May 7, 1968 E. W. REINWALL, JR 3,381,347

CATHODE RAY TUBE MANUFACTURE

Filed Sept. 3, 1964 8 Sheets-Sheet 1

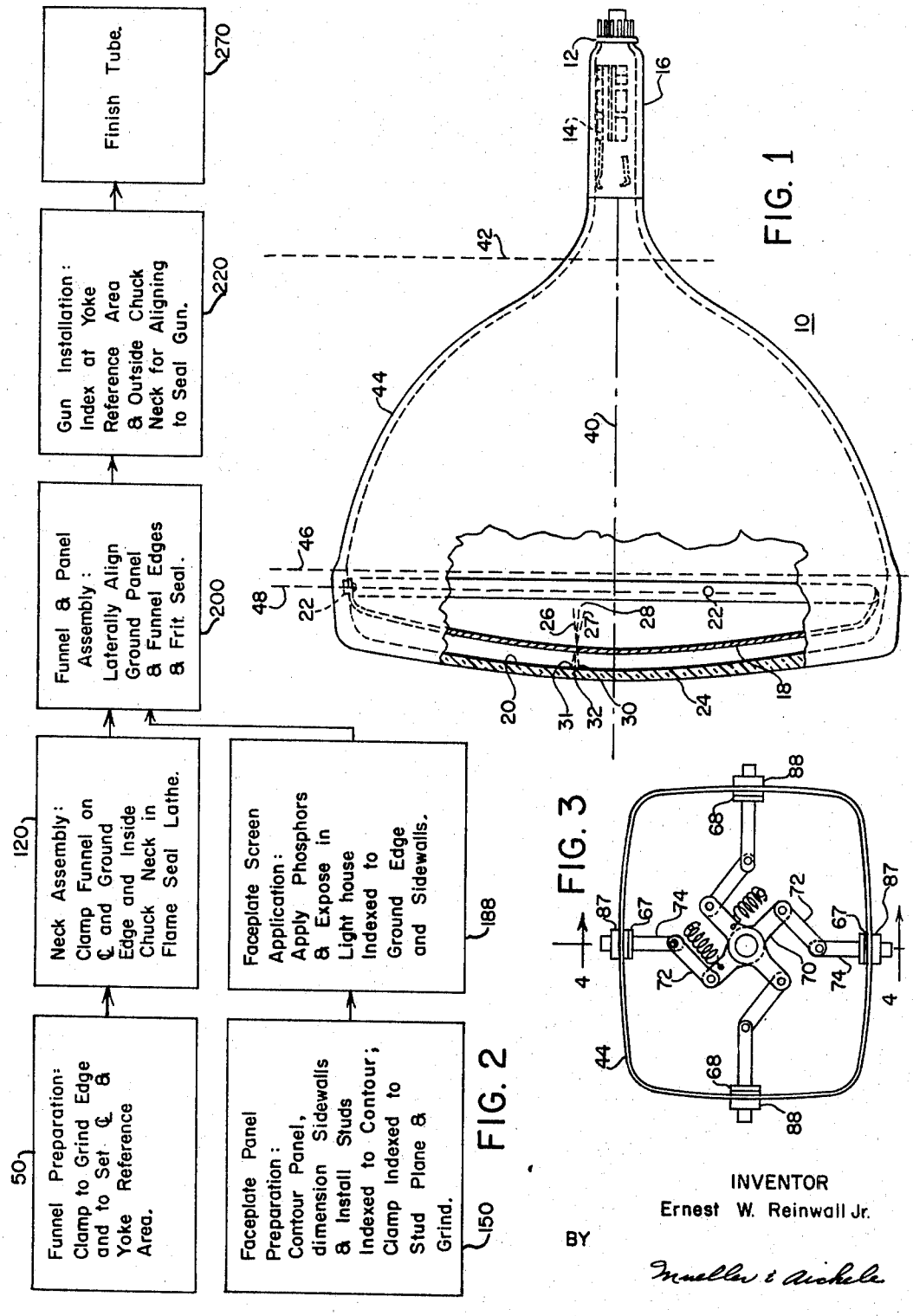


FIG. 2

FIG. 1

FIG. 3

INVENTOR
Ernest W. Reinwall Jr.

BY

Mueller & Nichols

Attys.

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FIG. 4

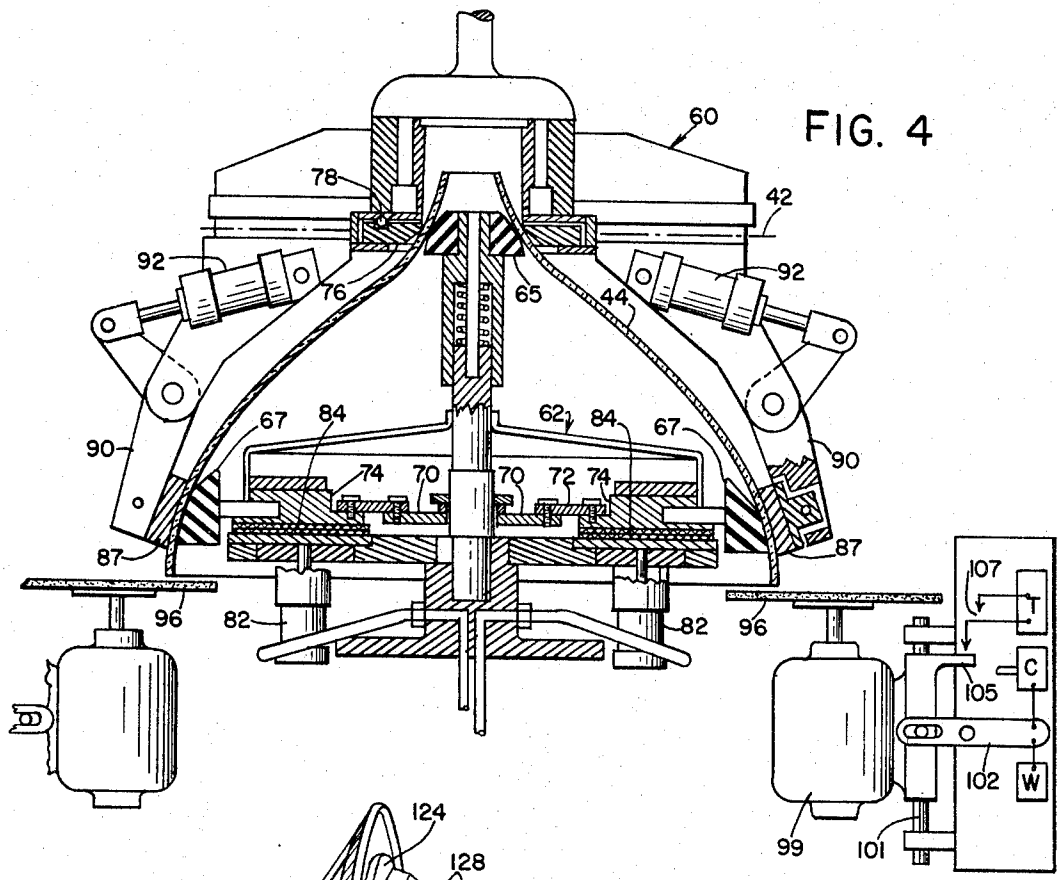
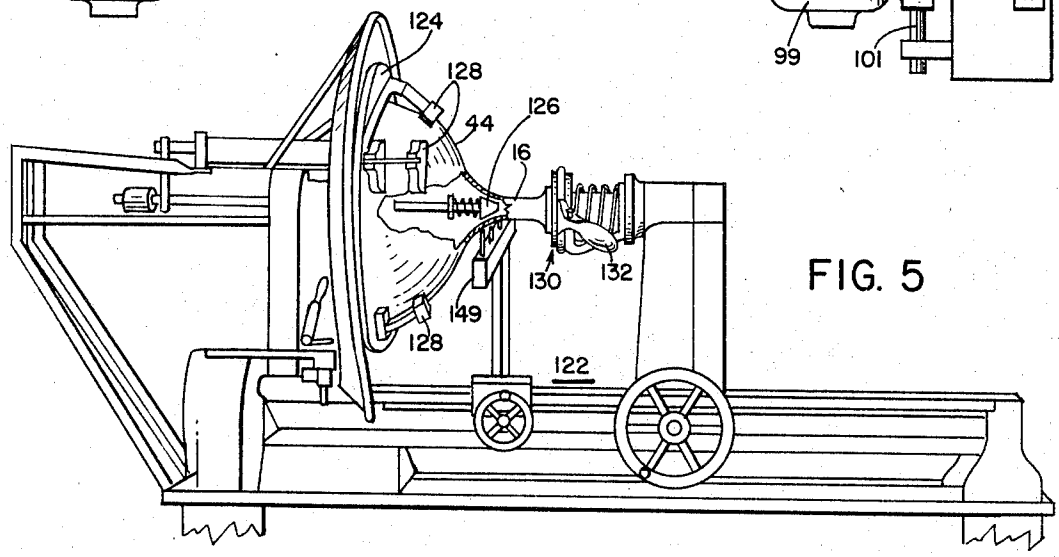


FIG. 5



INVENTOR

Ernest W. Reinwall Jr.

