

[54] **ELECTRON GUN CONSTRUCTION FOR
MULTI-BEAM COLOR CATHODE RAY
TUBE**

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[*] Notice: The portion of the term of this
patent subsequent to Nov. 6, 1990,
has been disclaimed.

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No. 3,771,002.

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[51] Int. Cl.² **H01J 29/32; H01J 31/20**

[58] Field of Search **313/411**

[56] **References Cited**

UNITED STATES PATENTS

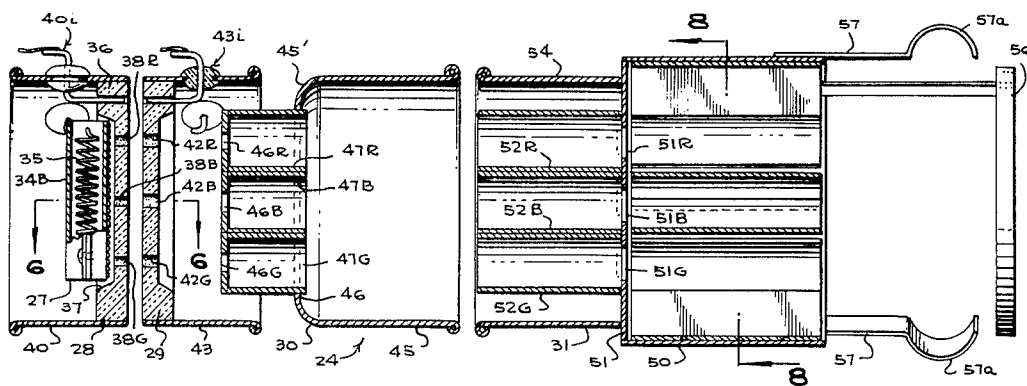
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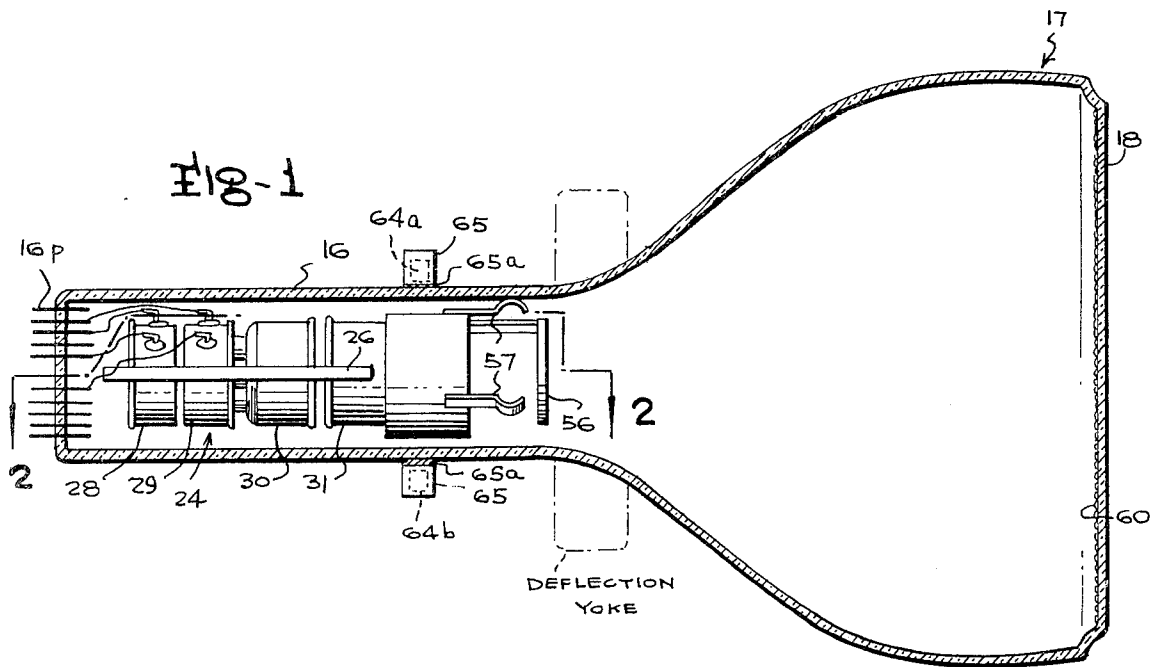
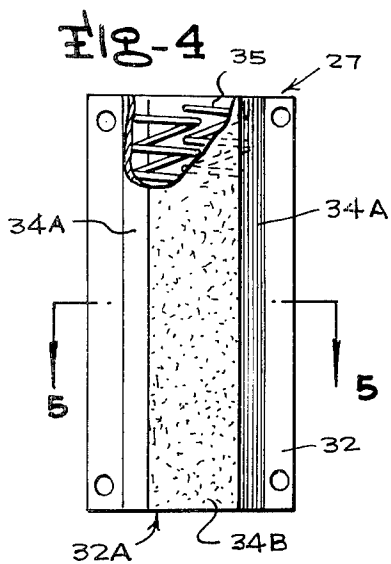
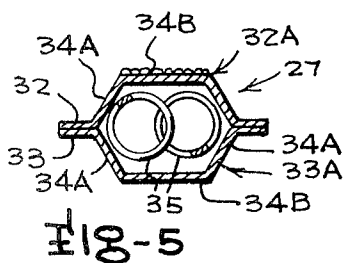
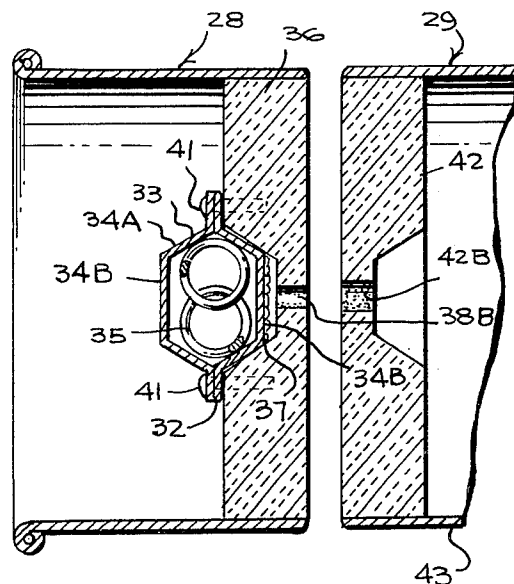
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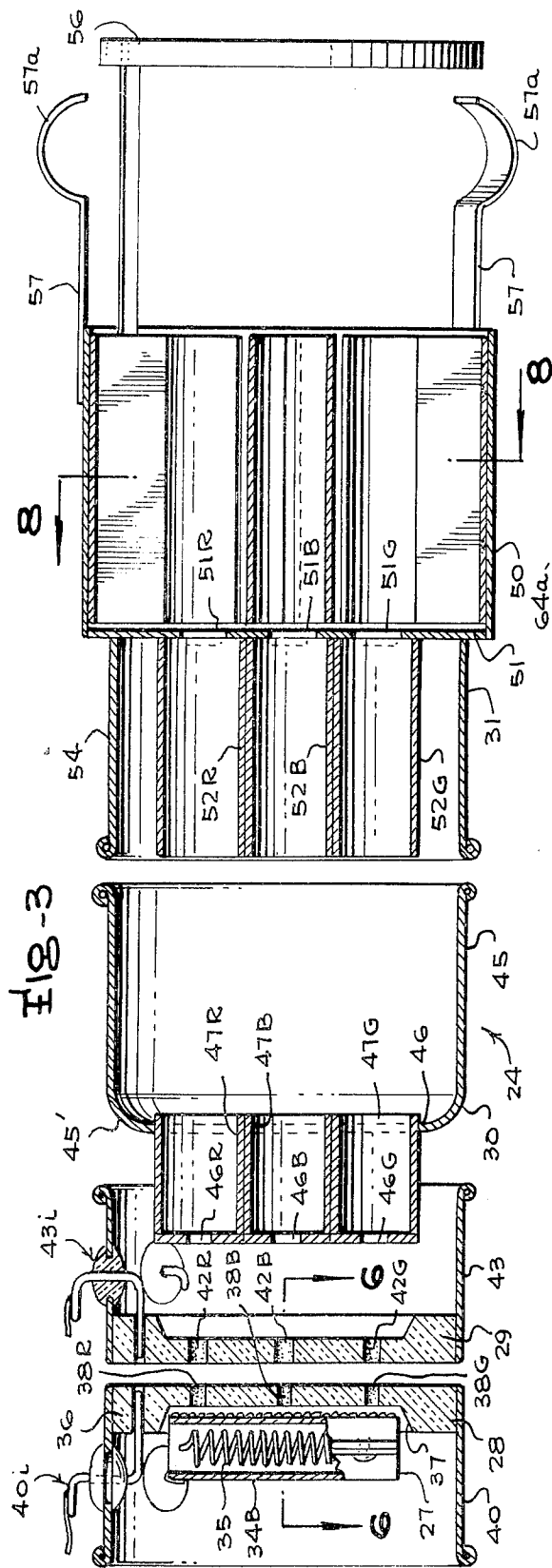
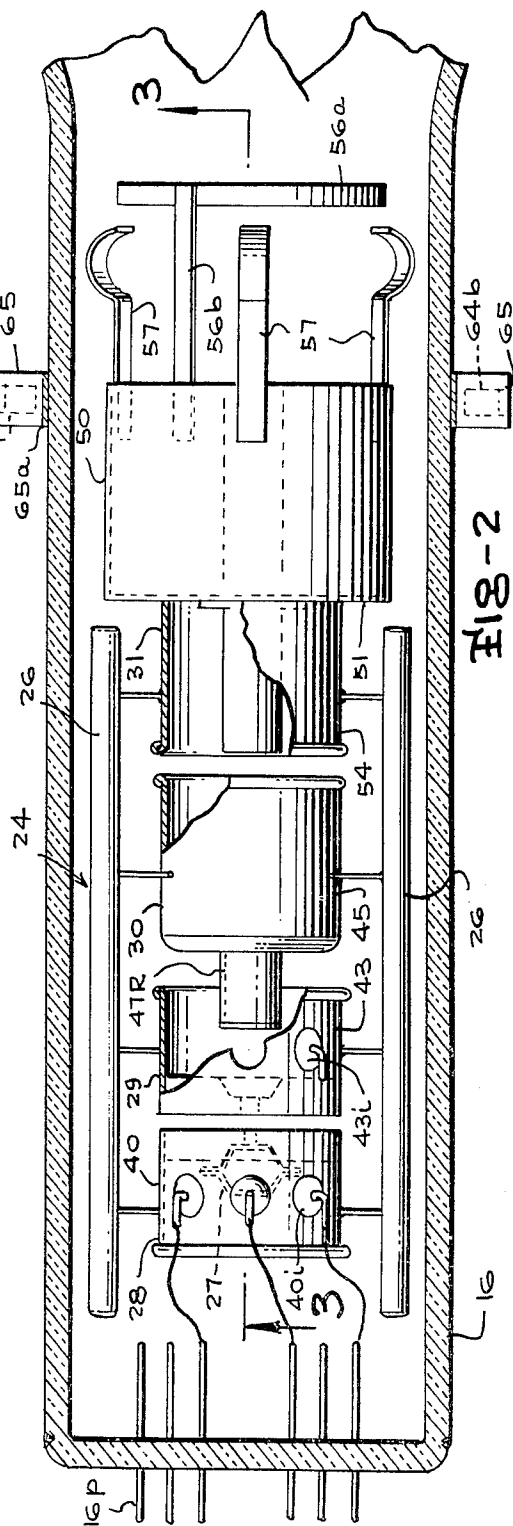
[57] **ABSTRACT**

