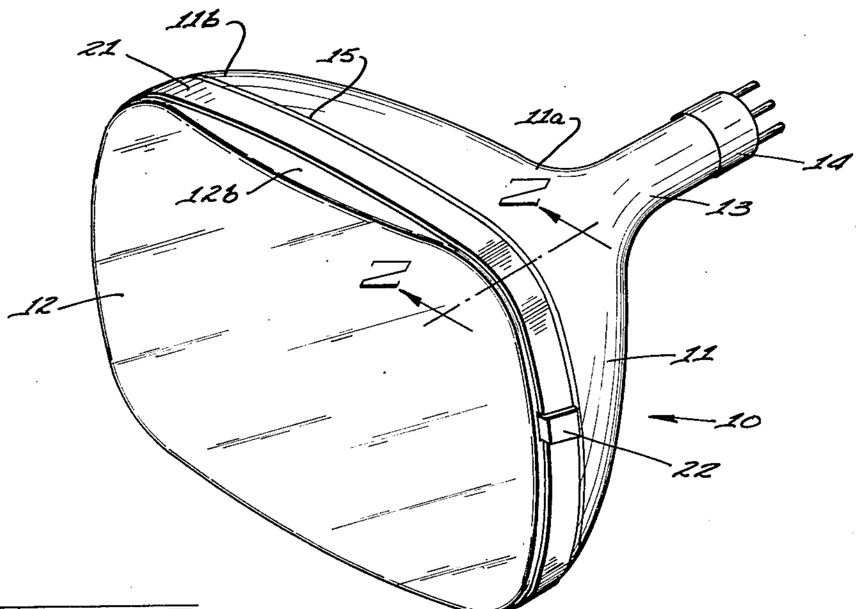
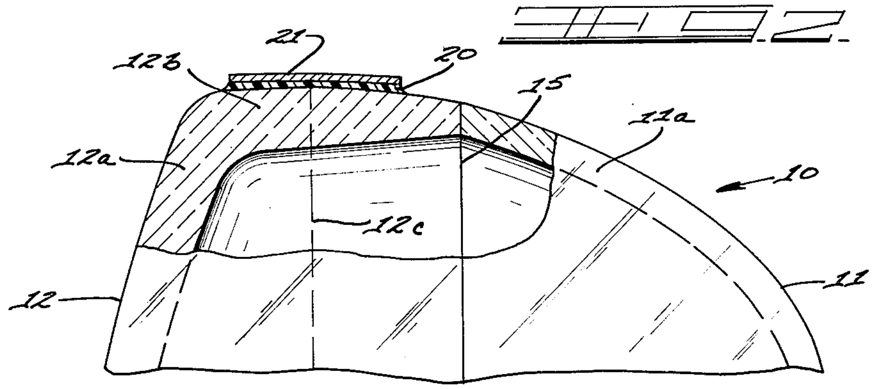


FIG. 1

FIG. 2



INVENTORS
D. E. POWELL &
B. W. SPEAR
BY
E. J. HOLLER &
W. A. SCHAICH
ATTORNEYS

FIG. 3

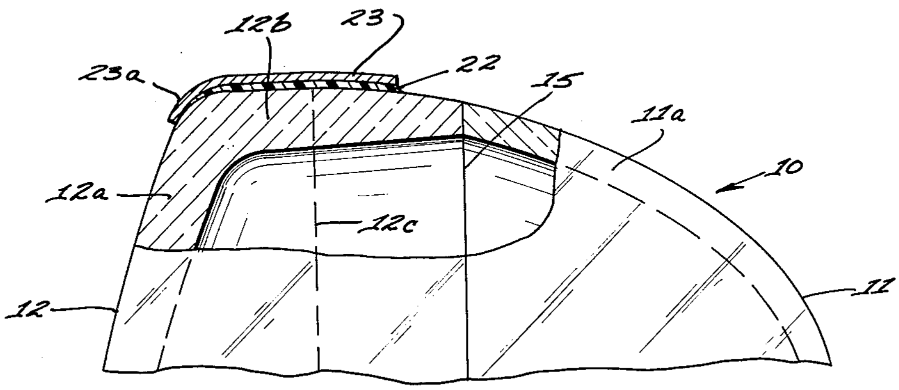
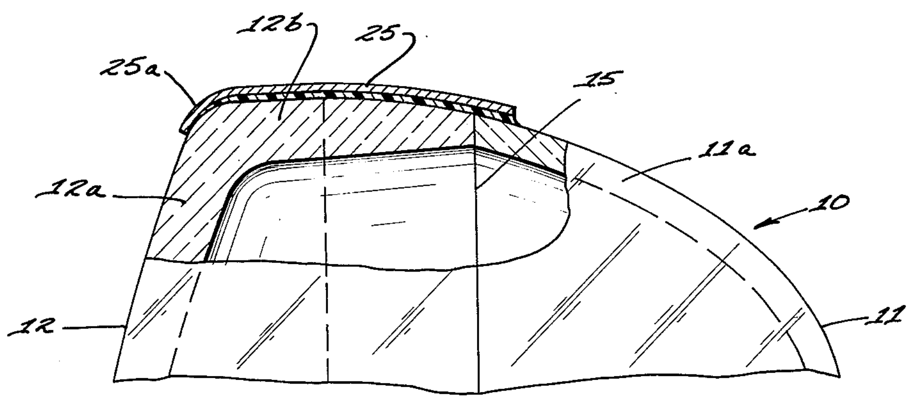


FIG. 4



INVENTORS
D. E. POWELL &
B. W. SPEAR
BY
E. J. HOLLER &
W. A. SCHAICH
ATTORNEYS

Nov. 30, 1965 D. E. POWELL ETAL 3,220,593
CATHODE-RAY AND OTHER VACUUMIZED TUBES RESISTANT TO FRACTURE
AND CAPABLE OF CONTROLLED DEVACUATION
Filed Sept. 24, 1962 11 Sheets-Sheet 3