By

Mueller & Aichele

Attys.

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FIG. 6

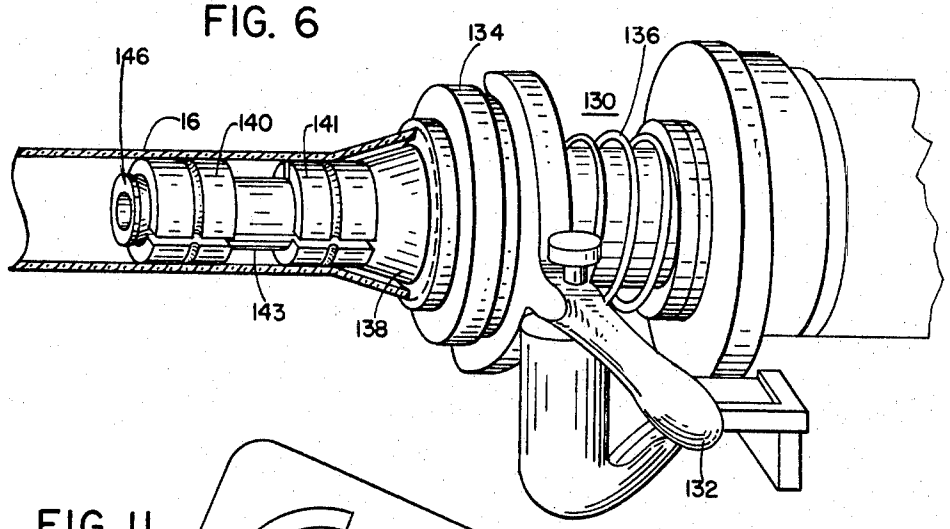
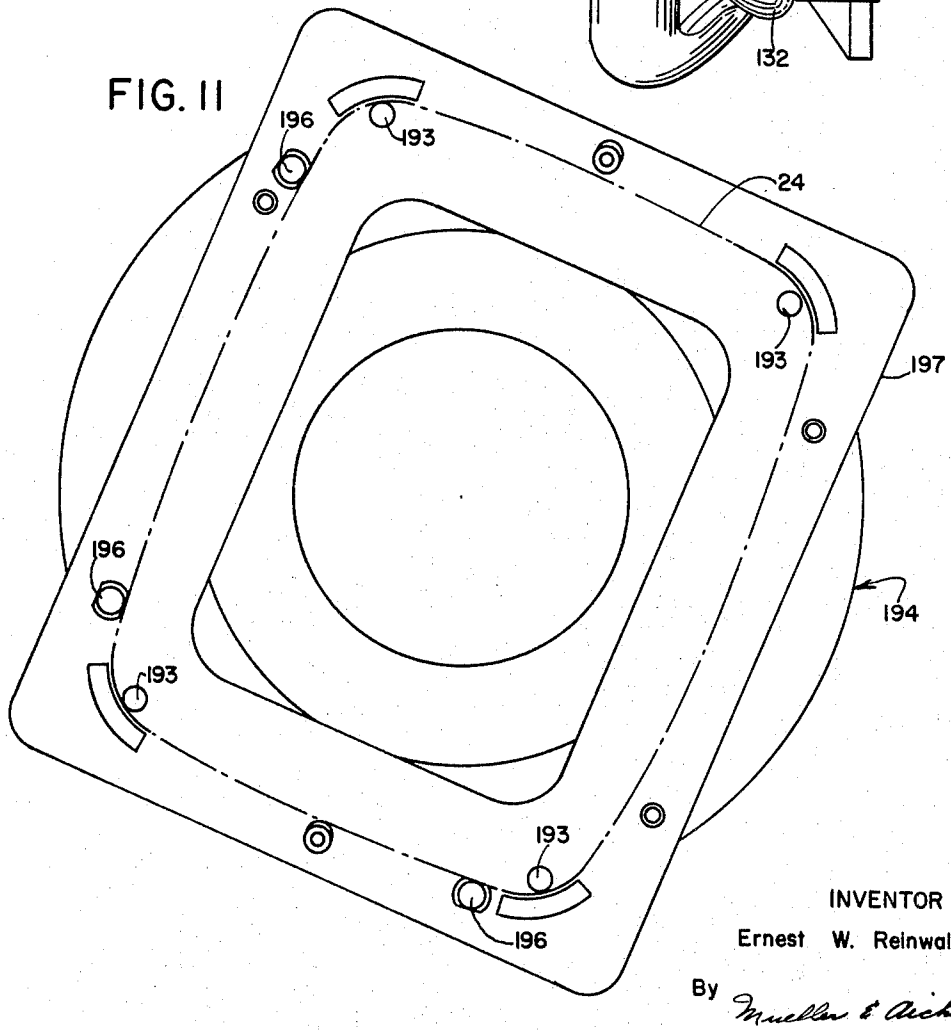


FIG. 11



INVENTOR

Ernest W. Reinwall Jr.

By Mueller & Aichele

Attys.

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FIG. 15

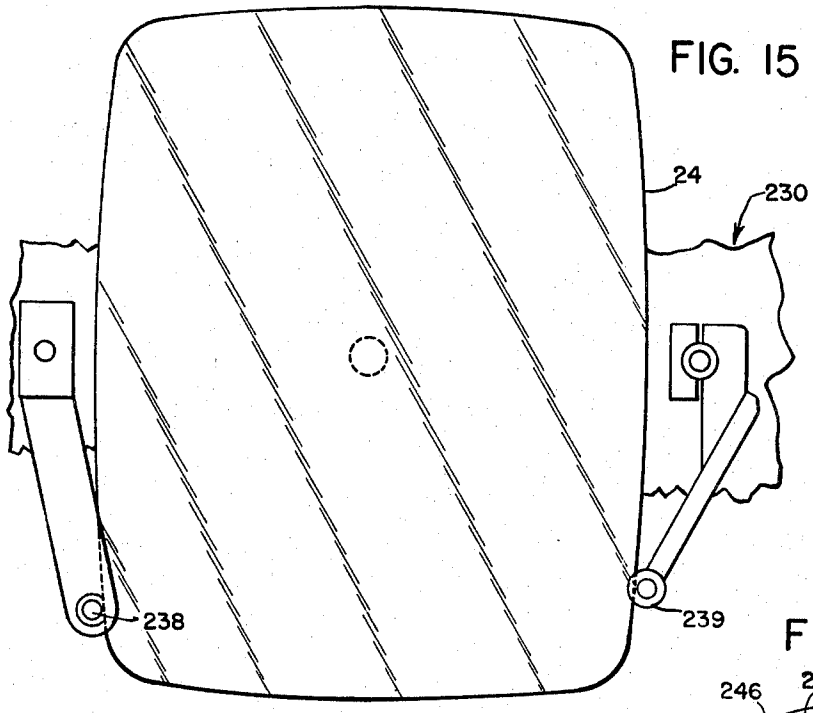


FIG. 16

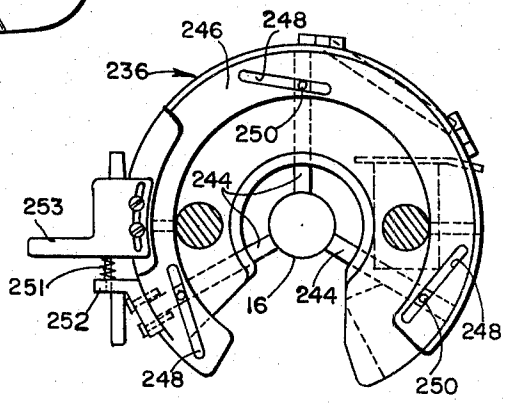
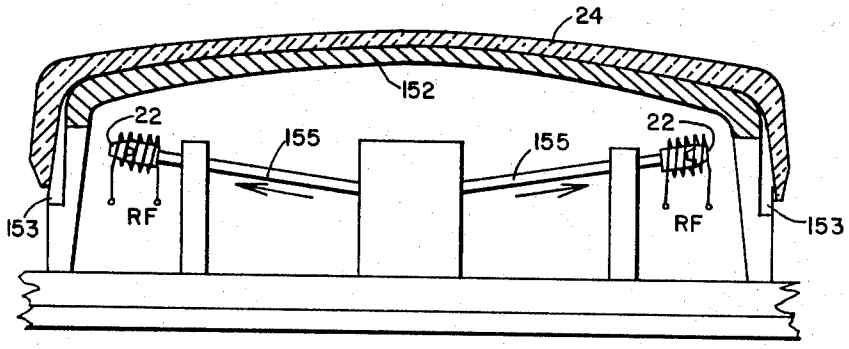


FIG. 7



INVENTOR
Ernest W. Reinwall Jr.