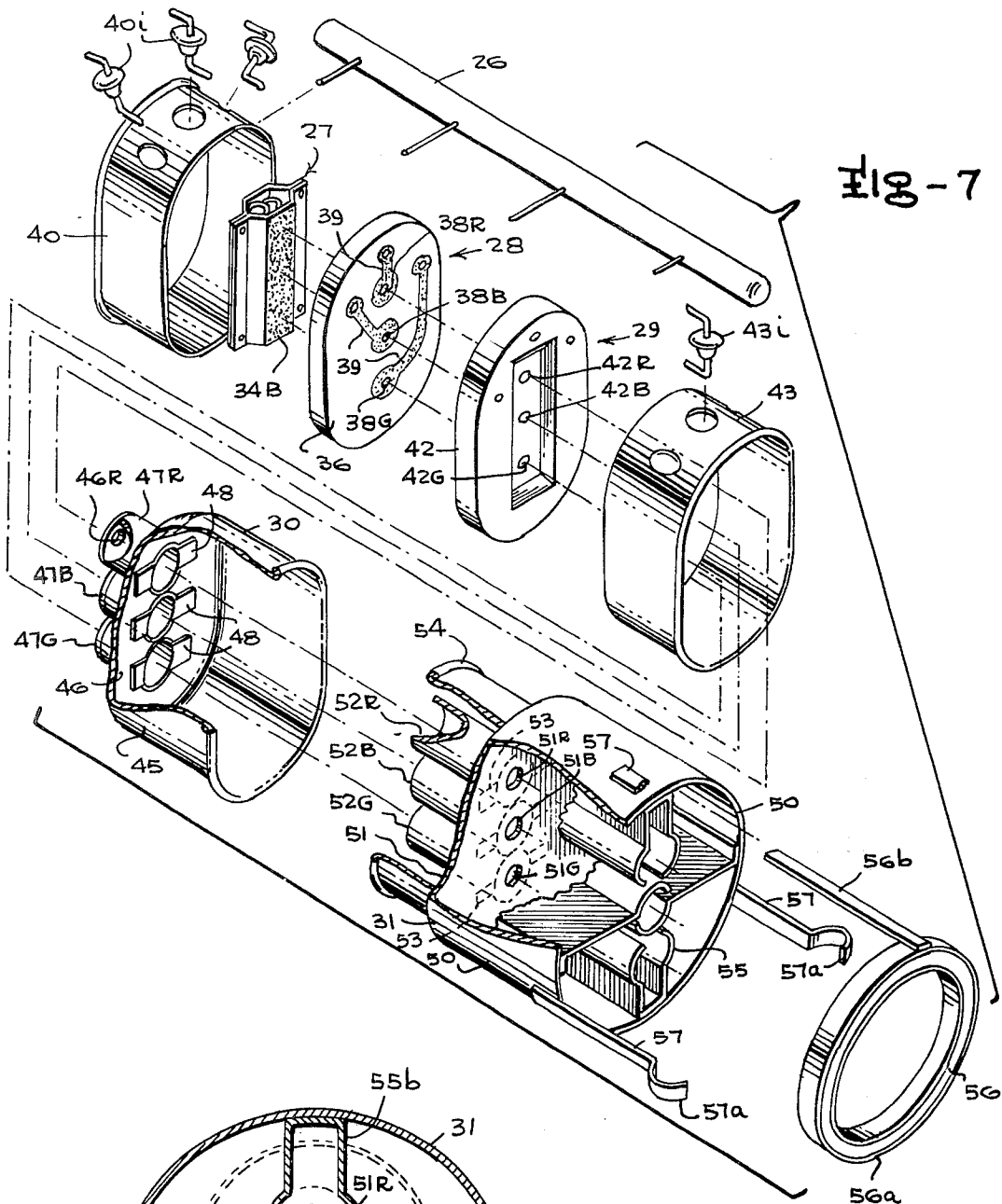
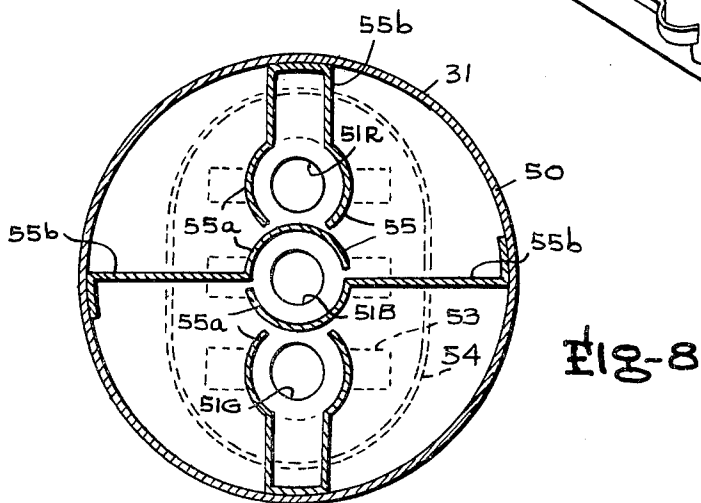
An electron gun construction for cathode ray tubes which produces plural beams from a single electron gun having a single cathode and having a control grid and a first anode each of which have at least three beam apertures arranged for example to produce three vertically spaced beams. Focus and accelerating anodes for the plural beams are also provided. In a preferred tri-color example, the phosphor screen is made up of successive vertical sets of color-producing phosphor zones arranged in three, substantially horizontal rows of red, blue and green producing phosphor spaced in vertical succession and scanned by the three beams.