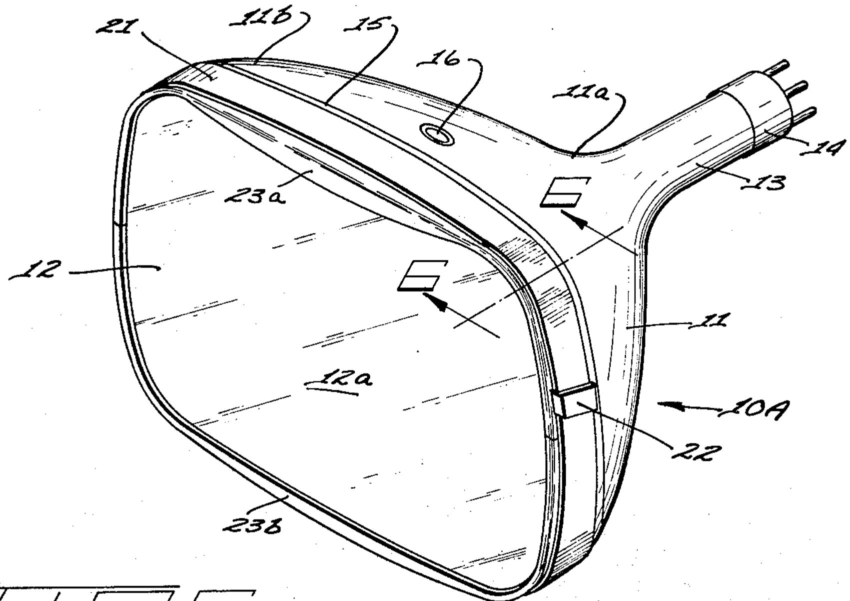
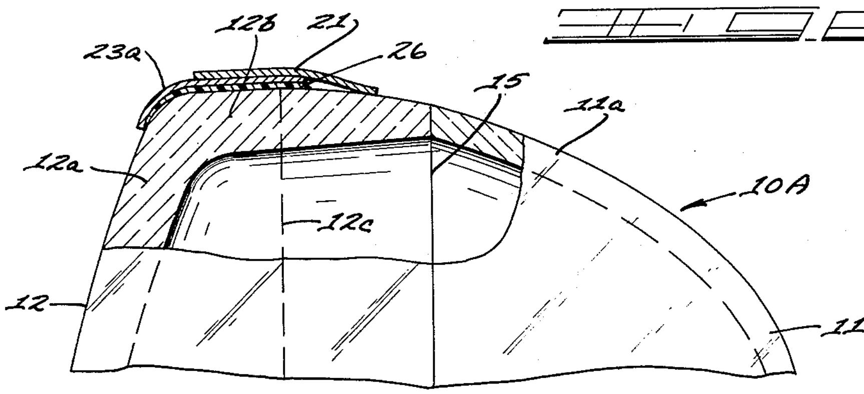


FIG. 5

FIG. 6



INVENTORS
D. E. POWELL &
B. W. SPEAR
BY
E. J. HOLLER &
W. A. SCHAICH
ATTORNEYS

FIG. 7

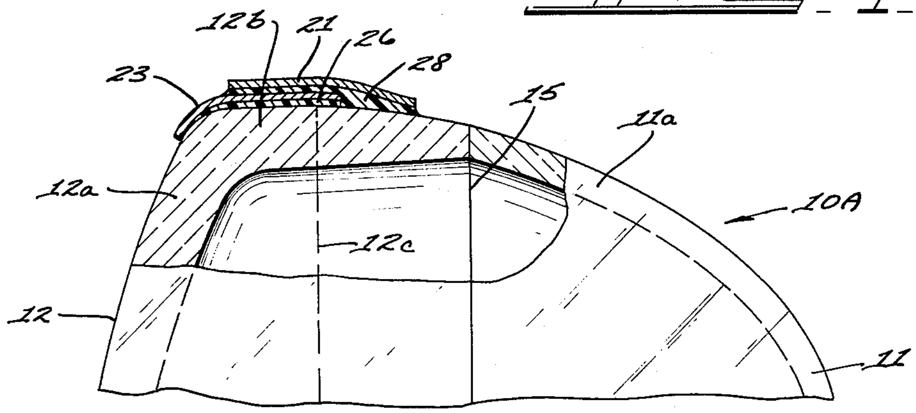
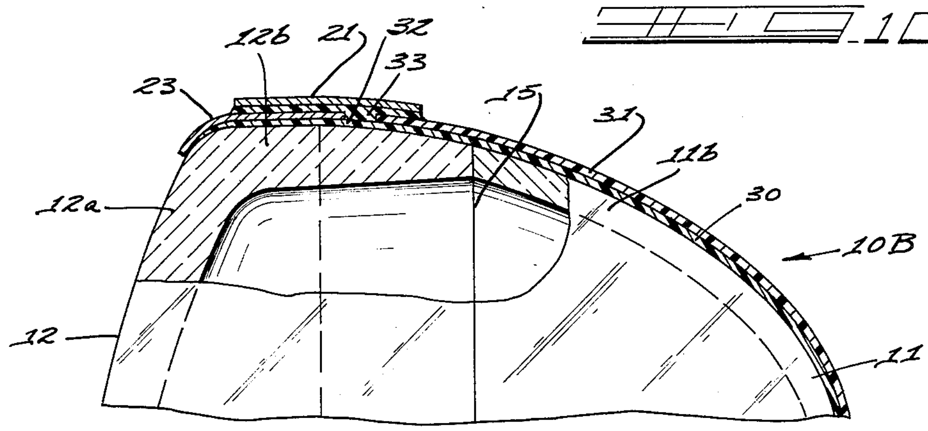


FIG. 10



INVENTORS
D. E. POWELL &
BY B. W. SPEAR
E. J. HOLLER &
W. A. SCHAICH
ATTORNEYS

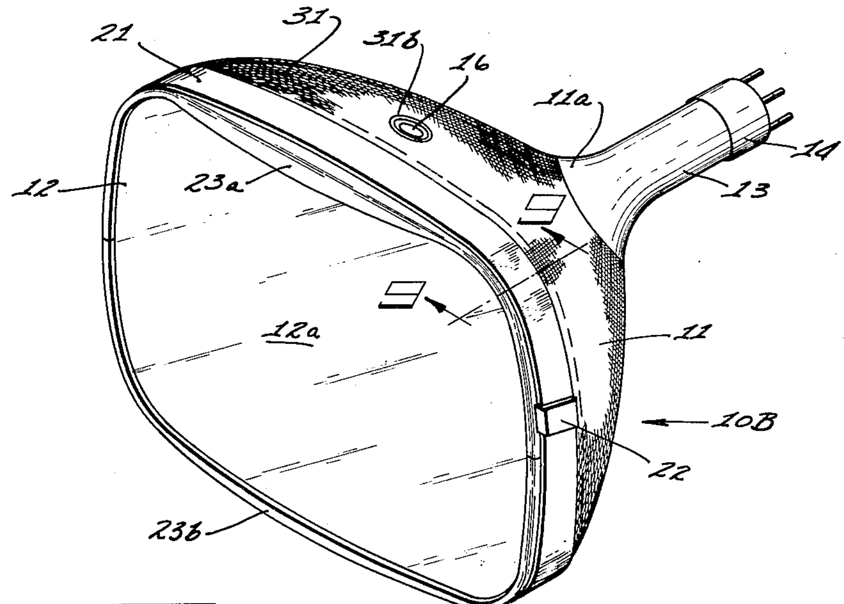
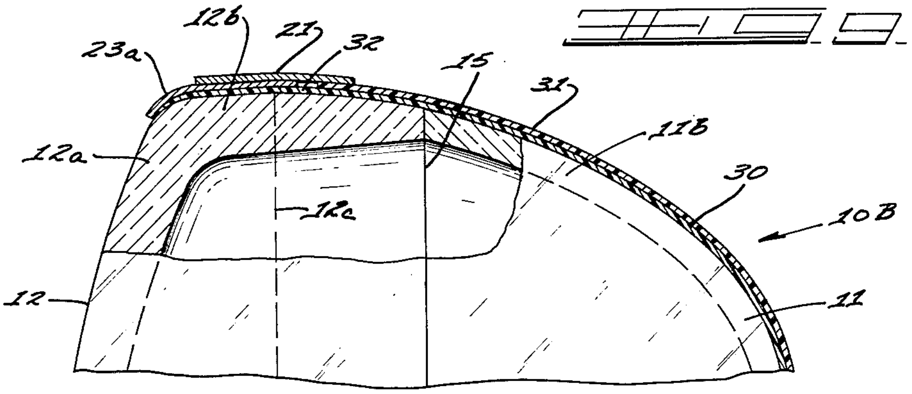