By

Mueller & Aichele

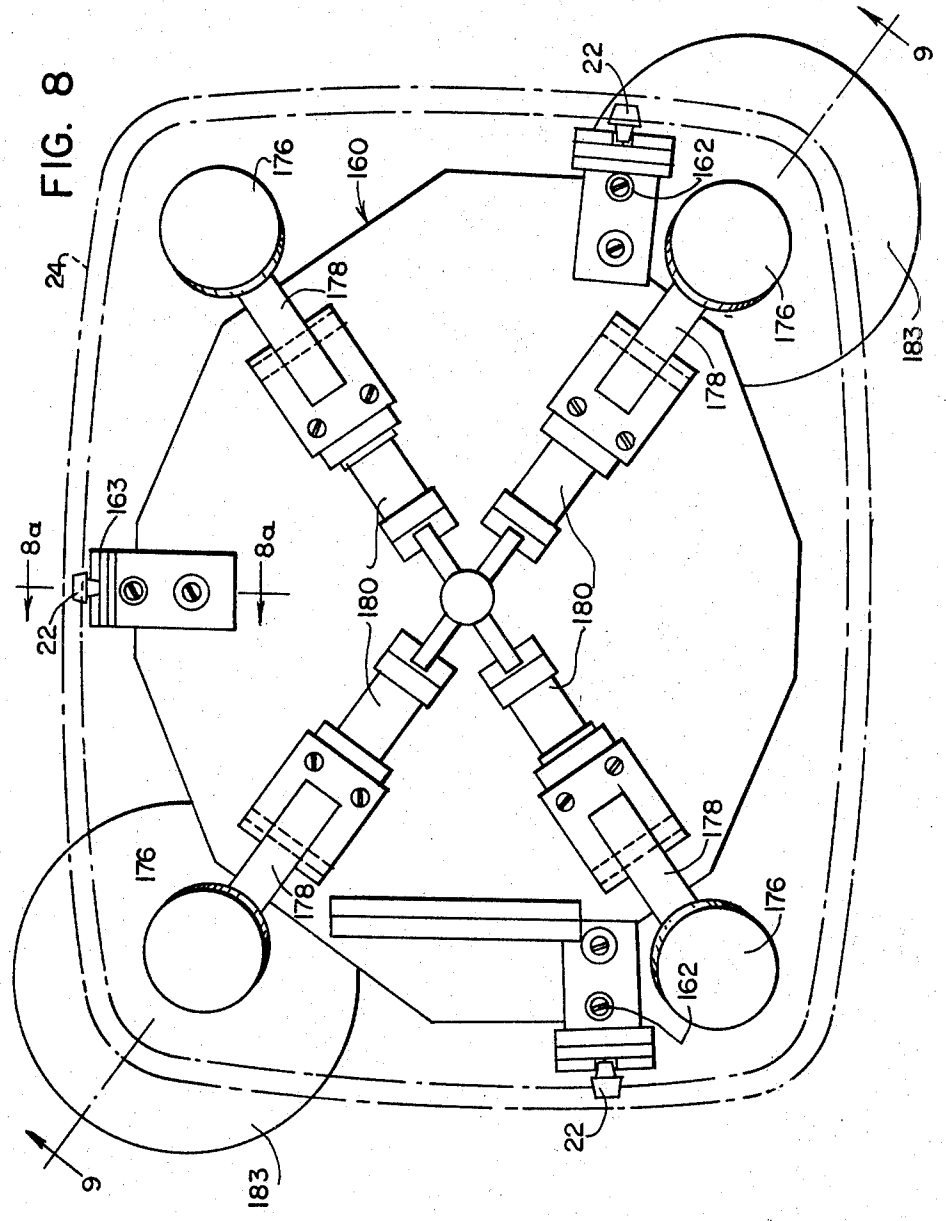
Attys.

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FIG. 8



INVENTOR
Ernest W. Reinwall Jr.

By Mueller & Aichele

Attys.

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FIG. 8a

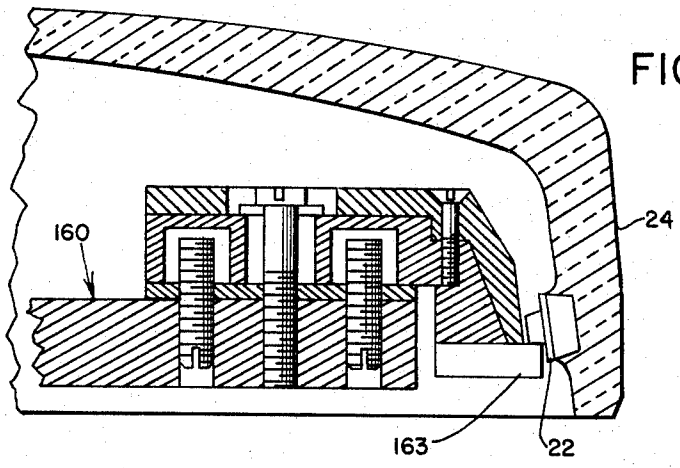
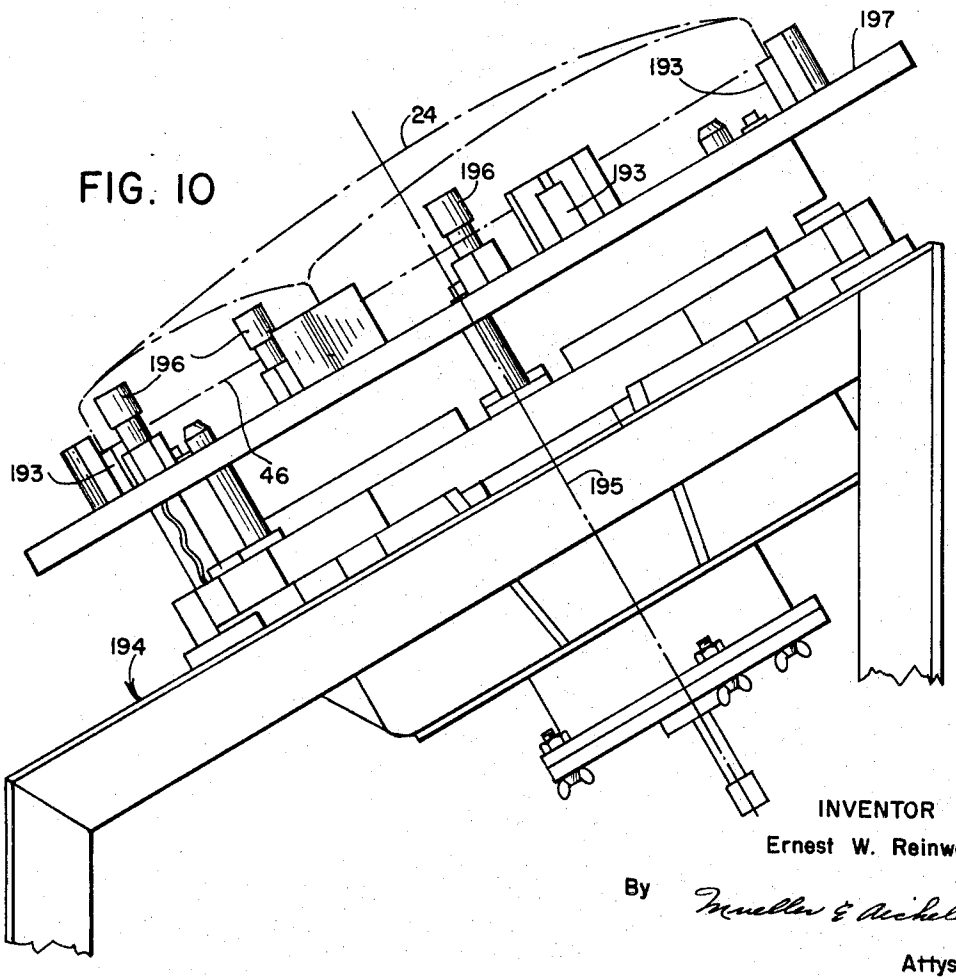


FIG. 10



INVENTOR
Ernest W. Reinwall Jr.