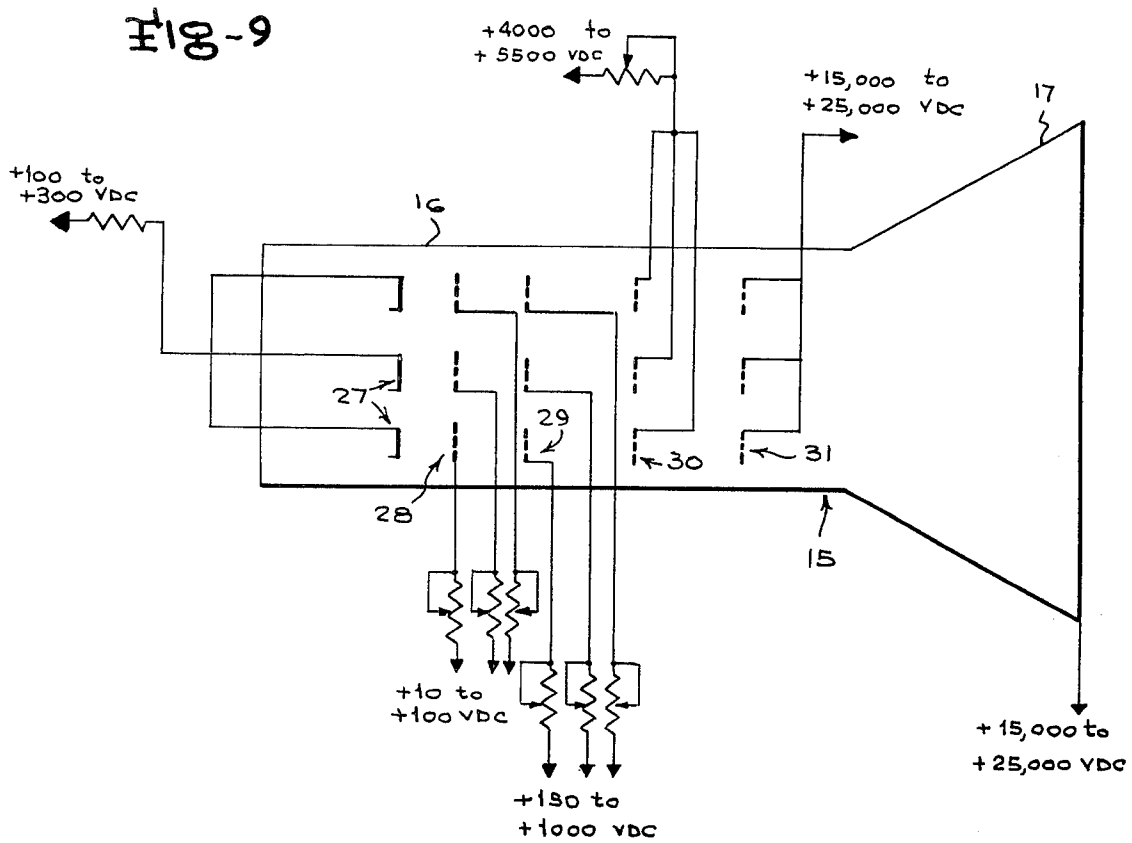
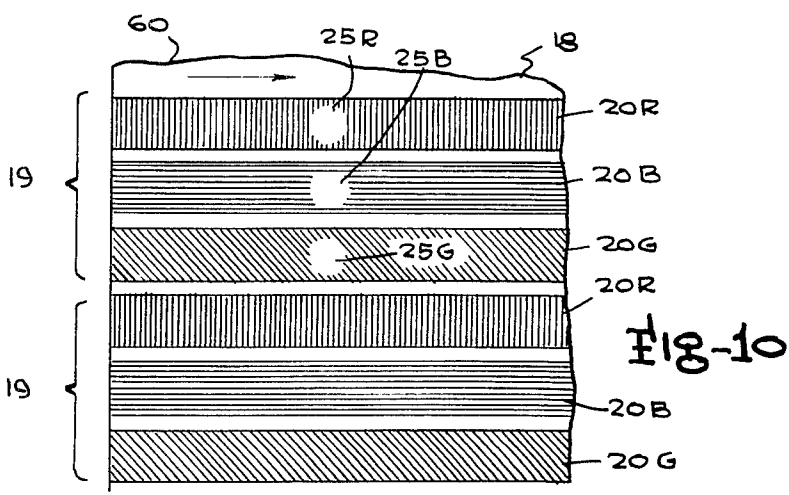
16 Claims, 10 Drawing Figures











ELECTRON GUN CONSTRUCTION FOR MULTI-BEAM COLOR CATHODE RAY TUBE

PRIOR RELATED APPLICATION

This application discloses and claims only subject matter disclosed in my prior application Ser. No. 272,795 filed July 18, 1972 now, U.S. Pat. No. 3,771,002.

BACKGROUND AND OBJECTS OF THE INVENTION

The present invention relates in general to cathode ray tubes, and more particularly to a cathode ray tube construction wherein a single electron gun having a single cathode, control grid, first anode, focusing anode, and accelerating anode, produces plural electron beams scanned respectively along elongated phosphor screen strips of small width transversely spanning the screen area to produce image displays, such as multi-color or character displays, on the face plate of the cathode ray tube.

Heretofore, it has been customary in the production of cathode ray tubes for multi-color image presentation, such as, color television tubes and multi-color computer readout display tubes, to provide a plurality of electron gun assemblies equal to the number of electron beams required to reproduce. Each electron gun includes its own cathode and heating filament unit, its own control grid, first anode, focusing anode, and accelerating anode for controlling the electron beam produced by the electrons emitted by the associated cathode. The electron beam from each gun is individually controlled, in the case of a color television receiver, by the control signal for the particular color to which that beam is assigned, and the three electron beams, in the case of a color television tube, are directed through a shadow mask and on to the dots making up the color phosphor pattern on the face plate of the cathode ray tube. Many disadvantages have been associated with such a multi-electron gun, multi-beam shadow mask type of color cathode ray tube.