FIG. 8

FIG. 9



INVENTORS
D. E. POWELL &
B. W. SPEAR
BY
E. J. HOLLER &
W. A. SCHAICH
ATTORNEYS

Nov. 30, 1965 D. E. POWELL ETAL 3,220,593

CATHODE-RAY AND OTHER VACUUMIZED TUBES RESISTANT TO FRACTURE AND CAPABLE OF CONTROLLED DEVACUATION

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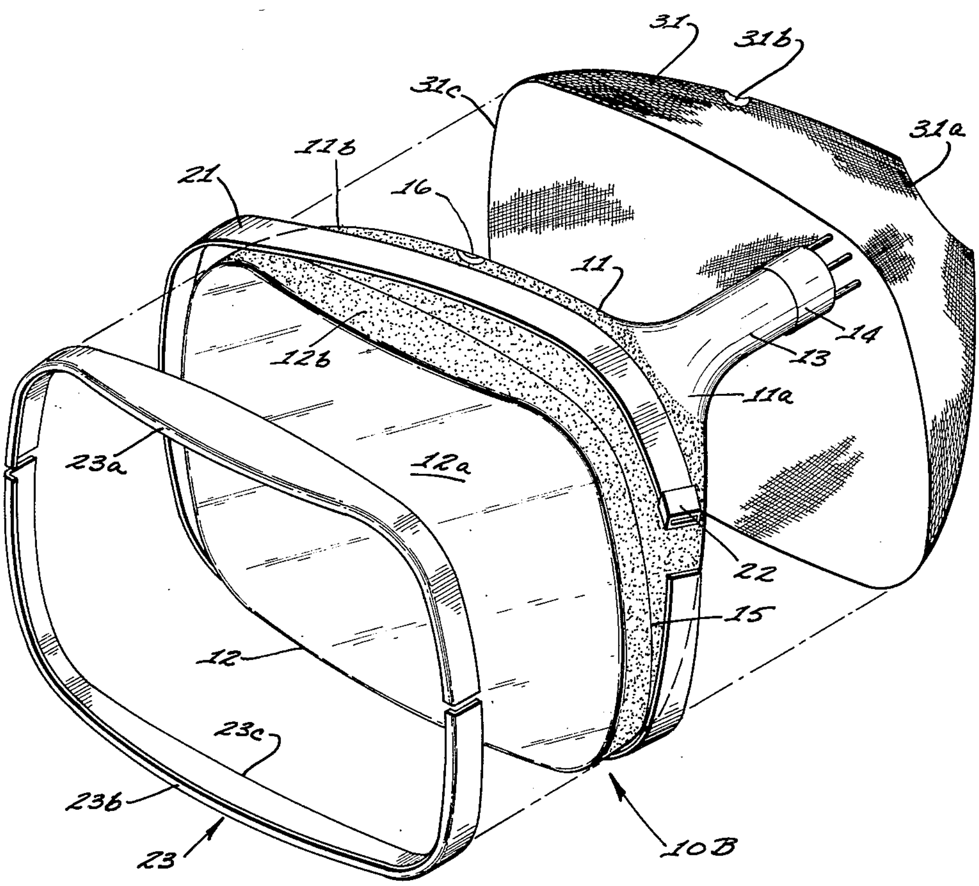
FIG. 11



INVENTORS
D.E. POWELL &
B.W. SPEAR
BY E.S. HOLLER &
W.A. SCHAICH
ATTORNEYS

FIG. 12

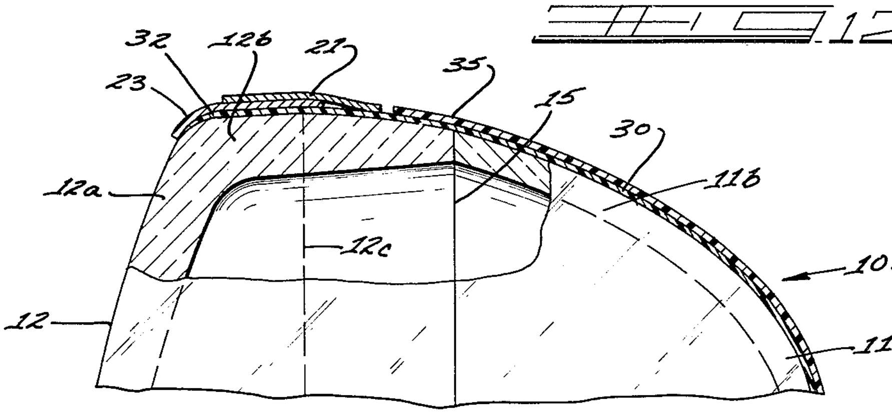


FIG. 13

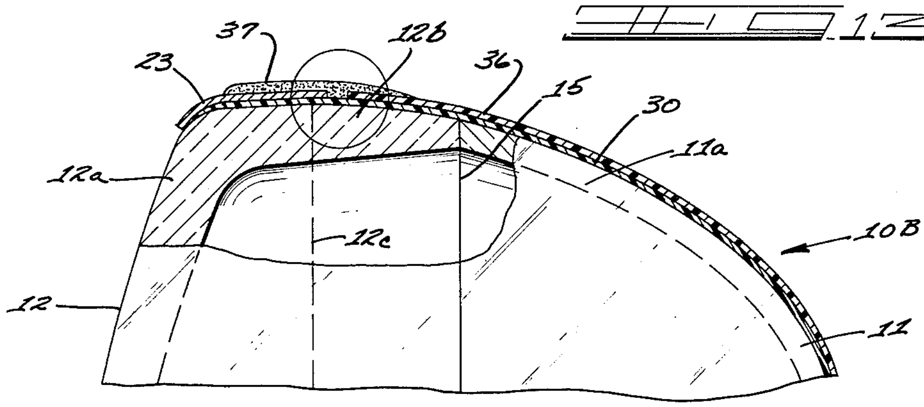
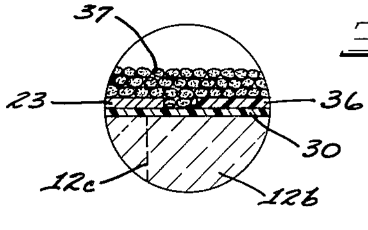