By Mueller & Aichele

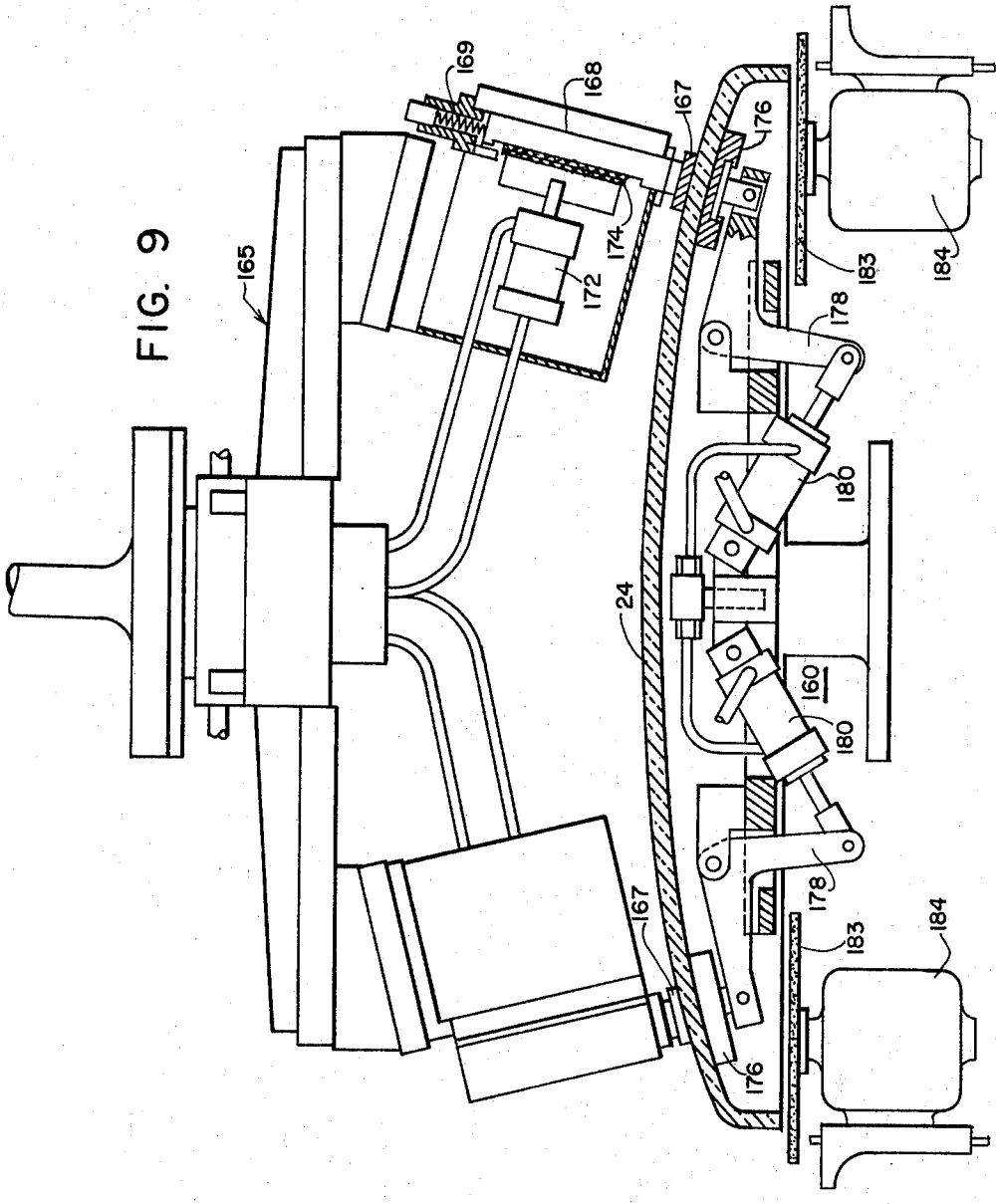
Attys.

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FIG. 9



INVENTOR
Ernest W. Reinwall Jr.

By Mueller & Aichele

Attys.

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FIG. 12

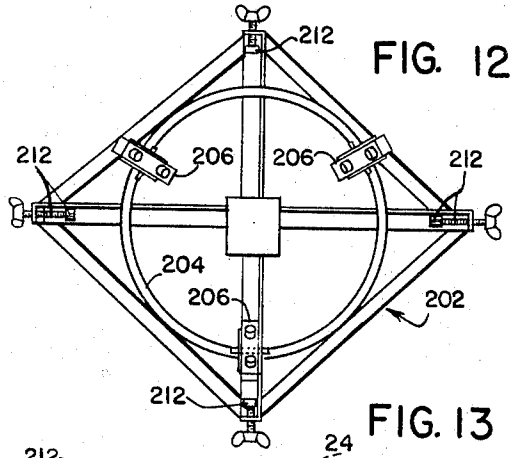


FIG. 13

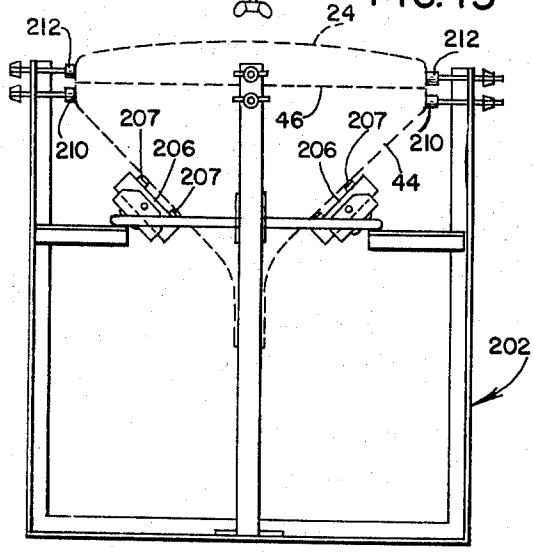
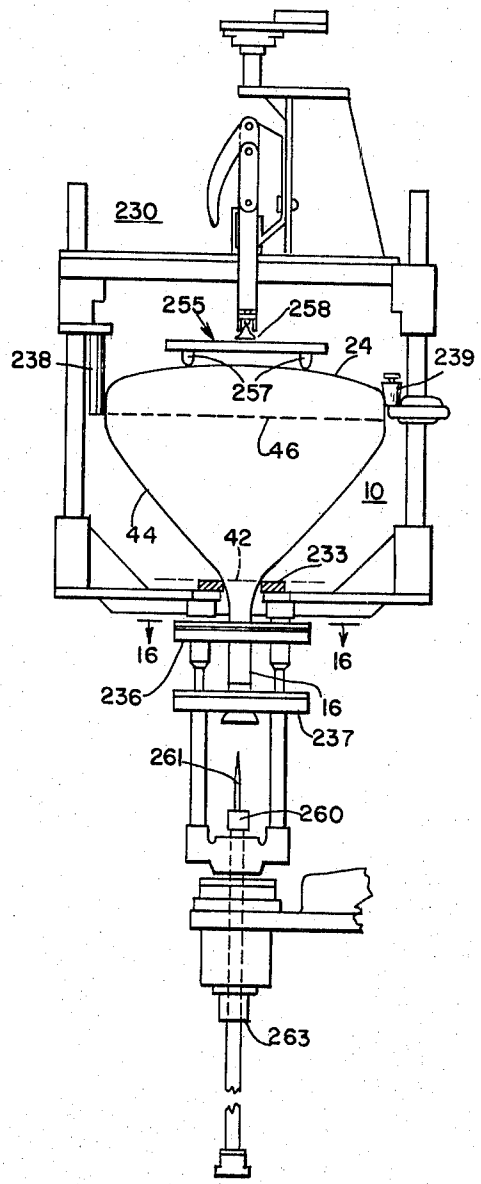


FIG. 14



INVENTOR
Ernest W. Reinwall Jr.
By Mueller & Aichele
Attys

United States Patent Office 3,381,347 Patented May 7, 1968

3,381,347

CATHODE RAY TUBE MANUFACTURE

Ernest W. Reinwall, Jr., McHenry, Ill., assignor to Motorola, Inc., Franklin Park, Ill., a corporation of Illinois

Filed Sept. 3, 1964, Ser. No. 394,152
6 Claims. (Cl. 29—25.13)

ABSTRACT OF THE DISCLOSURE

This is a method for making a rectangular color cathode ray tube. The rearward constricted section of the tube is internally indexed and positioned within a collar extending about the outside of the constricted section to establish a yoke reference plane. The edges of the forward flared section of the tube are ground flat at a predetermined distance from the yoke reference plane to form a panel edge plane perpendicular to the central geometrical axis of the tube. The funnel is then clamped in a neck sealing lathe using the panel edge plane and the yoke reference plane to locate its position. The glass neck is flame sealed to the rearward section of the funnel with the neck being internally chucked and brought into alignment with the funnel by the lathe mechanism. Three studs are inserted in the faceplate panel of the tube to establish a stud plane. The faceplate panel then is clamped in a fixture using the stud plane as a reference and the edges of the side walls are ground to define a panel edge plane parallel to the stud plane. The panel is then frit sealed to the funnel by aligning the front funnel edge plane with the plane of the panel.