The need to provide three separate electron gun units in such a tube has contributed to significant expense of manufacture of color cathode ray tubes, electron emission limits have made it difficult to attain desired brightness and other display requirements, the complexity of the construction of the electron guns and the components thereof has introduced many difficult manufacturing problems, and the need for a shadow mask both increases the cost and the complexity of such color cathode ray tube construction. Efforts have been made to produce color images or multi-color displays without the use of a shadow mask, for example, by providing a first phosphor layer for producing a first color on the inner surface of the face plate of the cathode ray tube and overlaying this with a second layer and then a third layer of phosphores for producing the other two basic color components. Experience with this type of cathode ray tube has shown that poor brightness uniformity characteristics exist, because, for example, if the phosphor layer nearest the electron gun is to be excited to produce its appropriate color, the brightness seen from the exterior of the cathode ray tube screen is low because of the light loss as light from the rearmost phosphor passes through the front two layers and the luminescence is considerably limited by the reduced anode voltage necessary to limit excitation to the desired phosphor layer. Such a cathode ray tube

requires complex high voltage switching to select which layer to excite and to attempt to achieve a level of excitation which will compensate for the brightness loss of light emitted by the two rearmost layers.

Also the conventional types of color cathode ray tubes employing patterns of phosphor dots on the face plate and shadow masks for selectively exciting the phosphor dots to produce the appropriate color pattern greatly limit the resolution which can be provided and deter the attainment of high resolution images which can be provided in extremely small spaces and subsequently magnified, such as are desirable in many information display cathode ray tubes.

An object of the present invention is the provision of a novel electron gun for a cathode ray tube construction capable of producing color images from plural beams generated by the novel electron gun construction.

Another object of the present invention is the provision of a novel electron gun construction for cathode ray tubes, for producing a plurality of separately controllable electron beams to excite an arrangement of phosphor material on a face plate in a manner to produce multi-color images suitable for color television displays or multi-color information displays of wide application.

Another object of the present invention is the provision of a novel electron gun construction for cathode ray tubes designed to provide plural electron beams from a single cathode, when the electron gun construction is such as to facilitate manufacture and assembly of the components into the electron gun and permits significant improvement in electron emission by the cathode and reduction of stray emission.

Other objects, advantages and capabilities of the present invention will become apparent from the following detailed description, taken in conjunction with the accompanying drawings illustrating the preferred embodiment of the invention.

BRIEF DESCRIPTION OF THE FIGURES

FIG. 1 is a vertical section view of a single electron gun, multi-beam, multi-color cathode ray tube embodying the present invention;

FIG. 2 is a fragmentary horizontal section view, to enlarged scale, of the electron gun section of the cathode ray tube, taken along the line 2—2 of FIG. 1;

FIG. 3 is a vertical longitudinal section view, to enlarged scale, of the electron gun;

FIG. 4 is a front elevation view of the cathode;

FIG. 5 is a transverse section view of the cathode, taken along the line 5—5 of FIG. 4;

FIG. 6 is a transverse section view of the control grid and first anode, taken along the line 6—6 of FIG. 3;

FIG. 7 is an exploded perspective view of the electron gun, with parts broken away;

FIG. 8 is a vertical section view, taken along line 8—8 of FIG. 3;

FIG. 9 is a diagrammatic illustration of the cathode ray tube, showing typical voltages for the elements thereof; and

FIG. 10 is a fragmentary rear elevation of a portion of the tri-color phosphor screen.

DETAILED DESCRIPTION OF A PREFERRED EMBODIMENT

The cathode ray tube of the present invention may be

broadly described as a single electron gun, multi-beam, multi-color cathode ray tube having a single glass envelope and narrow strips of color producing phosphors arranged in a band or set of plural strips transversely scanning the screen area or face plate of the cathode ray tube. A plurality of the bands, each having a plurality of the phosphor strips arranged in a particular sequence, are arranged in vertically spaced relation to cover the image area of the cathode ray tube so as to provide a recurring sequence of the phosphor strips. The number of electron beams produced by the single electron gun corresponds to the number of different color phosphor strips making up a single band of phosphor strips. The electron beams are scanned transversely across the image area of the screen and the scanning strokes progress downwardly over the screen area in a manner similar to the development of the usual raster or scanning pattern on a conventional television picture tube. In one example, a bi-color display, for example, as a readout for a computer or for any other image display application, can be produced by use of the single electron gun of the present invention to provide two beams which are scanned along phosphor bands each made up of two strips of color producing phosphor, for example, a magenta producing phosphor and a green producing phosphor. Alternatively, an electron gun produced in accordance with the present invention may be arranged to produce three beams for exciting respective, differently colored phosphor strips making up each of the plurality of bands forming the screen area, with the three phosphor strips of each band being of the type which produces respectively magenta, cyan and green illumination or fluorescence. Such a tube may be used to produce tri-color displays on the screen for computer readout and similar display applications, or for use as a color television tube for commercial television receivers. The ensuing description will be directed to a preferred embodiment producing three electron beams from a single electron gun, and associated with three different color phosphor strips extending generally horizontally in each of plural vertically spaced bands covering the screen area, for tri-color displays such as for television receivers and the like.

Referring to the drawings, wherein like reference characters designate corresponding parts throughout the several figures, the single cathode, multi-beam cathode ray tube of the present invention is indicated generally by the reference character 15, and comprises a single glass envelope having an elongated neck section 16 and a face plate section 17 of larger cross-section than the neck section terminating in the front face plate 18. In the embodiment illustrated, the front face plate 18, instead of having the pattern of phosphor dots for producing the three constituent colors for the color image usually employed in shadow mask type television tubes, has the tri-color phosphor deposited in an entirely different manner. In this cathode ray tube, the tri-color phosphor is arranged in generally horizontally extending bands 19, spaced vertically in close proximity to each other to substantially cover the screen area of the face plate, each band being made up of three substantially horizontally phosphor strips as indicated at 20R, 20B and 20G respectively producing red, blue and green light when activated by the electron beam. While the direction of the longitudinal axis of the phosphor strips 20R, 20B and 20G and of the bands

19 made up of such tri-color phosphor strips has been referred to hereinbefore and will be frequently referred to hereinafter as horizontal or generally horizontal, it will be appreciated that the direction of their longitudinal axes actually declines at a slight angle to the horizontal, as occurs in the successive scanning strokes of a scanning raster produced at the screen of a conventional color television tube, and it will be understood that the term "horizontal" as used herein refers to such slightly declining transverse direction rather than signifying a truly horizontal direction. The parallel strips of phosphor 20R, 20B and 20G may be arranged in phosphor strips having width of 0.008 inch to 0.039 inch or greater, with the preferred width being about 0.01 inch for a three beam kinescope or being about 0.039 inch for a 35 beam display cathode ray tube. Each phosphor strip is preferably separated by a guard space of from about 0.001 inch to 0.005 inch with the preferred separation being about 0.002 inch.

The three strips of color phosphor 20R, 20B and 20G are separately excited or activated by three electron beams which are vertically spaced at the target region so as to separately track along their respective associated phosphor 20R, 20B or 20G. The three electron beams are produced from a single electron gun, indicated generally at 24, located in the rear portion of the glass neck section 16 of the cathode ray tube. Either a conventional deflection yoke may be provided surrounding the neck of the tube to effect magnetic deflection of the electron beams, in accordance with standard practice, or the electron beam may be electrostatically deflected by electrostatic deflection plates positioned in the glass envelope. The electron gun 24 is designed to produce three parallel electron beams, indicated diagrammatically at 25R, 25B and 25G which normally, unless altered by modifying voltages along the beam path, would be of substantially uniform intensity producing uniform brightness of emission from the three phosphor strips. The electron gun 24 includes a preassembly supporting frame work, generally indicated by longitudinally extending frame members or rods 26, such as glass or the like, which directly or indirectly support a cathode, generally indicated at 27, a control grid generally indicated at 28, a first anode 29, a focus anode 30, and an accelerating anode assembly 31. The control grid, first anode, focus anode, and accelerating anode may, for example, be spot welded to end portions of supporting wires or strips extending from and embedded at their other ends in the elongated frame rods 26 during assembly of the electron gun, with the cathode supported from the control grid, so that the entire electron gun assembly can be inserted as a unit in the neck section of the cathode ray tube during manufacture.

