inner surface complemental to that of the underlying sidewall region, pressing said band in an untensioned condition into snug conformity with and peripherally encompassing said sidewall to leave no substantial space between the said band and sidewall such that the inner circumference of said band and the outer circumference of said tube are essentially the same at the point of installation, and setting said adhesive to establish a strong bond between said band and sidewall with said band and adhesive having a sufficient yield strength to prevent fracture propagation through the sidewall region beneath said band upon breakage of said envelope.

22. A method as claimed in claim 21 in which said reinforcing band is disposed to lie entirely forwardly of said seal line.

23. A method as claimed in claim 21 or 22, in which said reinforcing band comprises at least two separate metal pieces disposed about opposite sides of said envelope and their ends are brought into an overlapping relationship when said band is pressed into adhering contact with said sidewall.

24. A method as claimed in any one of claims 21 to 23 which comprises applying compression to said face portion well forward of said seal line through at least a portion of said reinforcing band while pressing said band into close conformity to said sidewall region, and maintaining said face portion in compression after said adhesive sets.

25. A method as claimed in claim 24 in which compression is applied by drawing a length of high-tensile strength material into tension around an annular circumferential area of said reinforcing band well forward of said seal line to form a tensioned band and securing said tensioned material to maintain said compression.

26. A method as claimed in claim 24 or 25 in which compression is applied by disposing a band of high-tensile strength material to overlie an annular circumferential area of said adhered reinforcing band well forward of said seal line, reducing the diameter of said band to bring it into tension in mechanical engagement with said reinforcing band and maintaining said reduced diameter.

27. A method as claimed in claim 26, in which compression is applied by disposing a



- discontinuous metal collar around at least a portion of said reinforcing band, drawing said collar into tension and then engaging the ends of said collar with a clip to maintain said tension. 70
28. A method as claimed in claim 27, in which said collar is placed into continuous tension in the range of from 100 to 2,000 pounds. 75
29. A method as claimed in any one of claims 21 to 27, in which the adhesive is applied to the interior surface of said reinforcing band prior to positioning said band around the envelope. 80
30. A method as claimed in any one of claims 21 to 29 in which an annular layer of rupture-resistant material is adhered to extensive non-viewing exterior surfaces of said envelope over a major area of said body portion and extending forwardly to adjacent said reinforcing band. 85
31. A method as claimed in claim 30, in which said rupture-resistant material is adhered by spraying an organic resin containing film over the major external area of said tube body, placing a sheet of glass fiber cloth thereover, and drawing said sheet into firm engagement with the coated tube portion. 90
32. A method of fabricating an implosion-resistant cathode-ray tube envelope from a bulb having a funnel-shaped hollow body portion peripherally joined along the rim of its large end to a face portion which encloses the larger end of said envelope, said face portion having a transverse light transmitting viewing screen which curvingly merges in a transitional zone around its outer periphery with a rearwardly projecting annular flange region which joins said body portion along a circumferential seal line and forms a sidewall region of substantially maximum cross-sectional dimensions of said envelope, which comprises adhering an annular layer of rupture-resistant high tensile strength material to extensive non-viewing exterior surfaces of said body portion, disposing a discontinuous, thin annular reinforcing band of high strength material around the periphery of said envelope sidewall to have the front portion closely adjacent said viewing screen with a film of high strength adhesive material between said band and sidewall, said band being contoured to have its inner surface complementary to that of the underlying side wall region, pressing said band in an untensioned condition into snug conformity with and peripherally encompassing said sidewall to leave no substantial space between said band and sidewall such that the inner circumference of said band and the outer circumference of said tube are essentially the same at the point of installation, and setting said adhesive to establish a strong bond between said band and sidewall with said band and adhesive having sufficient yield strength to prevent fracture propagation through the sidewall region beneath said band upon breakage of said envelope. 95 100 105 110 115
33. A method of fabricating an implosion-resistant cathode-ray tube envelope from a bulb having a funnel-shaped hollow body portion peripherally joined along the rim of its large end to a face portion which encloses the larger end of said envelope, said face portion having a transverse light transmitting viewing screen which curvingly merges in a transitional zone around its outer periphery with a rearwardly projecting annular flange region which joins said body portion along a circumferential seal line and forms a sidewall region of substantially maximum cross-sectional dimensions of said envelope, which comprises disposing a discontinuous, thin annular reinforcing band of high strength material around the periphery of said envelope sidewall to have the front portion closely adjacent said viewing screen with a film of high strength adhesive material between said band and side-wall, said reinforcing band being located forwardly of said seal line and being contoured to have its inner surface complementary to that of the underlying sidewall region, pressing said band in an untensioned condition into snug conformity with and peripherally encompassing said sidewall to leave no substantial space between said band and sidewall such that the inner circumference of said band and the outer circumference of said tube are essentially the same at the point of installation, and setting said adhesive to establish a strong bond between said band and sidewall with said band and adhesive having sufficient yield strength to prevent fracture propagation through the sidewall region beneath said band upon breakage of said envelope. 120 125
34. A method as claimed in claim 33, which comprises applying a tension band in a position overlying at least a rearward portion of said reinforcing band and tensioning said band, said tension band lying entirely forwardly of said seal line. 130
35. An implosion-resistant cathode-ray tube envelope substantially as hereinbefore described with reference to and as illustrated in Figures 1 and 2, or Figure 4, or Figure 7, or Figure 10, or Figure 12, or Figure 15, or Figure 16, or Figure 17, or Figure 18, or Figure 19 of the accompanying drawings.
36. An implosion-resistant cathode-ray tube



envelope substantially as hereinbefore described with reference to and as illustrated in Figure 3 of the accompanying drawings.

- 5 37. An implosion-resistant cathode-ray tube envelope substantially as hereinbefore described with reference to and as illustrated in Figures 5 and 6 of the accompanying drawings.

- 10 38. An implosion-resistant cathode-ray tube envelope substantially as hereinbefore described with reference to and as illustrated in Figures 8, 9 and 11, or Figures 13 and 14 of the accompanying drawings.

39. A method of fabricating an implosion-resistant cathode-ray tube envelope substantially as hereinbefore described with reference to and as illustrated in Figures 8, 9, 11 and 20 of the accompanying drawings. 15

40. An implosion-resistant cathode-ray tube produced according to the method of any one of claims 21 to 34 or 39. 20

W. P. THOMPSON & CO.,
12, Church Street, Liverpool, 1,
Chartered Patent Agents,

Published at The Patent Office, 25, Southampton Buildings by the Courier Press.—1966.

Leamington Spa: Printed for Her Majesty's Stationery Office, London, W.C.2, from which copies may be obtained.