This invention relates to color cathode ray tubes and more particularly to the structure and preparation of such tubes which incorporate a shadow mask and multiple electron beams for producing a composite image in color.

In the widely used tri-beam shadow mask color picture tube, three complete sets of phosphor dots are arranged as the screen on the faceplate panel of the tube. The three different sets of phosphor dots emit respectively light of red, blue and green color when impinged by an electron beam. Each group of three different phosphor dots is called a triad and is aligned with an aperture in a shadow mask so that the angle at which an electron beam passes through the mask will determine which of the phosphor dots is impinged. Accordingly, three electron beams are swept scross the shadow mask and screen to produce an image the color of which depends on relative excitation of the three dots in each color triad.

In constructing a cathode ray tube of the above described type for use in a television receiver, it is necessary to form the faceplate panel with its associated mask and phosphor screen as a subassembly and to secure this to the funnel portion of the completed tube. Of course, the electron gun structure which produces the three beams must also be positioned in the neck of the funnel and all of these parts are required to be exactly related in position within very stringent dimensional tolerances. Obviously each triad group of phosphor dots must be extremely small so as to be invisible to the unaided eye at any normal distance from the tube, and the electron beams must be very precisely controlled in order to impinge only the proper phosphor dots to avoid incorrect colors. Due to these stringent requirements on the dimensional accuracy and necessary associated structural rigidity of the completed tube, manufacturing costs of a color tube are substantial and there are numerous production problems in commercially producing quantities of these tubes.

In the past it has been common to use glass of special hardness and thickness (as distinguished from the standard commercially available glass normally used in the manufacture of one gun black and white type cathode ray tubes which do not have a shadow mask) in order to maintain the dimensional tolerances during manufacture and to insure the proper alignment of the various tube parts for correct color reproduction. Glass parts produced for black and white type tubes do not require the accuracy necessary for making shadow mask type color tubes. Black and white type tubes generally use "soft" glass molded with relatively low dimensional tolerance and with the faceplate panel sealed to the funnel prior to the application of the phosphor screen. Accordingly, heretofore commercially available color picture tubes have not been made in production quantities using glass as the "soft" type which is generally available for commercial manufacture of black and white type tubes.

In the past it has also been common to construct color cathode ray tubes with round faceplate panels, rather than rectangular faces as is usual for black and white type tubes. With a round tube face a portion thereof is masked off in order to approximate a more desirable raster shape and proportion for television viewing. The symmetry of a round face color cathode ray tube can present some advantages in manufacture, whereas a rectangular face tube, due to its lack of symmetry, has been found to be more difficult to manufacture and maintain the necessary dimensional accuracy and component alignment. Despite the possibly less difficult task of manufacturing a round face color picture tube, it still has been common to utilize carefully dimensioned external ground indexing areas on the tube parts as guides for assembling the various tube components. Furthermore, it has been frequently necessary to use special or "hard" glass which has been molded within precise dimensional tolerances in order to permit satisfactory manufacture of tubes in substantial quantities.

It is an object of this invention to provide a method of preparation and assembly of the parts of a color cathode ray tube having a rectangular face.

Another object is to improve the accuracy of color cathode ray tubes assembled in production quantities, without the need for external, ground index areas.

Another object is to insure the alignment of the electron gun structure, the shadow mask, and the phosphor screen in a color cathode ray tube, especially one having a rectangular faceplate panel.

A still further object is to use, in the production of color cathode ray tubes, a funnel and faceplate panel composed of "soft" glass having dimensional tolerances normally useful only in production of black and white type cathode ray tubes.

In a specific form of the invention the color cathode ray tube structure and process utilize a standard, commercially available glass panel, funnel, and neck of the type used in the manufacture of black and white type cathode ray tubes. The panel and funnel are dimensioned and processed, and the neck is assembled to the funnel, in order to come within the very close dimensional tolerances required for proper operation of a shadow mask type color tube, despite the fact that these glass components in their initial state are unsuited for use in such a tube.

An example of the glass usable in a black and white type tube, sometimes herein called "soft glass," would be formed of lead-barium type glasses which typically have annealing points in the range of 430° C.–460° C., softening points in the order of 655° C. or less, and have a thermal coefficient of expansion in the range of $85–100\times10^{-7}$/° C. One specific glass that is found to be successful is known as Kimble TM–5 glass (supplied by Kimble Glass Company, Toledo, Ohio) which has an annealing point of 450° C., a softening point of 655° C.

and a thermal coefficient of expansion of 90×10^{-7}/° C. from 0° to 300° C.

The glass funnel, having a rectangular, flared forward section, and a round, constricted rearward section, is clamped centrally of each side of the forward section. The rearward section is internally indexed and positioned within a collar extending about the outside of the constricted section thereby establishing a yoke reference plane. The edges of the forward flared section are then ground flat within a given distance from the yoke reference plane and perpendicular to the central or longitudinal axis of the funnel so that the ground edges form a panel edge plane which is perpendicular to the axis. The funnel is then clamped in a neck sealing lathe using the panel edge plane and an internal centering plunger to locate its position. A glass neck is flame sealed to the rearward section of the funnel with the neck internally chucked and brought into alignment with the funnel by the lathe mechanism.

A rectangular faceplate panel, having depending side walls, is contoured on a mold in an oven in order that the panel and side walls will assume an exact contour and dimension. Three shadow mask mounting studs are installed in the panel side walls, with the panel still supported on its shape determining mold so that these three studs accurately define a stud plane with respect to the contour of the faceplate panel. This faceplate panel is then clamped in a fixture with reference to the stud plane, and the edges of the side walls are ground to define a panel edge plane which is parallel to the stud plane and perpendicular to a central axis through the center of the panel as viewed from the front.

A shadow mask is supported by the studs during exposure of the three phosphor coatings to produce the groups of phosphor triads in the screen. During this exposure operation the faceplate panel is indexed on a light exposure device with reference to the ground panel edge plane and three areas along the exterior periphery of the side walls of the panel so that the nominal physical center of the panel appears on the light source center line.

The funnel is then supported and the panel is placed thereon with the side walls visually aligned with the funnel so that the panel and funnel edge plane and centers coincide for a frit sealing operation to assemble the panel and funnel. Subsequently the electron gun structure is installed in the neck of the tube by supporting the tube in a saddle at the yoke reference plane and jigging the tube neck about its periphery and indexing the periphery of the faceplate panel as it was indexed in the light exposure operation to produce the phosphor screen. The gun structure may then be flame sealed within the neck as it is retained in proper position by this gun sealing jig. Finally the tube is finished by known processes of exhausting the air, the sealing off of the neck, activating the cathode, and the like.

In the drawings:

FIG. 1 is an elevational view of a color cathode ray tube constructed in accordance with the invention;

FIG. 2 is a process flow chart descriptive of producing the tube of FIG. 1;

FIG. 3 is a plan, sectional view representative of a tube funnel clamped for grinding;

FIG. 4 is an elevational sectional view taken along the line 4—4 of FIG. 3 and including further portions of the apparatus not illustrated in FIG. 3;

FIG. 5 is a perspective view of lathe apparatus for flame sealing a neck to the funnel of the tube;

FIG. 6 is a perspective view of the neck chucking apparatus in greater detail than depicted in FIG. 5;

FIG. 7 is a sectional elevational view of a faceplate panel, its contour mold and a representation of stud installing apparatus;

FIG. 8 is a plan view of a portion of the apparatus for clamping a faceplate panel preparatory to grinding its edges;

FIG. 8*a* is a sectional view along the line 8*a*—8*a* of FIG. 8;

FIG. 9 is a sectional view along the line 9—9 of FIG. 8, and illustrating further portions of the apparatus not shown in FIG. 8;

FIG. 10 is a partial elevational view showing the apparatus for light exposing the phosphor screen of a faceplate panel;

FIG. 11 is a plan view of the apparatus of FIG. 10;

FIG. 12 is a plan view of a fixture for supporting the funnel and panel during the frit sealing operation;

FIG. 13 is an elevational view of the fixture of FIG. 12;

FIG. 14 is an elevational view of a portion of the apparatus for supporting the assembled panel and funnel during the installation of the electron beam gun structure;

FIG. 15 is a sectional view along the line 15—15 of FIG. 14; and

FIG. 16 is a sectional view along the line 16—16 of FIG. 14.