FIG. 14



INVENTORS
D. E. POWELL &
B. W. SPEAR
BY
E. J. HOLLER &
W. A. SCHAICH
ATTORNEYS

CATHODE-RAY AND OTHER VACUUMIZED TUBES RESISTANT TO FRACTURE AND CAPABLE OF CONTROLLED DEVACUATION

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FIG. 15

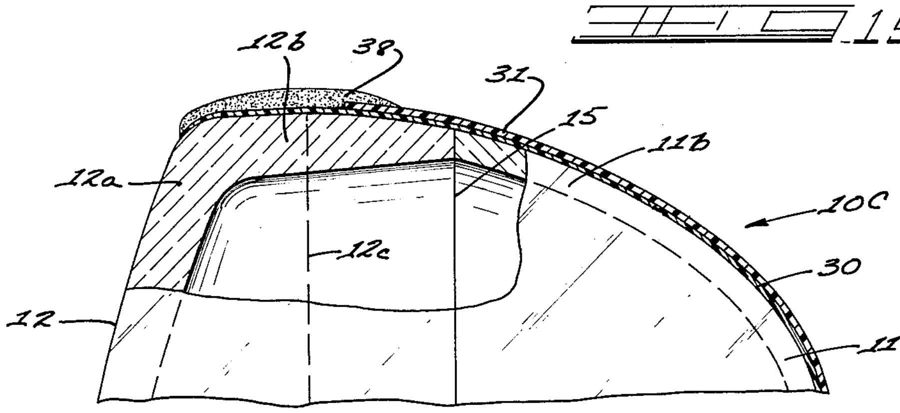


FIG. 16

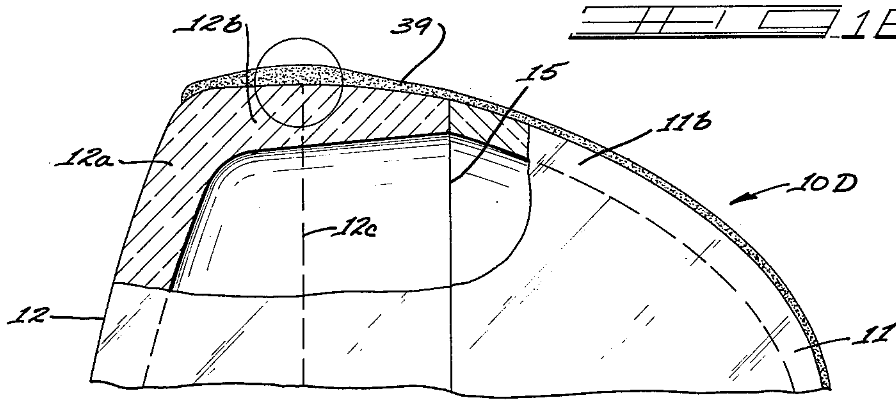
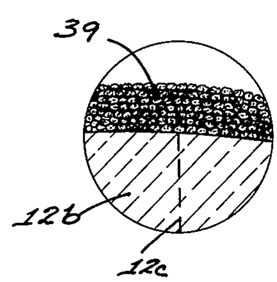


FIG. 17



INVENTORS
D. E. POWELL &
B. W. SPEAR
BY E. J. HOLLER &
W. A. SCHAICH
ATTORNEYS

Nov. 30, 1965 D. E. POWELL ETAL 3,220,593

CATHODE-RAY AND OTHER VACUUMIZED TUBES RESISTANT TO FRACTURE AND CAPABLE OF CONTROLLED DEVACUATION

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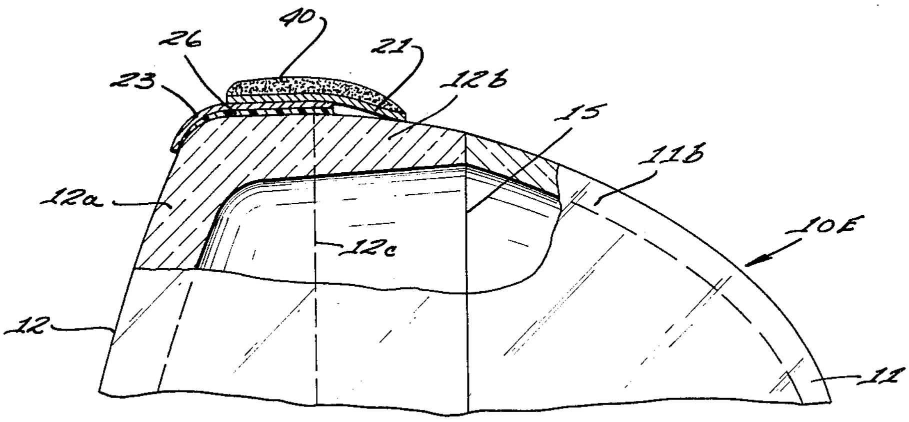
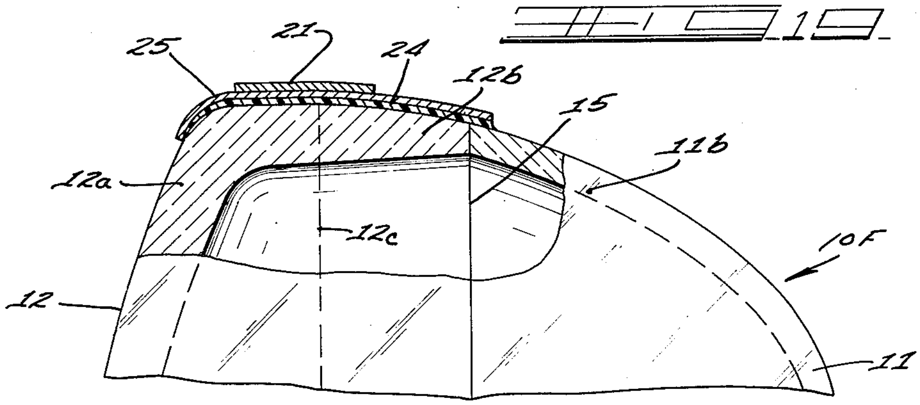