As will be seen particularly from FIGS. 4, 5 and 6 the cathode 27 is formed from a pair of sheet members, such as two nickel sheet members 32, 33 having a thickness of about 0.010 inch, each shaped to define an outwardly projecting, truncated V-shaped or channel shaped ridge 32A, 33A extending the height of the cathode. The channel formations defining the ridges 32A, 33A have outwardly convergent, similarly inclined sides 34A and a flat outer wall 34B paralleling the main or medial plane of the cathode, giving the channels a truncated V-shape or truncated isosceles triangular configuration. The flat outer walls 34B extend the full height of the cathode and the sheet members

32, 33 are assembled, as by spot welding at the corners thereof, to form a rigid and stable cathode structure wherein the registered truncated V-shaped ridge formations 32A, 33A collectively define a tunnel of hexagonal or honeycomb configuration to receive the filament winding or winding 35. The cathode height may vary from 10 to 15mm for mounting condition ease, but in a preferred embodiment has a height of 15mm, and a total width of 7mm, with the flat outer walls 34B having a width of 3mm. The filament winding or windings 35 are preferably formed of spiral tungsten coils, indicated at 35, having for example a length of about 16mm and an outer diameter of about 2mm, coated by an insulating layer of high temperature ceramic such as alumina or fused aluminum oxide, or other suitable coating material. In the preferred embodiment, a dual interlocking coil filament is preferably employed, wound in such a manner that one of the filament coils has clockwise turns and the other has counterclockwise turns, intermeshed up to 50% of the coil diameters, to present maximum heat at the center area of the cathode and simultaneously cancel AC frequencies which would exist on a single phase filament, by a phase cancellation. The honeycomb design of the ridge formation produced by the channel sections 32A, 33A provides maximum resistance to heat warpage from heating the cathode to operating temperature, thus assuring that the cathode flat surface 34B will remain parallel to the control grid for maximum efficiency of electron emission. To provide high electron emission from the cathode flat wall or surface 34B, this surface is coated by spray, paint, or electrophoretic deposit of standard cathode material, such as that referred commercially as "Tri-Carbonate" or oxide coating, deposited, for example, to a thickness of about 100 to 250 microns over the 3mm width and 10 to 15mm height of the cathode flat surface 34B. This cathode coating over the cathode flat 34B is protected from atmosphere poisoning by a layer of organic lacquer until the cathode ray tube is activated in the final fabrication stages.

The control grid 28, illustrated in detail in FIGS. 3, 6, 7 provides control for each individual beam intensity and current. The control grid 28, when viewed in front elevation from the face plate of the tube, has a generally oval appearance, and comprises a ceramic substrate or panel 36 of oval profile, similar to the substrate for a printed circuit board, having a truncated V-shaped well or trough 37 extending the major portion of the height thereof having inclined, forwardly converging side walls and top and bottom walls, and having three holes or apertures 38R, 38B and 38G arranged in a vertical row registering with the vertical center line of the substrate 36. The substrate 36 in one preferred example may have a width of about 15mm, a total height of about 20mm, and the well or trough 37 therein may have a width of 2.5mm at its base and 5.5mm at the plane of the substrate face through which it opens. The vertical height of the well may be 15mm at its base and 16mm at the plane of the substrate at which it opens. When used with the cathode 27 having the coated emission panel 34B sized to provide a width of 3mm and a height of 15mm, the well 37, which is only 2.5mm at its base, receives the major portion of the confronting half of the hex shaped ridge formation but the 2.5mm width of the well 37 maintains the coating on the panel 34B spaced slightly from physical engagement with the confronting portion of the ceramic

substrate. The ceramic substrate is about 3mm in thickness, the three apertures 38R, 38B and 38G therein are located about 5mm on centers from each other, and have an internal diameter of about $\frac{3}{4}$ mm in their final coated or plated condition. These control grid apertures have a stepped entrance and exit end formed by an annular slightly larger cross-section aperture portion at the entrance and exit ends, as illustrated and described in my earlier patent application, Ser. No. 172,756. The ceramic substrate is provided with a gold plating, formed for example by first applying an initial thickness of approximately 1000 angstrom units or gold by a vacuum process known as sputtering. The sputtered gold layers applied to the exit surface of the substrate (that surface which faces the face plate of the cathode ray tube) and to the inside walls of the grid apertures 38R, 38B and 38G assure firm adhesion of the electroplated metallic gold to the ceramic substrate. The control grid substrate is then electroplated to increase the thickness of the gold to about 0.001 inch. Alternatively, copper may first be applied to the ceramic substrate, after which the substrate is then electroplated with nickel to provide a thickness of about 0.001 inch. After electroplating the control grid, it may then be given a coating of a photosensitive etch resist, such as Eastman Kodak Company's KPR or KMER or KTRF resist. This photosensitive etch resist is then exposed to a precision glass photographic plate containing a negative image of the control apertures and the attachment metal path leading to the conductor terminals at the top portion of the substrate illustrated in FIG. 7 and the resist is then processed in accordance with the manufacturer's recommendations to etch away the unwanted metal gold or nickel. This yields a control grid substrate and metallic gold or metallic nickel having conductor paths indicated at 39 in FIG. 7. The substrate 36 and metallic portions for the control grid are shielded by a nickel shielding sleeve or tubing indicated at 40 secured to the periphery of the substrate 36, for example, by press-fitting the substrate in the shield, to reduce outside interference from electrical or magnetic sources. The cathode 27 is supported from the control grid substrate by suitable fasteners or mounting posts indicated at 41 secured to the corners of the cathode 27 and to the substrate of the control grid 28.

Because of the control grid structure hereinabove described, a number of advantages are realized. It has been found that while a substrate thickness of one millimeter or less may have been used to provide control grid apertures of appropriate axial length, manufacturers do not want to work with such great thicknesses of such small dimensions. By going to a substrate thickness of about 3mm, which can be readily handled by commercial manufacturers, and providing the truncated V-shaped well or trough 37 to receive the forwardly projecting one-half hexagonal or truncated triangular portion of the cathode, with the base of the well $\frac{1}{2}$ mm narrower than the width of the emission panel of the cathode, separation was maintained between the metallic aperture plating for the control grid and the oxide cathode coating, and also the nesting of the cathode portion in the well provided radiation shielding against leakage of stray emission such as X-radiation.

Instead of forming the grid aperture liners and grid connections of electroplated nickel, gold or other non-

oxidizing metal conductor, larger diameter apertures could be provided in the substrate 36, and thin strips of metallic conductor material having annular mid portions equal to or slightly larger than the holes in the substrate could be provided on the front or exit face of the substrate to cover these holes and have $\frac{3}{4}$ mm diameter openings in these annular portions of the metallic conductor strips. The opposite ends of the strips could be mounted in slots in, or be otherwise be fixed to, the substrate and the ends of the metallic conductor strips at one side or edge portion of the substrate would provide a terminal connection to the wires leading to the grid control circuitry.