In FIG. 1 there is shown a tri-gun, shadow mask type color television tube 10 which may have a beam deflection angle, for example, of 92° and a rectangular face of approximately 16.5 inches by 20.5 inches. The tube 10 includes a base 12 with suitable electrical connectors wired to the electron beam gun structure 14 which is disposed within the tube neck 16.

An apertured shadow mask 18 is spaced from the phosphor screen 20 and supported on the studs 22 melted into the side walls of the faceplate panel 24.

The operation of the tube 10 is generally understood in the art and involves the production of three electron beams by the gun structure 14 which are modulated by video signals and which are deflected across the screen 20 by suitable deflection apparatus. As representative, the beam associated with the so-called red, blue and green guns of the device 14 would travel the paths 26, 27 and 28 and pass through the apertured shadow mask 18 to impinge respective phosphor dots 30, 31 and 32 which form a triad, as previously discussed.

In FIG. 1 the longitudinal center axis of the tube is represented at line 40 and the yoke reference plane is represented by line 42 which passes through the constricted region of the funnel 44 perpendicular to the axis 40 and at an area where the funnel is, for example, 2½ inches in diameter. The line 46 in FIG. 1 represents the juncture of the edge planes of the faceplate panel 24 and the funnel 44. Both of these planes are perpendicular to the axis 40. Line 48 represents the stud plane, which is also perpendicular to the axis 40 and passes through the three studs 22, one on the top of the tube and one on each side, which align and support the shadow mask 18.

The apparatus illustrated in FIGS. 3 and 4 represent a funnel jigging and grinding mechanism to carry out funnel preparation 50 in FIG. 2 and more particularly to establish the seal edge 46 at the proper distance from the yoke reference plane 42 and perpendicular to the funnel center line 40. As previously stated the funnel 44 before treatment may have dimensions totally unfitted for the accuracy required in a color picture tube.

With the upper fixture 60 (FIG. 4) removed for clearance, the funnel 44 is placed on the lower fixture 62. A spring biased centering plunger 65 will engage the interior of the constricted portion of the funnel in the region of the yoke reference plane 42. The centering pads 67 and 68 engage the interior of the forward or flared section of the funnel centrally of each side thereof as shown in FIG. 3. The pads 67 are aligned along the minor axis of the front of the tube and the pads 68 are aligned along the major axis of the front of the tube. The pads 67 and 68 are mounted on respective spring loaded, self-centering linkages to establish the physical center of the funnel and so that each of the pads is firmly engaged with the interior surface of the funnel, despite dimensional variations therein.

As seen in FIG. 3, a rotatably mounted member **70** is spring biased in a clockwise direction and the ends of member **70** are pivotally joined through links **72** to the ends of the slide bars **74**. The bars **74** carry the pads **67**. As shown in FIG. 3, a corresponding linkage mechanism is coupled to the pads **68** to perform a similar self-centering function.

With the funnel **44** thus centered on the lower fixture **62**, the upper fixture **60** (FIG. 4) is lowered to a fixed height so that this fixture will remain vertically locked throughout the remainder of the grinding operation. The upper fixture **60** includes a centering yoke member **76** which is mounted to permit lateral movement within the upper fixture, but which precisely locates the yoke reference plane **42** (FIG. 1) at a particular diameter of the constricted portion of the funnel. Three ball rollers, one being shown as ball bearing **78** in FIG. 4, are disposed between the top of the member **76** and its mounting in the upper fixture **60**. These roller balls are disposed equally about the central axis of the upper and lower fixtures to define an exact plane, with the member **76** bearing against and encircling the funnel neck, the spring biased plunger **65** supporting the inner portion of the funnel on center, and the upper fixture **60** locked to a fixed vertical height.

At this point the centering pads **67** and **68** are locked in their spring biased positions against the interior of the funnel. As shown in FIG. 4, the air cylinders **82** operate a brake mechanism which drives the brake pads **84** upwardly to lock the slide bars **74**. The centering pads **68** are similarly locked in position.

The exterior clamping pads **87** and **88** are locked against the outside of the forward portion of the funnel **44** opposite the location of the centering pads **67** and **68**. As FIG. 4 shows, the clamping pads **87** are pivotally mounted on the rocker arms **90** and these rocker arms are pivotally mounted to the upper fixture. Suitable pneumatic cylinders **92** provide a mechanical drive for pivoting the rocker arms **90** so that the pads **87** are driven into engagement with the exterior of the funnel along its minor axis and opposite the centering pads **67** which have been previously locked in place. In the same manner pads **88** are positioned so that the funnel is clamped preparatory to the operation for grinding its forward edge.

Continuing with step **50** in FIG. 2 and with the funnel **44** clamped as shown in FIG. 4, the upper fixture **60**, the lower fixture **62**, and the funnel are rotated about the central axis of the apparatus by apparatus not shown. Rotating grinding discs **96**, diagonally spaced with respect to the funnel cross section, are fed against the edge of the funnel to provide a ground, seal edge (**46**) perpendicular to the center line of the funnel.

In FIG. 4 there is a representative showing of the control of the grinding disc **96**. An electric motor **99** is slidably mounted on the shaft **101** and a pivotally mounted lever **102** has one end connected to the motor and the other end connected to a weight W and an air cylinder C. The cylinder C can apply an upward force to lower the motor after the grinding operation while the weight W provides gravity drive of the motor upward so that the grinding disc **96** is fed against the edge of the funnel. As much as one-eighth or one-quarter of an inch may be ground from the edge of the funnel **44** in order that this edge will be established at a predetermined distance from the yoke reference plane established by the aperture in member **76**.

The mounting for the electric motor **99** carries a projection **105** (FIG. 4) which engages a switch **107** when the grinding of the funnel edge has progressed to a point just short of the desired edge dimension. At that time the switch **107** is closed to start the timer T which will permit the motor **99** to continue to operate for a predetermined time and then the timer will retract grinding discs **96**, turn off the motor and cause stopping of the rotation of the funnel in its supporting fixture. It should be understood that the apparatus shown associated with the grinding motor **99** is represented schematically to facilitate understanding of its function. The other grinding wheel **96** in FIG. 4 is also controlled in accordance with the above description. Obviously when the funnel has been ground, it is removed from the fixtures **60** and **62** by reversing the previously described clamping operation. After grinding the funnel is acid treated or fortified to remove any sharp surface imperfections which could become focal points for later cracking.

FIGS. 5 and 6 represent the apparatus used in sealing the neck **16** on the constricted portion of the funnel **44** in the performance of step **120** in the process of FIG. 2. The lathe **122** includes a flat head plate **124** having a spring biased centering plunger **126** projecting therefrom. The funnel **44** is placed against the plate **124** and the plunger **126** centers the funnel by engaging it internally of its constricted portion. The ground edge of the funnel is held in contact with the plate **124** by means of clamps **128** which engage the outside of the funnel at its corners. In this way the ground edge of the funnel (**46** in FIG. 1) is perpendicular to the center line of the lathe and the center line of the funnel (**40** in FIG. 1) coincides with the center line of the lathe.

As best seen in FIG. 6, the tube neck is moved into place on the lathe by a tail stock chuck **130**. Movement of pivotally mounted handle **132** to the left will cause sliding movement of the ring **134** to the right against the compression spring **136**. The cone **138** moves to the right with ring **134** thus releasing the expansion pressure on the split collets **140** and **141**. The collets **140** and **141** are surrounded by garter springs which will cause them to collapse, or reduce in diameter so the neck **16** may be placed as shown in FIG. 6. Then subsequent release of handle **132** will cause spring **136** to urge the ring **134** to the left and move the cone **138** to the left against the collet **141**. Collets **140** and **141** slide to the left, and are maintained in their spacing by means of a spacing collar **143**. A central spindle **146** of the tail stock is stationary and includes a conical portion against which the collet **140** is expanded. In this way both collets **140** and **141** are compressed between the cones **138** and **146** to expand and support the neck **16** on the center line of the lathe.

Referring again to FIG. 5, and with the neck **16** inside chucked as described, the lathe mechanism is used to bring the neck to a position against the constricted portion of funnel **44** so that the funnel and neck can be flame sealed through melting of the glass by means of the burner **149**. During the flame sealing operation the lathe stocks are rotated and the neck is thus secured in accurate alignment with the center line of the funnel. By reversing the above described setup procedure, the assembled funnel and neck may be removed from the lathe for later assembly with the faceplate panel.