FIG. 18

FIG. 19



INVENTORS
D. E. POWELL &
BY B. W. SPEAR
E. J. HOLLER &
W. A. SCHAICH
ATTORNEYS

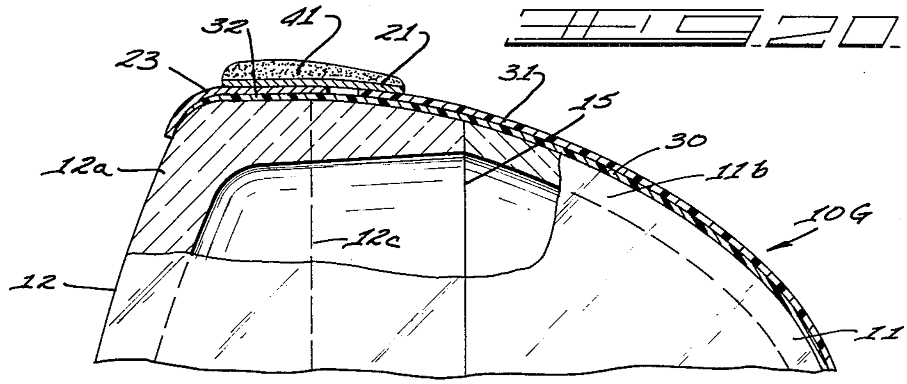


FIG. 20

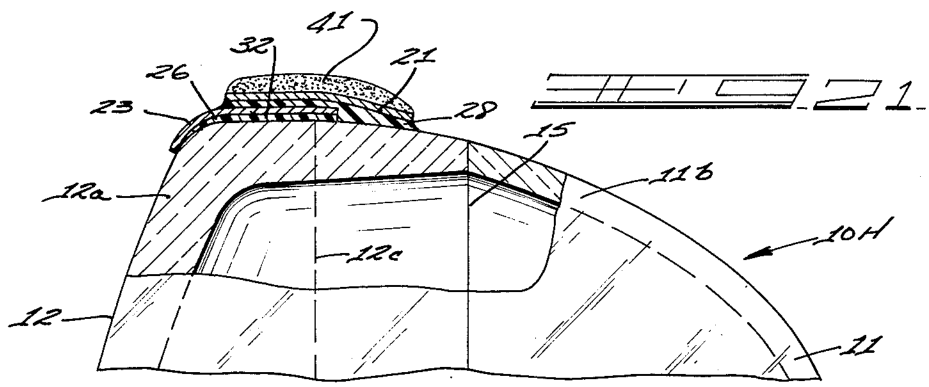


FIG. 21

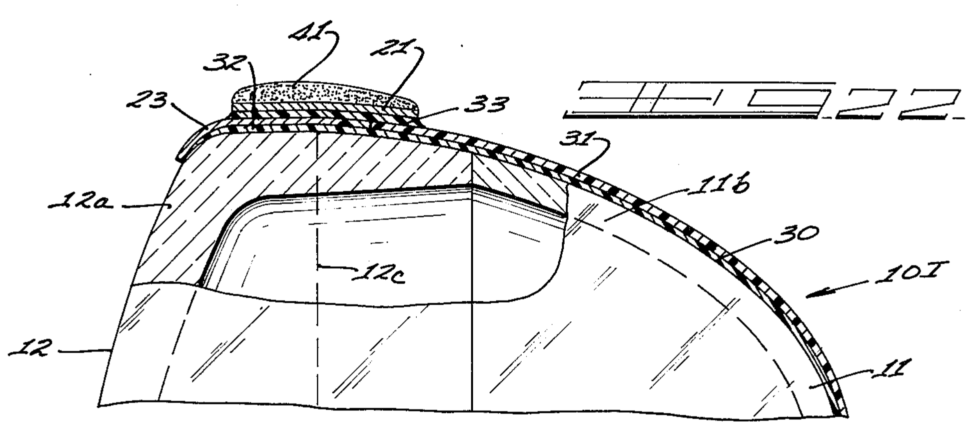
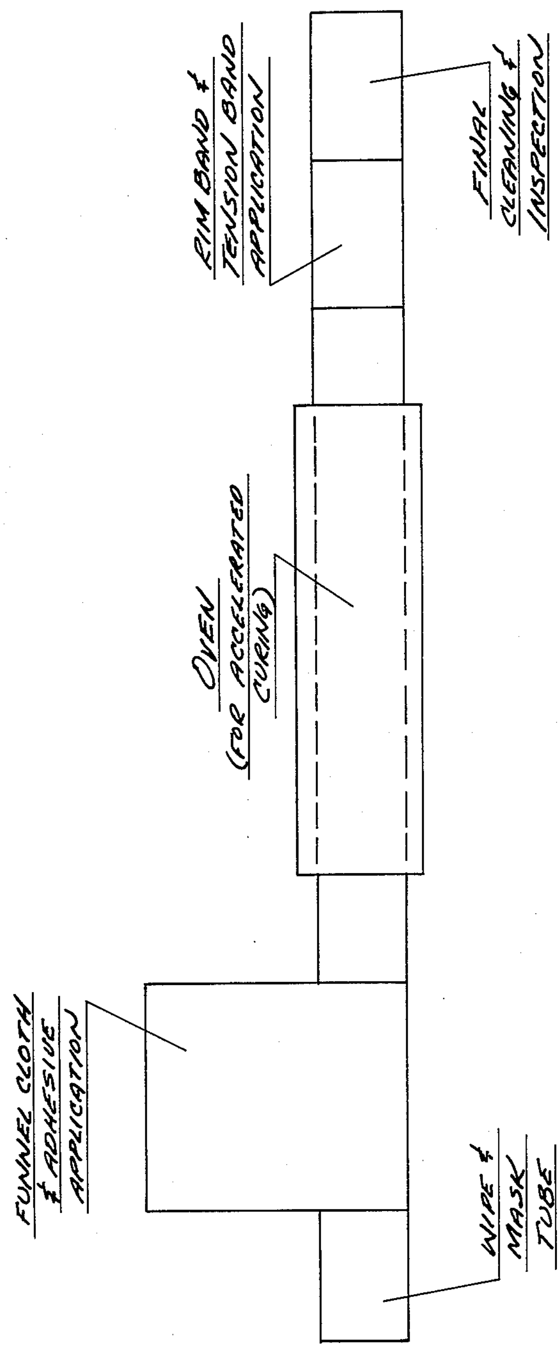


FIG. 22

INVENTORS
D. E. POWELL &
B. W. SPEAR
BY E. J. HOLLER &
W. A. SCHAICH
ATTORNEYS

FIG_12



INVENTORS
D. E. POWELL &
B. W. SPEAR
BY E. S. HOLLER &
W. A. SCHAICH
ATTORNEYS

United States Patent Office

3,220,593

Patented Nov. 30, 1965

3,220,593

CATHODE-RAY AND OTHER VACUUMIZED TUBES RESISTANT TO FRACTURE AND CAPABLE OF CONTROLLED DEVACUATION

Daryl E. Powell, Maumee, and Burton W. Spear, Toledo, Ohio, assignors, by mesne assignments, to Owens-Illinois Glass Company, Toledo, Ohio, a corporation of Ohio

Filed Sept. 24, 1962, Ser. No. 225,448

8 Claims. (Cl. 220—2.1)

The present application comprises a continuation-in-part application based upon our earlier-filed applications, U.S. Serial No. 180,490, filed March 19, 1962, entitled "Cathode-Ray and Other Vacuumized Tubes Resistant to Violent Devacuation," and U.S. Serial No. 210,117, filed July 16, 1962, now abandoned, entitled "Reinforced Cathode-Ray and Other Vacuumized Tubes Resistant to Violent Devacuation."