The oval shaped nickel shield or sleeve 40 may be conveniently provided by using a circular cross-section nickel tube of the appropriate diameter, which is placed in a die to swage its shape to an oval configuration, after which the edge is then rolled to produce the nickel shield configuration shown in the drawings. The ceramic substrate may then be simply press fitted in the nickel shield 40 to complete the assembly of the control grid. By having a substrate of at least 3mm thickness, problems are eliminated in press fitting the substrate in the nickel shield because of the increased strength of the substrate.

The first anode 29 is similar in construction to the control grid in that it employs a ceramic substrate 42 which may be of the identical size and design of the control grid substrate 36 and is likewise provided with apertures 42R, 42B and 42G corresponding in number and location to the apertures in the control grid. While the well or trough similar to the well 37 in the control grid substrate is unnecessary and redundant for the first anode substrate, economy of manufacture can be achieved by using the same substrate construction, and merely facing the well or trough in the first anode substrate toward the front of face plate of the cathode ray tube. The first anode has the entrance face or rear surface of the substrate 42 provided with the layer of metallic gold or metallic nickel electroplated thereon and etched in a manner similar to the etching procedure employed for forming the conductor portions of the control grid. In the preferred example, the apertures 42R, 42B and 42G in the first anode substrate are of such diameter as to produce one millimeter diameter apertures for the final plated or metallic coated first anode apertures. A shield 43, like the shield 40 of the control grid, surrounds the first anode substrate, in which the latter is press-fitted.

Immediately forwardly, or toward the face plate, from the first anode 29 is the focus anode 30. The focus anode, in the preferred embodiment, comprises a forward oval tube section 45 formed of a nickel tube shaped into configuration and edge rolled in a manner similar to the nickel shields 40 and 43 for the control grid and first anode. The rearmost end of the oval nickel tube section 45 is curved inwardly, as indicated at 45', to join a vertical rear wall 46 which may be integrally formed with the oval tube 45 or may be welded or fastened to the oval tube section, as desired. The rear wall 46 is provided with three vertically aligned apertures, into which three vertically aligned, rearwardly extending beam isolation tubes 47R, 47B and 47G are fitted. Each of the tubes 47R, 47B and 47G are about 5 millimeters in diameter and are joined at their forward edges to the rear wall 46 for example by mounting tabs 48 spot welded to the front surface of the rear wall

46. The isolation tubes 47R, 47B and 47G are also spot welded together to make a one piece assembly, and have rear focus apertures 46R, 46B and 46G, each about 1.5mm in diameter. As will be later described, a controlled voltage of about 5,000 volts is applied to both the oval tube segment 45 and the isolation tubes 47 whereby the focus anode serves as an electronic lens to focus the beams. In one preferred embodiment, the oval nickel tube segment 45 may have a width of about 15 millimeters, a height of about 20 millimeters, the width of the flat portion of the rear wall may be about 10 millimeters, the axial length of the oval tube segment 45 may be about 14 millimeters, and the axial length of each of the 5 millimeter diameter beam isolation tubes 47R, 47B and 47G, may be about 6 millimeters. It is important to roll the forward edge of the oval tube section 45 to insure a burr-free edge, so as to avoid distortion of the field, since any place where there is a burr would distort the field rather than aid it. The provision of the smaller diameter segments formed by the isolation tubes 47R, 47B and 47G is to achieve a higher field strength close to the anode 29 than could be attained with isolation tubes which are too large to nest within the nickel shields 43 and reach close to the substrate of the first anode.

Alternatively, the focus anode can be formed simply of three swaged nickel tubes, spot welded one on top of the other in a vertical stack, having smaller diameter rearwardly extending tube sections projecting from each. For example, the forward segment of each of the three larger diameter tubes may be tubes of 5 millimeter inner diameter having a length of about 16 millimeters, rolled at their forward edges, and curving inwardly to define an annular rear wall having a center aperture of three millimeters diameter. A rearward nickel tube segment having a 3 millimeter outer diameter and a length of about 4 millimeters has its forward end fitted into the 3 millimeter opening in the rear of the 5 millimeter diameter forward nickel tube segment, with the edge of the smaller tube flared outwardly and spot welded to the rear wall of the larger diameter forward tube, and the rear of the smaller diameter (3 millimeter) tube segment is rolled inwardly to define an aperture of about 2.5 millimeters diameter. These three tube assemblies, each of the assemblies comprised of the forward larger diameter tube segment and a rearward smaller diameter tube segment, may then be spot welded at the sides of the larger forward tubes to one or a pair of vertically extending mounting straps, to locate the aperture centers spaced five millimeters apart.

Forwardly, or toward the face plate, of the focus anode 30 is the accelerating anode assembly 31, shown more clearly in FIG. 8. The accelerating anode assembly 31 includes a cylindrical forward tube section or segment 50, formed of 0.010 inches nickel which is concentric with the axis of the neck and has a rear vertical wall 51, also of nickel, having three aligned apertures of about three millimeters diameter, indicated at 51R, 51B and 51G, spaced 5 millimeters on centers. Projecting rearwardly from the vertical wall 51 is a vertical series of three cylindrical isolation tubes 52R, 52B and 52G, each formed of five millimeter diameter seamless nickel tubes in a manner similar to the tubes of the focus anode, having diametrically opposite laterally extending mounting tabs 53 for spot weld fastening of the rearwardly projecting isolation tubes 52R, 52B and 52G to the wall 51 of the forward tube segment 50.

If desired, an oval nickel shield, indicated at 54, formed in the same manner as the nickel shields 40 and 43, is provided with the forward edge of the nickel shield being spot welded to the vertical wall 51. If desired, mounting to assist in spot welding may be provided at the forward end of the nickel shield 54. To maintain isolation of the three electron beams passing through the forward tube section 50, substantially semi-cylindrical beam isolating elements 55 are provided, having the substantially semi-cylindrical concave end portions 55a formed at the ends thereof supported by flat portions 55b extending to the cylindrical wall of the tube section 50 and spot welded thereto. Alternatively, 5 millimeter diameter seamless beam isolation tubes formed of 0.010 inches nickel or similar material may be arranged in coaxial relation to the extended axes of the three millimeter diameter apertures 51R, 51B and 51G and end mounted by spot welding tabs to the vertical wall 51 in a manner similar to the mounting of the tubes 47R, 47B and 47G of the focus aperture.

A getter ring 56 in the form of an annular, forwardly facing channel member 56a is positioned in forwardly spaced relation from the forward edge of the tube section 50 by an elongated support 56b. Three metallic contact members 57 project forwardly from the tube section 50 of the accelerating anode, forming spring supporting members having outwardly convex end portions 57a to bear against the inner surface of the neck of the cathode ray tube envelope in contact with the aqua dag coating and thereby support and position the forward end portion of the electron gun assembly and make electrical contact to the high voltage anode. In one embodiment of the accelerating anode, the forward tube section 50 has an axial length of 17 millimeters and a diameter of about 24 millimeters, the rearwardly projecting shield section 54 has an axial length of 13 millimeters, a height of 20 millimeters, and a width of 15 millimeters, the getter ring has an outer diameter of about 24 millimeters and is spaced about 15 millimeters forwardly of the front edge of the tube section 50, has an axial depth of about 2 millimeters, and the contact strips 57 may extend about 13.5 millimeters forwardly from the tube section 50 with the curved end portions thereof curving outwardly to a maximum distance from the axis of the accelerating anode of about 15 millimeters.