The process step **150** in FIG. 2 is carried out by means of apparatus illustrated in FIGS. 7, 8 and 9. The faceplate panel **24** is contoured, dimensioned and studded as illustrated schematically in FIG. 7. The panel **24** is placed on the contour mold **152** which is passed through a suitable oven so that the glass becomes soft and sags or drapes over the mold surface to precisely contour the screen area of the panel. The mold **152** additionally includes sizing areas **153** so that the side walls of the panel **24** will conform to these sizing areas thus accurately determining the spacing between the side walls .

After emerging from the contouring oven, the panel **24**, still on the mold **152**, is placed in apparatus for inserting the studs **22**. While the panel **24** is hot from the contouring operation, the studs **22** are heated by means of radio frequency energy and the arms **155** are driven outwardly so that the heat from the studs **22** melts the glass in the side walls to permit them to be melted into place (see FIG. 8*a* showing a stud completely installed). The radio frequency energy is then turned off and the

studs are held in place while the glass resolidifies so that the studs 22 are precisely located with respect to an accurately contoured faceplate and its side walls. The studs 22, located about the side walls as shown in FIG. 8, thus define a stud plane 48 (FIG. 1). The apertured shadow mask 18 can then be accurately supported on the studs so that its distance and location with respect to the screen 20 is fixed.

As previously noted the faceplate panel 24 may be composed of commercial soft glass and/or glass which has not been originally molded to sufficient tolerance to enable it to be used in the color tube 10. Accordingly, the bottom edges of the side wall flanges are ground with respect to the stud plane 48 so that this ground edge, 46 in FIG. 1, will match the panel to the ground edge of the funnel. Thus further faceplate panel preparation in step 150 involves the grinding of as much as one-fourth to three-eighths of an inch from the edge of the side wall flange of the panel 24.

The panel 24 is located on the lower fixture 160 shown in FIG. 8 with the studs 22 resting in the V-shaped stud supports 162 and on the flat stud support 163. These supports also align wtih the stud ends for lateral positioning of the panel. In this way the stud plane 48 will be accurately located in the fixture 160, and, of course, the stud plane has been previously established with high accuracy with respect to the contour of the face of the panel. FIG. 8*a* shows the detail of engagement between the top stud 22 and the flat rest pad 163. It may be noted that the rest pads are made adjustable and then capable of being locked into place when properly set.

With the panel accurately indexed on the grinding fixture, the upper fixture 165 (FIG. 9) is lowered to bring four spring biased pads 167 into engagement with the top of the panel 24 in the region of each corner of the rectangular panel. Pads 167 are mounted on slidable members 168 which are spring biased by springs 169 towards the top of the panel. Accordingly all four pads 167 firmly engage the top surface of the panel. The members 168 are then locked in place by means of air cylinders 172 which apply pressure to the break pads 174, similar mechanisms control each pad.

The lower fixture 160 includes four pressure pads 176, one located immediately under each of the top pressure pads 167. The pads 176 are pivotally mounted to the rocker arms 178 which are driven by the air cylinder 180 to pivot the pads 176 upwardly so that the panel 24 is sandwiched between the pads 167 and 176.

With the panel 24 locked as depicted in FIG. 9, the upper fixture 165, the lower fixture 160 and the panel 24 are rotated by means not shown while the grinder wheels 183 are fed against the edge of the side walls of the panel. The grinder wheels 183 are powered by electric motors 184 which may be driven and controlled by apparatus represented schematically in FIG. 4. That is, the grinding wheels are gravity driven against the panel edge until a predetermined stop is reached, at which time a timed finishing operation takes place to complete the side wall edge perpendicular to the center axis 40 (FIG. 1) and parallel to the stud plane 48. When this edge has been completed, the grinding wheels 183 are lowered, the rotation of the fixtures 160 and 165 is stopped and the panel is removed by reversing the above described process. The panel is acid fortified to remove sharp edges.

Upon completion of panel preparation 150 in FIG. 2, the phosphor screen application 188 is carried out. In step 188 three different phosphor coatings are applied to the interior of the panel 24, each coating is exposed in a lighthouse through the shadow mask 18, and it is developed to produce one of the sets of phosphor dots 30, 31 or 32. More particularly a phosphor slurry of one light emitting type is deposited on the screen area 20 of the panel 24 and then dried. Shadow mask assembly 18 is inserted and the lighthouse exposure is made, which will be described in more detail subsequently. Following the light exposure the exposed set of phosphor dots is developed and the unexposed phosphor is removed, leaving a set of phosphor dots emitting a light of one color. The entire procedure is repeated twice more so that there are three complete sets of the phosphor dots, for example, dots 30, 31 and 32 in FIG. 1. Since the production of the dots is associated with the particular apertures of the shadow mask 18 the angle of approach of each of the three electron beams will determine which dots are impinged by each beam. This is a known and understood operation of a tri-beam shadow mask type color television tube.

Apparatus for performing step 188 is illustrated in FIGS. 10 and 11. After a phosphor slurry has been deposited on the interior of the faceplate panel through procedures known in the art, shadow mask 18 is installed in the panel on the studs 22 and the panel is placed on the lighthouse exposure device 194. The device 194 has a reference center line 195 with respect to which a point source of light is located to correspond to the location from which an electron beam would be produced from one of the three electron guns in the gun structure 14 (FIGURE 1). For each of the three different operations for producing the separate phosphor dots the lighthouse apparatus 194 has a source of exposing light positioned differently so that an exposure is made corresponding to the position of each of the three electron guns, one associated with each of the three different prosphor coatings that are deposited on the screen. This means that the beam from each gun in the gun structure 14 will thus pass through the shadow mask 18 to strike only its intended phosphor dots.

In order to assure that the phosphor dots are accurately located with respect to the associated electron beam of the completed tube, the panel 24 must be precisely indexed in the device 194. Accordingly the ground edge of the panel corresponding to the panel edge plane 46 is supported on the four posts 193 to establish the distance between the screen of the panel and the exposing light source. Further to insure that the center line 195 of the lighthouse apparatus coincides with the nominal center line of the faceplate panel (line 40) there are three centering posts 196 extending upwardly from the face 197 of the lighthouse apparatus. Two of the posts 196 engage the long side of the faceplate panel 24 and one of the posts engages the short side. The lighthouse face 197 is disposed at an angle so that the weight of the panel 24 (it may weight 15 pounds, for example) will cause it to nest against the posts 196. It will be noted that the side walls of the panel 124 have been previously sized (FIG. 7) so that they are accurately spaced from one another. It has been found that the wall thickness of the side walls is sufficiently accurate that outside indexing of the panel on the lighthouse structure 194 will maintain a sufficient accuracy for coincidence of the panel center line 40 with the lighthouse center line 195.

Further details in the performance of step 188 (FIG. 2) include lacquering of the completed phosphor screen and aluminizing of the panel, as is familiar to those in the cathode ray tube art. The shadow mask 18 is then finally installed in the panel 24 and the panel subassembly is glass soldered or frit sealed to the funnel 44 in the step 200. FIGS. 12 and 13 show a fixture or jig 202 for supporting the funnel and panel as they pass through an oven to make the air tight seal along the panel and funnel edge plane 46.

The frame or fixture 202 includes a loop 204 containing three equally spaced, pivotally mounted supports 206. Supports 206 each carry carbon buttons 207 which support the funnel in its relatively strong region, intermediate the front and back thereof. In addition there are four carbon buttons 210, which are mounted on manually adjustable thumb screws so that the buttons 210 can be turned against the center of each side of the front of the

funnel 44 to prevent lateral movement thereof. The complete faceplate panel assembly 24 is diagonally centered upon the forward section of the funnel 44 with the ground edges thereof mated along line 46. A frit sealing compound is deposited along the ground edges of these glass parts and the panel is laterally shifted for optimum centering, which can be satisfactorily accomplished by visually determining the best match across the diagonals of the panel and funnel. The wall thickness of the glass parts 24 and 44 is accurate enough, and the described apparatus is capable of sufficient accuracy, that matching of the panel and funnel is well within the necessary manufacturing tolerances. The four additional carbon buttons 212, which are also mounted on adjustable thumb screws are then turned against the centers of the sides of the panel 24 to prevent lateral shift. With the panel and the funnel so aligned the assembly may be passed through an oven for melting the frit compound and soldering the parts together along the edge plane 46.

Step 220 (FIG. 2) involves installation and sealing of the electron gun assembly 14 within the neck 16 of the tube 10. Apparatus illustrated in FIGS. 14, 15 and 16 is used to properly support and index the tube for this step of assembly. It is necessary that the gun structure 14 be accurately aligned with the central axis 40 and positioned at a predetermined distance from the yoke reference plate 42.