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 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 reevacuation, for example, may introduce excessive stresses into the tube envelopes, 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. Tensive 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 usualy consisting of a tempered glass panel is mounted in adjacent spaced relation fully coextensive with the tube viewing portion. Alternately, 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 unlaminated 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 sidewalls 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 overall 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 television picture tube which is resistant to both fracture and sudden devacuation without serious fragmentation under widely varying adverse conditions.

Another object of this invention is to provide an improved type of glass vacuum tube envelope having characteristics of resistance to fracture and control over sudden devacuation wherever or however caused, the completed tube being reinforced at the periphery of its viewing area and fully capable of functioning in its normal manner.

Another object of this invention is to provide a novel non-imploding type cathode-ray image tube which may be viewed directly without a light-transmitting implosion panel being mounted adjacent and coextensive with its viewing area, said tube envelope having adhered reinforcing elements extending peripherally over at least its non-viewing exterior surfaces surrounding said viewing area to facilitate controlled devacuation of the envelope on breakage.

Another object of this invention is to provide resistance to fracture and control of breakage in an evacuated hollow glass article having integral means to control sidewall framgentation upon its rapid devacuation upon accidental or spontaneous breakage caused by any source.

Another object of this invention is to provide an improved type of cathode-ray picture tube envelope adapted to direct-viewing wherein at least one circumferential band of high-tensile strength material is adhered to the non-viewing external surface areas of the tube closely surrounding its viewing area, said circumferential band being bonded to the exterior surfaces therebeneath to provide an integral reinforced region having sufficient yield strength to maintain the contiguous envelope sidewalls substantially intact on breakage of the envelope.

A further object of this invention is to provide a method of imparting resistance to fracture and control of devacuation in an essentially all-glass electron-discharge tube envelope to mechanically control and restrain the major non-viewing sidewalls in a prescribed manner to minimize crack propagation therethrough upon breakage of the envelope due to any form of physical damage or thermal shock.

A still further object of this invention is to provide a method of making a glass cathode-ray television picture tube envelope resistant to fracture and implosive-explosive effects on breakage of the tube envelope having substantial dimensions whereby upon breakage the envelope is permitted to controllably devacuate without deleterious fragmentation of its sidewalls.

A still further object of this invention is to provide a novel method of providing structural reinforcement in an essentially all-glass picture tube envelope by mounting high-tensile strength reinforcing elements in adhered relation around the tube exterior area of maximum cross-sectional dimensions closely adjacent its viewing area and mounting an enveloping covering of rupture-resistant high-tensile strength material in adhered relation over the body portion of the tube envelope to minimize fragmentation of the enclosed portions on envelope breakage.

The specific nature of this invention, as well as other objects and advantages will become apparent to those skilled in the art from the following detailed description taken in conjunction with the annexed sheets of drawings on which, by way of preferred example only, are illustrated the preferred embodiments of the invention.

On the accompanying drawings:

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 FIG. 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 one portion of FIG. 13;

FIGS. 15 and 16 are views similar to FIGS. 12 and 13 showing modifications thereof;

FIG. 17 is an enlarged fragmentary view of one portion of FIG. 16;

FIGS. 18, 19, 20, 21, and 22 are views similar to FIGS.

3 and 4 illustrating further modifications of the invention; and

FIG. 23 is a schematic drawing of one method of fabricating the tube illustrated in FIGS. 8, 9, and 11.

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 different types of glass envelopes, particularly those having substantial dimensions which are subject to implosion and concomitant explosion on sudden devacuation.

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 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 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.

The prior art has disclosed the various tube constructions for minimizing implosion-explosion effects, one such construction is shown in U.S. Patent No. 2,785,820 to Vincent and Logue, issued March 19, 1957, entitled "Controlling Implosions in Cathode-Ray and Other Tubes." This patent is assigned to the same parent assignee as the present application. The referenced patent discloses a theory of providing fracture resistance in the form of a tension band applied to 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 adjacent and underlying the band. Picture tubes fabricated in accordance with the Vincent et al. invention are capable of resisting implosion to some degree; however, such tubes are not intended to be direct-viewing or utilized without an implosion 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, their invention does not provide the same degree of 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 invention.

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 methods which are capable of supplementing normal tube production.

The invention preferably involves the application of reinforcing elements including at least one annular band firmly adhered to the non-viewing 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 panel and 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 forwardly of the tube seal line. An annular layer of bonding material comprised of organic or inorganic adhesive material fills the space intermediate at least the next adjacent annular band and exterior glass surfaces 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 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 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 fiber cloth is adhered to major non-viewing external surfaces of the tube body portion extending substantially between its larger and smaller ends in a virtually continuous annular pattern.

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 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 either frusto-conical or frusto-pyramidal in contour with its small end **11**_a_ sealed to neck **13** and its large end **11**_b_ 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 end **11**_a_ are joined to provide proper electron beam deflection and scanning of the tube screen

Face plate **12** consists of a concavo-convex or curvilinear viewing portion **12**_a_ surrounded by a depending perimetrical side panel or flange **12**_b_. Face plate flange **12**_b_ and large end **11**_b_ 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 complemental 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 basic shape of face plate viewing area **12**_a_ 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 the 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 1¼ pound steel ball striking at various impact levels, the thermal shock method and guillotine method.

Face plate impact tests consist of striking various preselected regions of the tube viewing area with widely-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 ¼ inch 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 center of the inscribed cross by physical contact. 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 ⅛ to ¼ 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 **10** 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 **12**_b_ of the face plate **12** is coated over a major portion of its exterior surfaces closely adjacent viewing panel **12**_a_ with a continuous annular layer **20** of bonding material. The bonding material consists of either synthetic resinous material such as epoxy resin, polyester resin or other bonding material such as silicon-containing lead borate solder glasses having relatively low-melting temperatures. An enveloping annular band **21** is mounted around annular layer **20** and face plate skirt portion **12**_b_ 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 medical region coincidental with the mold match line **12**_c_ of the face flange **12**_b_. Annular band **21** is placed in tension by drawing its ends together by an air-operated wrench, for example, and applying a crimped clip member **22** to its ends to maintain the band in permanent tension. Tension band **21** consists of a flexible strap of metallic material such as annealed steel strapping having a substantially uniform cross-sectional configuration. The band tension for a 23 inch tube ranges from 1200 to 1600 pounds tension. 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 percent, a tensile strength of 1300 p.s.i. and will cure at a temperature of 150° to 200° F. in ½ hour or less and at room temperature in about 3 hours. 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. Dow Epoxy Resin (D.E.R.) No. 741–A is a clear resin system developed for laminating glass implosion panels to glass cathode-ray tube faces and is described in Dow Bulletin No. 146, published July 1959 by Dow Chemical Company. As described in this bulletin, Dow Epoxy Hardener No. 61 is a clear water-thin material of the amine-type for curing D.E.R. No. 741–A by a nonreversible chemical reaction. The reacted resin system forms a stable, firmly adhesive bond to glass. The above-identified Union Carbide products are components of a liquid epoxide resin system, the properties of which are described in a Union Carbide Plastics Company bulletin dated August 6, 1962, entitled "Rim Band Bonding System." Another suitable bonding agent is Plaskon Polyester Resin No. 9407 which is a rigid-type promotor-containing resin to which it is only necessary to add a catalyst such as methyl ethyl ketone peroxide to initiate tack-free cure. This particular resin system is designed for use with glass fibers and glass fiber cloth and is manufactuerd by Allied Chemical Corporation. 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 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 rim band **23** preferably comprised of two similar U-shaped half-sections is taken for joinder to the face plate skirt area **12b**. Peripheral rim band **23** is contoured to have internal surfaces which are closely complemental to the geometry of the external corner surfaces where face plate flange **12b** and the periphery of viewing area **12a** intersect. Rim band **23** is comprised of either one endless band, which may be sweated onto the tube exterior surfaces, or be 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 rim band **23** and the exterior surfaces of face plate flange portion **12b**. 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 7½ 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 **23** 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 turned lip portion **25c** which closely 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 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 **21** is applied exteriorly over a rearward portion of rim band **23** in parallel relation transversely of the tube axis, the tension band having an appreciable width and disposed coincidentally 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 without the bonding material being applied therebeneath. With the band applied in tension 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 resistant to fracture on low level impact and capable of controlling devacuation on breakage caused by all face impacts delivered at the 15 foot-pound 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 resistance 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. 23 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 portion **12*b*** are wiped clean or treated with a suitable solvent to ensure their cleanliness. A mask (not shown) is mounted around the viewing area **12*a*** 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 **12*a*** the tube is moved into a spray chamber.