The previously described elongated frame members or rods 26, to which the shield portions 40, 43, 45 and 54 of the control grid, first anode, focus anode and accelerating anode are affixed by mounting pins embedded in the frame or support rods 26 and spot welded to the shields, form a unitary sub-assembly of each of these electron gun elements and of the cathode 27 which is rigidly supported by the control grid 28. This provides a convenient sub-assembly arrangement for installation of the electron gun in the neck portion of the cathode ray tube envelope. Cathode ray tube envelopes, as customarily made, are initially open at the rear end portion of the neck, and therefore the electron gun sub-assembly as herein described can simply be inserted through the rear opening of the neck to the proper position within the neck, the forwardmost portion of the electron gun being supported by the contact members 27 engaging the inner surface of the neck. The connection terminals for the various elements, such as the connection terminals at the upper edges of the control grid and first anode, are connected by con-

ductors to appropriate pins preformed in a conventional glass base for the cathode ray tube, and the shield portions of the focus anode and accelerating anode and the filament terminals of the cathode are connected to their appropriate pins in the glass base, after which the glass base is flame sealed to the edge of the rear opening in the glass envelope neck. Thus the connections from the various elements of the electron gun to the pins in the glass base provide support for the rearmost end portions of the electron gun assembly. In one preferred example, conductor pins spot welded to the connection terminals on the control grid and first anode pass through feed-through glass or ceramic inserts, indicated at 40i and 43i, mounted in the holes in the shields 40 and 43, with the external ends of these pins spot welded to conductive strips leading to the base pins 16p to form these connections. After the vacuum is drawn in the cathode ray tube glass envelope through the nipple in the glass base sealed to the end of the neck, the nipple is then flame cut to seal the opening and complete the rearmost end of the neck.

The phosphor screen or target area 60 is formed on the rearward surface of the face plate of the glass envelope and, in the preferred embodiment, the multi-color phosphors are arranged in parallel strips which are substantially horizontal, actually declining about 0.5° from the horizontal. For a tri-color configuration, such as may be required to produce a color image for a television receiver, the phosphors would be arranged in the manner illustrated in FIG. 10, to provide an upper phosphor strip 20R for producing red light, an intermediate phosphor strip 20B for producing blue light, and a lower phosphor strip 20G for producing green light. These phosphor strips 20R, 20B and 20G forming the three constituent colors for the color screen in this example, are arranged in a vertical series of bands, indicated generally by the reference character 19, each laterally spanning the screen area and provided in sufficient number to cover the vertical extent of the screen. For example, for a conventional 525 line system, the total vertical width for the band 19 formed of the three primary color phosphor strips is about 0.034 inches, with the phosphor strips 20R, 20B and 20G each having a vertical width of about 0.010 inches and a guard band between each successive pair of phosphor strips of about 0.002 inches. It will be understood that the phosphor strips can be deposited in various widths ranging from about 0.005 inches to 0.039 inches with the guard bands varying from 0.002 inches to 0.001 inches depending upon the particular applications and the number of different colors to be presented. The phosphor strips, such as the strips 20R, 20B and 20G are deposited on the inner surface of the face plate in bands located on 0.012 inch centers, in the described example, by the same electrophoretic process and phosphor screen forming procedure as is described in my earlier patent application Ser. No. 193,818 entitled Color Cathode Ray Kinescope Tube and Method of Forming the Same, except that the phosphor material, and the underlying conductive base layers, are arranged in the configuration of strips of uniform appropriate width, for example 0.010 inches, transversely spanning the screen or image area, rather than in interconnected chains of circular conductive pads and the spaced circular phosphor dots formed thereon as produced with the process of said earlier application.

With such an arrangement of transverse phosphor strips having about a 0.010 inches vertical width each, it will be appreciated that the three vertically spaced electron beams, which originate on about 5 millimeter centers, corresponding to the spacing of the center of the beam apertures in the grid and anode elements of the electron gun, must be converged and focused into spots which are on 0.012 inches centers at the face plate, to register the proper beams with their associated phosphor strips. This is accomplished in the preferred embodiment, by the provision of adjustable permanent magnets 64a, 64b, located above and below the electron gun externally of the neck of the glass envelope in such manner that the upper magnet 64a is adjustable to bend the top electron beam downwardly to the desired position, and the bottom permanent magnet is adjustable to bend the bottom electron beam upwardly to the desired position. These adjustable magnets may be movably mounted in plastic supports, such as indicated generally at 65, carried for example on a mounting strap 65a which encircles the glass neck section 16 at a position near the accelerating anode with the magnets located 180° apart aligned with the vertical plane through the three electron beams. The magnet strength is selected so as to achieve a desired degree of converging movement of the top and bottom beam without causing their axes to cross, and without affecting the path of the center beam. The strength to accomplish the appropriate convergence will vary proportionately to the potential on the accelerating anode, with low strength magnets required for a 25,000 volt potential and high strength magnets required for 15,000 volt potential. The magnet strengths will ordinarily be within a range of about 50-250 Gauss.

The above described construction, when employed for a tri-color television picture tube or a cathode ray tube for general tri-color display applications, provides a cathode design having a honey-comb or hexagonal shaped ridge formation providing a flat coated emission panel which is equidistant from the beam apertures in the control grid and the first anode to facilitate attainment of uniform electron current density in the beams. The particular construction of the cathode insures minimum cathode distortion from filament heat, and the dual compensating intermeshed filaments present maximum heat at the center area of the cathode and eliminate any undesirable polarity effects. The construction of the cathode, with a cathode panel having a width of about three millimeters, together with the use of grid apertures of about $\frac{3}{4}$ millimeter diameter and first anode apertures of about one millimeter diameter, make possible the production of very powerful electron beams capable of exciting the phosphor strips to produce high levels of optical energy suitable for magnification of up to 10X for information display cathode ray tubes. The nickel shielding shields 40, 43, 45, 50 and 54 reduce outside interference from electrical or magnetic sources and also facilitate mechanical mounting of the electron gun elements on the supporting rods or frame members. These shielding elements also reduce the stray radiation emission which might otherwise leak out from between the elements of the electron gun. The construction of the elements of the electron gun are such as to facilitate their manufacture and assembly into a stable and dependable electron gun assembly capable of producing one or a plurality of electron beams of high electron current density capable of producing

with the phosphor strips very good brightness uniformity characteristics and high resolution in the image generated on the cathode ray tube screen.

In one example of a three beam tube designed for color television use, the potentials on the various elements may be within the following ranges to attain satisfactory operation:

ELEMENT	VOLTS DC
Cathode	+100 - +300
Control Grid	+10 - +200
First Anode	+150 - +1,000
Focus Anode	+4,000 - +5,500
Accelerating Anode	+15,000 - +25,000

In one satisfactory example, the cathode voltage was +100 volts, the control grid was +10 volts DC, the first anode was at +150 volts DC, the focus anode was at +4000 volts DC, and the accelerating anode and voltage at the forward end of the tube were at +15,000 volts DC.

An electron gun for producing 35 electron beams for example, for information display cathode ray tubes and the like of the general type disclosed in my earlier patent application Ser. No. 172,756 entitled Multi-Beam Cathode Ray Tube, may be constructed with the control grid, first anode, focus anode and accelerating anode generally corresponding to the construction of the three beam electron gun hereinabove described rather than constructing the elements in the manner disclosed in said earlier application. The cathode, in such a 35 beam electron gun, would preferably have 5 hexagonal ridge formations defining five vertically elongated flat emission panels like the panel 34b of the above described construction, with dual compensated filaments in each ridge formation similar to that employed in the above described three beam tube. The substrates for the control grid and first anode will be provided with 35 beam apertures, rather than three beam apertures, with appropriate conductor connections to terminals along the edges thereof, produced in a manner similar to that described in my said earlier application Ser. No. 175,756 preferably produced by printed circuit techniques as previously described. The focus anode and accelerating anode will be appropriately modified to provide 35 beam isolating tubes and 35 apertures each, rather than providing three of such tubes and apertures. In such a display tube, designed for example for a two-color display, the phosphor strips may be provided in alternating strips of different color, for example red and green, or red and blue, or green and blue, or red and white, each of the phosphor strips being preferably about 0.039 inches in width and having a guard band of 0.001 inches between each successive pair of phosphor strips. In this way, in each one inch of vertical space along the screen area, 25 total lines could be provided, 13 of which could be in one of the colors and 12 of which, arranged alternately with the first color phosphors, would be in the second color. The 35 beams can be scanned in conventional fashion by beam deflection means, either magnetic or electrostatic, and the control grid can be gated by appropriate signals produced, for example, by a computer programmed for character generation, so that alpha numeric characters are displayed in either of the two colors, by selectively exciting the appropriate color of phosphor strips. An electron gun produced in accor-