The gun sealing fixture 230 includes a laterally movable saddle 233 having an aperture which supports the funnel 44 at its yoke reference plate 42. The upper and lower neck centering chucks 236 and 237 are then closed to engage the tube neck 16 so that the tube is axially aligned along its axis 40 within the fixture 230.

As seen in FIG. 15 the fixture 230 includes a fixed rotational alignment pin 238 which bears against the side wall of the panel 24 in the same location that post 196 engages the panel (FIG. 11). A rotating alignment pin 239 is then moved in a clockwise direction against the opposite side wall of the panel 24 and locked in this position so that the tube is secured against rotational movement during the gun sealing operation 220.

FIG. 16 shows a plan view of the upper neck centering chuck 236. This chuck includes jaws 244 equally spaced about the tube neck 16 and radially slidable forward and away from the neck. A cam plate 246 is rotatably mounted and includes slots 248 into which the jaw mounted pins 250 extend. Thus it may be seen that rotation of the cam plate 246 will change the relative radial positions of the jaws 244.

Member 252 is coupled to the cam plate 246 and is coupled through spring 251 to the control handle 253. The handle 253 is slidably mounted so that moving this down in FIG. 16 will bring the compression spring 251 against the member 252 and cause cam plate 246 to move in a counter clockwise direction thereby closing the jaws 244 into engagement with the neck 16. A suitable locking clamp (not shown) for the handle 253 will therefore maintain a spring controlled pressure on the jaws 244 for axially aligning the tube neck within the gun sealing fixture 230. Lower centering chuck 237 may be similarly constructed.

With the tube 10 axially centered and located with respect to the yoke reference plane and secured against rotational movement, the upper clamp 255 (FIG. 14) is lowered so that the clamping pad 257 engages the face of the panel 24. The clamp 255 includes a universal joint 258 so that the pads 257 will securely engage the faceplate panel and prevent any vertical movement of the tube. It may be noted that the clamp 255 will secure the tube 10 in the floating yoke saddle 233.

The electron gun holder 260 is precisely located on the center line of the fixture and includes sutiable apertures (not shown) to engage the pins of the electron gun structure 14 and properly center it in the fixture 230. The rotational position of the electron gun structure must coincide with the different positions of the light sources in the lighthouse apparatus 194 and this is accomplished in the gun support 260. The pin 261 further centrally aligns the gun structure on the fixture so that the holder 260 and gun can be moved upwardly into a central position within the neck 16 of the tube. The electron gun structure is moved upward until its support engages the stop surface 263 which accurately determines the axial position of the gun with respect to the yoke reference plane 42. With the gun structure thus positioned, the lower centering chuck 237 is released and moved clear of the open end of the neck 16 while a flame sealing apparatus (not shown) is brought up to this area for melting the glass at the neck and securing the gun structure in place. During this operation the fixture 230 is rotated about its central axis for uniformly forming the glass gun seal.

With the gun installation step 220 complete (FIG. 2) various additional tube finishing steps 220 are performed. These finishing steps include the known and understood processes of pumping the tube to a vacuum, baking it in an oven, and sealing off the gun tip. There are further conventional steps of activating the cathode, installing the Bakelite base on the connector pins of the gun structure and the like, elaboration of these additional steps not being necessary in understanding the processes and structure described herein.

The process and structure described in the foregoing permit the establishment of a locating central axis through the tube parts and the finished cathode ray tube in order to assist in manufacture and assembly of such a tube with a rectangular faceplate. Furthermore, it is possible to utilize glass parts which have only dimensional tolerances suitable for black and white one gun picture tubes, and to process these parts so that they can be assembled with precision and on a production basis for the manufacture of a tri-gun shadow mask type color picture tube. Through the use of the described process and fixtures or jigs for machining and assembling the parts, very stringent dimensional tolerances can be maintained so that the tubes operate properly without undue beam landing errors, while still maintaining a desirably high production yield.

I claim:

1. A process for producing a color picture tube, including the steps of: providing a glass funnel having a forward section and a constricted rearward section with a central axis extending therethrough, establishing a yoke reference plane in the region of said rearward section and perpendicular to said central axis, forming an edge of said forward section at a specified distance from said yoke reference plane, providing a faceplate panel having side walls depending therefrom, forming the edge of said side walls in a single plane at a specified distance from the face of said panel, applying a phosphor screen to said panel by reference to the edge of said side walls and to an axis through said panel perpendicular to the plane of the edge of said side walls, joining said funnel to said faceplate panel with the edges thereof abutting one another, and installing an electron gun structure in said constricted section aligned with the central axis and spaced a given distance from the yoke reference plane.

2. A process for producing an envelope for a color picture tube, including the steps of: providing a glass funnel having a forward section and a constricted rearward section, said funnel having a central longitudinal axis and a yoke reference plane perpendicular to said axis in the region of said rearward section, grinding the edge of said forward section to a given distance from said yoke reference plane and perpendicular to said central axis, providing a faceplate panel with shadow mask mounting studs on the interior side walls thereof, said studs being indexed with respect to the contour of the face of said panel, grinding the edge of the side walls of said panel to a specified distance from the face of said panel and in a plane

parallel to said stud plane, and joining the ground edges of said panel and said funnel with the side walls and the forward section aligned to provide a picture tube envelope.

3. In producing a faceplate panel for a color picture tube the steps of: providing a faceplate panel having side walls depending therefrom and shadow mask supporting studs disposed in said side walls in predetermined relation with respect to the face of said panel, supporting said panel on said studs, applying spring biased pads against the outer surface of said panel, locking said pads in fixed relation against said panel, clamping the inner surface of the face of said panel against said pads, and grinding the edge of said side walls to form a plane providing a reference with respect to said studs and the face of said panel so that a phosphor screen may be applied to said panel referenced to the ground edge of said side walls.

4. A process for producing a color picture tube, including the steps of: providing a glass funnel having a forward section and a constricted rearward section, said funnel having a central longitudinal axis and a yoke reference plane perpendicular to said axis in the region of said rearward section, grinding the edge of said forward section to a given distance from said yoke reference plane and perpendicular to said central axis, providing a faceplate panel with shadow mask mounting studs on the interior side walls thereof, said studs being indexed with respect to the contour of the face of said panel, grinding the edge of the side walls of said panel to a specified distance from the face of said panel and in a plane parallel to said stud plane, applying a phosphor screen to said panel referenced with respect to the ground edge thereof and the contour of said side walls, sealing the ground edges of said panel and said funnel with the side walls and the forward section of said funnel in alignment, and installing an electron gun structure in said constricted section aligned with said central axis at a given distance from said yoke reference plane.

5. In the manufacture of cathode ray tubes the process for producing a rectangular screen color picture tube, including the steps of: providing a glass funnel having a rectangular forward section and a round rearward section, clamping said forward section centrally of each side thereof, center indexing said rearward section within a collar to establish a yoke reference plane thereabout and a funnel central axis, grinding the edges of said forward section to a given distance from said yoke reference plane and perpendicular to said funnel center line, flame sealing a glass neck to the rear end of said funnel with the neck and the rearward section internally aligned along the funnel central axis and the ground funnel edge perpendicular to the neck, providing a faceplate panel with three shadow mask mounting studs on the interior side walls and indexed with respect to the contour of said panel to establish a stud plane, clamping said panel with respect to the studs and grinding the edges of said side walls of said panel to a specified distance from, and parallel to, said stud plane, applying a screen to said faceplate panel referenced to the ground edges thereof and to the periphery of the side walls thereof, sealing the ground edges of said faceplate panel and said forward section of said funnel with said funnel forward section and the side walls of said panel in alignment across diagonals thereof, and installing an electron gun structure indexed to said yoke reference plane and said neck.

6. In producing a funnel for a color picture tube the steps of: providing a glass funnel having a forward section and a constricted rearward section with a geometric central axis extending therethrough, aligning said funnel on a spring biased central plunger and engaging said forward section internally thereof on spring biased self-centering linkage arms mutually extendable to engage and position at the geometric center thereof the interior surface of said funnel adjacent said forward section, locking the linkage arms, clamping the outside of said forward section against the linkage arms, grinding the edge of said forward section perpendicular to the geometric central axis and at a given distance from a yoke reference plane in the region of said rearward section, aligning the ground funnel on a spring biased central plunger and clamping the ground edge thereof in a neck sealing lathe so that the funnel turns about the geometric central axis, chucking a tube neck in alignment with said rearward section and joining said neck to said funnel.

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WILLIAM I. BROOKS, *Primary Examiner.*