In the spray chamber the tube is placed on a 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 **11*a*** of the funnel member is also masked such as by a paperboard 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. 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 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 dimensional stability and strength. The reacted resin system forms a stable adhesive somewhat flexible bond between glass fibers 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 percent and a tensile strength of 565 p.s.i. Other resins such as Dow Epoxy Resin No. 741–A utilized with 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 the bonding material remains in liquid workable condition, a piece of glass fiber cloth **31** having a central opening **31*a*** is placed downwardly over and around the tube neck portion. A second opening **31*b*** is provided in an intermediate area of glass fiber cloth **31** for its alignment with the masked anode button **16**. The piece of glass fiber 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 over the glass cloth to impregnate and fill its openings between individual strands and bundles of glass fiber.

Upon removal of the tube from the spray 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. The lower extremity of glass fiber cloth **31** is pulled down and pressed tightly against the glass surfaces either to or adjacent mold match line **12*c*** of the face plate flange **12*b***. The anode button and neck masks are removed from the tube. The epoxy resin-glass fiber 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, such as by heating to a temperature of up to 250° F. over a period of approximately 8 minutes.

After curing the thermosetting synthetic resin to chemically bond the glass fiber 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 fiber cloth is trimmed in an annular pattern normal to the tube axis. Glass cloth **31** is severed at an area adjacent to or about ¼ inch above mold match line **12*c*** 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 complemental to the exterior of the major external surfaces of the funnel member may be substituted for the sheet of glass fiber cloth to eliminate lower edge trimming and to provide better contouring of the funnel covering to the tube exterior surfaces.

Prior to affixing peripheral rim band **23** to the envelope, the exterior surfaces of face plate flange portion **12*b*** are coated with an application of bonding material such as an epoxy resin either similar to those described hereinabove and preferably Union Carbode 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 portion **12b** in the form of an annular layer **32** as shown in FIG. 9. Peripheral rim band **23** is contoured to have internal surfaces closely complemental to the frontal non-viewing exterior surfaces and is mounted thereover. Rim band **23** has a width relative to face plate flange **12*b*** suitable to extend longitudinally with respect to the tube axis around the face corner radius and encompass mold match line **12*c*** extending into close proximity with the terminating forward edge of glass cloth element **31**. Termination of the respective edges of rim band **23** and glass cloth **31** is variable over the exterior surfaces of face plate flange **12*b*** and for certain conditions, their adjacent termination is preferably located intermediate mold match line **12*c*** and seal line **15**.

Tension band **21** consisting of high-tensile strength material such as annealed steel strapping is then place 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 ½ 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 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 a clip member to form a permanent connection 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 aforementioned operations. Where 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 tensive 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 12½ 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 disclosed 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 envelop sidewalls of the face plate flange.

In the modification of the invention shown in FIG. 12 the enveloping covering of glass fiber 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**.

As shown in FIG. 13 the forward edge of the sheet of glass fiber cloth **36** having an intermediate layer of bonding material **30** is brought forwardly to adjacent mold match line **12*c***. 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 fiber yarn or roving **37**. A relatively-hard unflexiblized resin is employed to cement about fifty turns of yarn around the face plate flange **12*b*** with its medial region being disposed in alignment with the mold match line. Each turn of yarn consists of about twelve individual strands of glass fiber and the yarn is wound in tension of about 10 to 15 pounds tension. Utilizing the glass fiber 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 fiber yarn or roving is preferably comprised of epoxy resin, such as those described above.

In another form of the present invention as shown in FIG. 15, the tube **10C** has a funnel coating which consists of a layer of resinous bonding material **30** with an integrally-bonded layer or sheet of glass fiber cloth **31** adhered thereto as described. In this case both the rim band **23** and tension band **21** are eliminated and a heavier layer of resinous material **30** is continued over face plate flange **12*b*** and its corner region which interconnects with face plate viewing area **12*a***. Glass fiber or yarn roving **38** is wound circumferentially around the area where the several annular bands comprised of rigid metallic material are normally applied. The roving extends over and adjacent the corner region of the face plate commensurate with satisfactory winding of the roving. The roving extends lengthwise to engage and encircle a terminating region of glass fiber cloth **31** as well as a substantial frontal portion of face plate flange **12*b***. A sufficient number of turns of fibrous roving to impart substantial reinforcement to the area of maximum exterior cross-sectional dimensions of the tube at mold match line **12*c*** is required. The roving serves to replace the metallic bands as the reinforcing elements of the previous embodiments. The resinous material in solidified hardened form is useful for maintaining the glass fibers in finally-disposed permanent arrangement to provide both mechanical reinforcement and positive physical restraint of the face plate flange area. Shrinkage of the bonding material and introducing tensive force into the strands of the roving serve to introduce compressive stresses into the glass surfaces and sidewall portions therebeneath. It is necessary that the roving be concentrated in a forward region ahead of seal line **15** in order to maintain face flange **12*b*** substantially intact on breakage of any other portions of the envelope.

In the construction shown in FIG. 15 satisfactory resistance to implosion effects is obtainable in low level tests, however, this construction is not capable of providing results which are as satisfactory for high-level impacts as where a rim band or rim and tension bands in combination are employed.