dance with the principles and techniques described herein in conjunction with parallel phosphor strips arranged in bands as herein described paralleling the direction of the scan lines of the electron beams, yields a very high resolution image of sufficient brightness to provide great flexibility of displays. For example, the 35 beam electron gun and 0.039 inches wide phosphor strips can produce single color displays of 4 to 8 lines of characters per inch with character heights ranging from 0.125 inches to 0.0250 inches for direct display viewing, or can produce two to four lines of characters in two colors per inch for direct viewing. Alternatively, with such arrangement single color displays can produce up to 25 lines of characters per inch of vertical height (when the vertical span of the 7 vertical rows of 35 beams is concentrated in the 0.039 inches phosphor width) or can produce 12 lines of characters per inch in two colors, where projection viewing is to be employed. The resolution and contrast provided by the cathode ray tube is such that the image can be projected with 3X to 10X magnification while still maintaining contrast and legibility.

What is claimed is:

1. An electron gun for producing at least one electron beam to excite phosphors in a phosphor screen area of a cathode ray tube to produce visible light, the electron gun forming an elongated assembly extending along a longitudinal axis and including a single cathode comprising a pair of joined metallic sheet members, each having an outwardly projecting truncated V-shaped channel formation projecting outwardly from a common plane between the sheet members collectively defining an elongated six-sided channel of substantially honeycomb cross-sectional configuration providing a flat emission panel spanning the cathode transversely of said longitudinal axis along a longitudinal panel axis, the channel housing filament wire along the length thereof, a coating of electron emission material on said emission panel which is thermally activated to emit electrons for forming the electron beam, control grid and first anode elements in spaced planes paralleling the plane of said emission panel and each having a hole for the electron beam for controlling and shaping the electrons emitted by the cathode into the beam, the holes in said grid and first anode elements for the electron beam being axially aligned along a beam axis extending substantially perpendicular to said emission panel electrically conductive material about said holes, means defining electrically conductive paths for applying selected electrical potentials to said conductive material for the holes, the control grid being formed of a nonconductive substrate panel having said hole for the electron beam extending therethrough and having a rearwardly facing recess in the center region of the substrate to receive the cathode channel formation in partially nested relation therein, the hole in said control grid for said beam being positioned so that it opens into said recess, accelerating anode means for accelerating the electrons in said beam toward said phosphor screen area, a plurality of elongated supporting members, and connecting elements extending from the supporting members for rigidly supporting the cathode and control grid and first anode elements and accelerating anode means therefrom.

2. An electron gun for a multi-beam cathode ray tube, as defined in claim 1, wherein said control grid and first anode elements each have three vertically

aligned holes spaced along a vertical plane providing a hole in each said element for each of three electron beams for respectively activating three different zones of different color-producing phosphors of a phosphor screen, and said longitudinal panel axis being arranged in a vertical plane passing through all of the three holes of said control grid and first anode elements.

3. An electron gun for a cathode ray tube, as defined in claim 2, wherein said flat emission panel has a width in a direction perpendicular to said vertical plane of about 3 mm, the holes in said control grid have a diameter of about $\frac{3}{4}$ mm, and the holes in said first anode have a diameter of about 1 mm.

4. An electron gun as defined in claim 1, including a pair of filament winding coils in said channel formation rearwardly of said emission panel having their coils intermeshed to intensify heating adjacent the central axis of the emission panel.

5. An electron gun as defined in claim 2, wherein said filament wire includes a pair of filament winding coils in said channel formation rearwardly of said emission panel having their coils intermeshed to intensify heating adjacent the central axis of the emission panel and wound in relatively opposite directions.

6. In an electron gun as defined in claim 1, said control grid having electrically conductive material lining said hole and connected by a photoetched conductor path to an edge terminal for applying selected potentials to the lining material for control of the electron beam.

7. In an electron gun as defined in claim 2, said rearwardly facing recess being of truncated V-shaped cross section in the center region of the substrate to receive the cathode channel formation in partially nested relation therein, and said control grid having electrically conductive material lining the holes and connected by conductor paths to edge terminals for applying selected potentials to the lining material for individual control of the electron beams.

8. In an electron gun as defined in claim 1, said rearwardly facing recess being of truncated V-shaped cross section in the center region of the substrate to receive the cathode channel formation in partially nested relation therein, and said control grid having electrically conductive material lining the holes and connected by photoetched conductor paths to edge terminals for applying selected potentials to the lining material for individual control of the electron beams.

9. An electron gun construction as defined in claim 1, wherein said recess in said control grid has a flat base wall confronting said emission panel of slightly smaller width than the emission panel to effect engagement of edges of the panel with side walls of the recess when the panel is spaced slightly rearwardly of the recess base wall to maintain such spacing.

10. An electron gun construction as defined in claim 7, where said recess in said control grid has a flat base wall confronting said emission panel of slightly smaller width than the emission panel to effect engagement of edges of the panel with side walls of the recess when the panel is spaced slightly rearwardly of the recess base wall to maintain such spacing.

11. An electron gun as defined in claim 7, wherein said control grid and first anode elements each include metallic lined apertures therethrough forming said holes and having a metallic shield extending from the substrate periphery as closed surround rearwardly from

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the control grid and forwardly from the first anode to minimize external interference and radiation effects.

12. An electron gun as defined in claim 1, wherein said control grid and first anode elements each include metallic lined apertures, therethrough forming said holes and having a metallic shield extending from the substrate periphery as a closed surround rearwardly from the control grid and forwardly from the first anode to minimize external interference and radiation effects.

13. An electron gun as defined in claim 7, wherein said control grid and first anode elements each include metallic lined apertures therethrough forming said holes and having a metallic shield extending from the substrate periphery as a closed surround rearwardly from the control grid and forwardly from the first anode to minimize external interference and radiation effects.

14. An electron gun as defined in claim 10, wherein said recess in said control grid has a flat base wall con-

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fronting said emission panel of slightly smaller width than the emission panel to effect engagement of edges of the panel with side walls of the recess when the panel is spaced slightly rearwardly of the recess base wall to maintain such spacing.

15. An electron gun as defined in claim 14, wherein said control grid and first anode elements each include metallic lined apertures forming said holes and having a metallic shield extending from the substrate periphery as a closed surround rearwardly from the control grid and forwardly from the first anode to minimize external interference and radiation effects.

16. An electron gun as defined in claim 2, wherein said control grid and first anode elements each include metallic lined apertures forming said holes and having a metallic shield extending from the substrate periphery as a closed surround rearwardly from the control grid and forwardly from the first anode to minimize external interference and radiation effects.

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UNITED STATES PATENT AND TRADEMARK OFFICE
CERTIFICATE OF CORRECTION

PATENT NO. : 3,914,641
DATED : October 21, 1975
INVENTOR(S) : Adrian W. Standaart

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

Column 13, line 48, after "panel" insert a comma;
Column 15, line 11, "claim 7" should read --claim 6--;
Column 15, line 19, "claim 10" should read --claim 8--.

Signed and Sealed this

twenty-fourth Day of February 1976

[SEAL]

Attest:

RUTH C. MASON
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents and Trademarks