Another modification of the present invention is shown in FIG. 16 wherein the exterior non-viewing surface areas of the funnel and face plate non-viewing portions of the tube **10D** are coated over their exterior surfaces with a suitable glass bonding medium such as a film or layer of epoxy resin. Strands of individual glass fibers or glass fiber roving **39** are wound around the tube envelope between its larger and smaller ends in a continuous enclosing pattern. The fibers **39** which are wound around the funnel and face flange replace both the glass fiber cloth and metallic band elements of the previous constructions. The fibers or strands of high-tensile strength material are wound in a plane normal to the tube axis or randomly over the non-viewing external surfaces.

The face plate flange 12*b* closely adjacent its viewing area and more particularly at mold match line 12*c* is surrounded by a greater number of turns to strengthen this prescribed area and to provide substantial reinforcement thereof. The concentration of fibers is disposed ahead of seal line 15 and a bonding layer must exist between fibers and glass. Glass fibers 39 are embedded within a coating of synthetic resin which is applied either during or subsequent to winding of the fibers as required. The fibers are indicated in an enlarged showing in FIG. 17 as being built up to a maximum depth in the area of mold match line 12*c* for appreciable reinforcement of this critical area. The structure shown in FIG. 16 results in implosion resistance and devacuation results which are comparable to those achievable by the structure shown in FIG. 15. The structure is capable of passing low-level tests but is more susceptible to cave-in on impact of the order of 15 foot-pounds or greater possibly due to variations in application of the roving which must be carefully controlled.

In a modification of the essentially two-component system shown in FIG. 18 the tube 10E has a rim band 23 adhered to a frontal region of flange 12*b* 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 FIG. 6. An annular layer comprised of a plurality of strands of glass fiber 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 12*b*. Insofar as reinforcement of flange 12*b* 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. 19 an extended rim band 25 comparable to that shown in FIG. 4 is mounted over the face flange 12*b* 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 applied in direct physical contact over and around a medial region of the rim band in alignment with mold match line 12*c*. 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. 20, 21 and 22 wherein essentially four-component systems are disclosed. In FIG. 20 a structure comparable to that disclosed in FIG. 9 is provided with the addition of supplemental glass fiber 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 fiber 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. 20 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. 21 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. 20. 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 12*c* 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 possibly 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. 22 a structure 10I comparable to that shown in FIG. 10 is provided with the addition of a plurality of strands of glass fiber roving 41 applied over tension band 21. In this case the structure includes the adhered enveloping sheet of glass fiber 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 shale 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 per se 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 safeguarded 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 the 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 sidewalls 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 retained 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 fiber 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 spirit and scope of the appended claims.

We claim:

1. A cathode-ray television picture tube envelope resistant to fracture and implosive-explosive effects on breakage comprising a generally frusto-pyramidal shaped hollow glass body member and a generally rectangular-shaped concavo-convex light-transmitting glass viewing member sealed to the larger end of said body member at a transverse planar seal line, the periphery of the viewing portion of said viewing member being surrounded by integral annular sidewalls of substantially maximum cross-sectional dimensions of said envelope forming a non-viewing annular rim portion, a first discontinuous annular band of high-tensile strength material having a concavo-convex cross-sectional contour complemental to said rim portion disposed in closely surrounding relation thereto, a second annular band of high-tensile strength material having a flat rectangular cross-sectional contour disposed exteriorly of said first band in at least partially overlapping relation, both bands being mounted substantially forward of the seal line, and a continuous annular layer of synthetic resin bonding material disposed intermediate said first and second annular bands and the glass exterior surfaces of said rim portion therebeneath, said annular bands and annular layer of synthetic resin bonding material conjunctively reinforcing the glass sidewalls therebeneath to maintain the same essentially fully intact upon breakage of the envelope.

2. A cathode-ray television picture tube envelope in accordance with claim **1**, wherein said annular layer of synthetic resin bonding material comprises a reacted epoxy resin containing material chemically bonded to said first and second annular bands and the glass surfaces therebeneath in film thickness.

3. A cathode-ray tube envelope in accordance with claim **1**, wherein the said first and second annular bands are comprised of metal disposed in partial overlapping arrangement around said rim portion, the second exterior band being mounted over the area of maximum cross-sectional dimensions of said envelope forwardly of the seal line and maintained in continuous tension, the said annular layer of synthetic resin material being fully co-extensive with said first and second annular bands and chemically bonded to the glass and metal surfaces.

4. A cathode-ray tube envelope in accordance with claim **1**, wherein said first annular band is comprised of two individual U-shaped half-sections arranged in circumferentially telescoping relation around said rim portion closely adjacent the viewing portion, and fastening means joining the ends of said second annular band maintaining the same in tension.

5. A cathode-ray tube envelope in accordance with claim **1**, wherein intermediate annular layers of the same bonding material are disposed between each of said first and second annular bands and the glass exterior surfaces therebeneath.

6. A cathode-ray tube envelope in accordance with claim **1**, wherein a third annular band comprised of glass fibers is mounted exteriorly around at least said second annular band in firmly adhered relation.

7. The method of making a direct-viewing television picture tube resistant to fracture and rapid devacuation without implosive-explosive effects, said tube being comprised of an essentially all-glass hollow envelope having a frusto-pyramidal shaped body portion and a light-transmitting generally rectangular face plate portion sealed together at a transverse seal line, said method comprising the steps of firmly adhering a rupture-resistant continuous coating containing glass fibers over extensive external surfaces of said envelope body portion extending substantially between its larger and smaller ends, disposing a first metallic discontinuous annular band around said envelope closely surrounding the non-viewing periphery of said face plate portion in adhered relation, said first annular band having substantial cross-sectional width and a contour complemental to the exterior surfaces of the non-viewing periphery of said face plate portion, disposing a second metallic annular band around said envelope in adhered relation encompassing portions of both said first annular band and said rupture-resistant coating, and placing said second metallic annular band in continuous controlled tension to thereby produce increased compression in exterior surface portions of the envelope sidewalls underlying and adjacent said second band, said annular bands being capable of maintaining the underlying envelope sidewalls intact upon breakage of remaining sidewalls of said envelope.

8. The method of making a direct-viewing television picture tube resistant to fracture and implosive-explosive effects on rapid devacuation due to breakage, said tube being comprised of an essentially all-glass hollow envelope having a frusto-pyramidal-shaped hollow body portion and a light-transmitting rectangular-shaped face plate portion enclosing the large end of said body portion at a transverse annular seal region, said method comprising the steps of applying a firmly-adherent rupture-resistant coating by spraying a synthetic-resin-containing film over the major external surfaces of said body portion extending substantially between its larger and smaller ends, placing a sheet of glass fiber cloth thereover, drawing said sheet into firm engagement with the coated body portion, curing said resin-containing film to bond said sheet to said body portion, mounting at least one contoured annular face plate retention band around the non-viewing peripheral flange of said face plate viewing portion disposed closely adjacent its viewing screen and adjacent a frontal area of said rupture-resistant coating, bonding said face plate retention band to the envelope exterior surfaces therebeneath, and placing said annular band in continuous tension ranging from 100 to 2000 pounds tension thereby producing increased compression in the envelope sidewalls underlying and adjacent said band.

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THERON E. CONDON, *Primary Examiner.*