

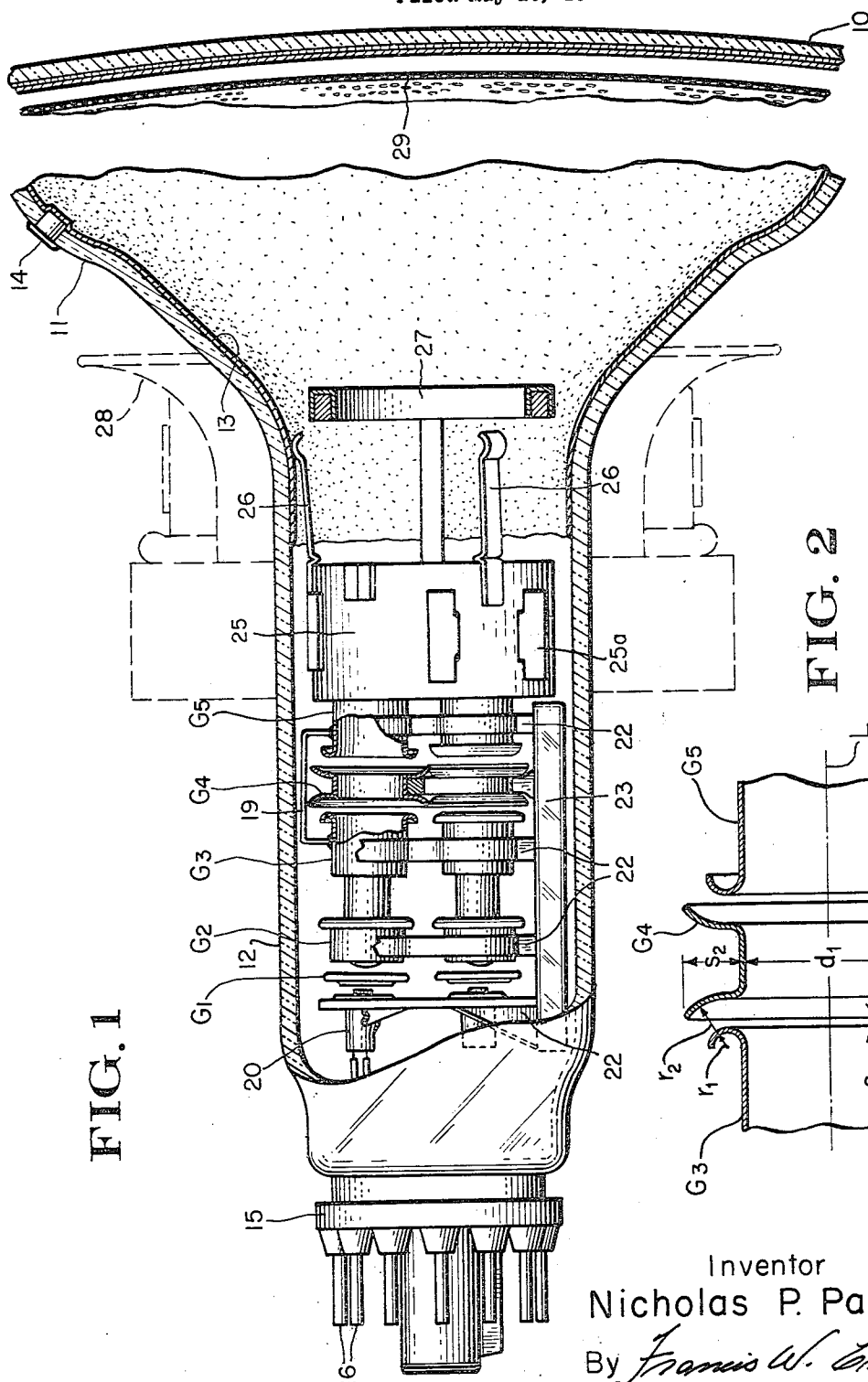
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LOW FOCUS VOLTAGE ELECTRON GUN FOR CATHODE-RAY TUBES

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LOW FOCUS VOLTAGE ELECTRON GUN FOR CATHODE-RAY TUBES

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ABSTRACT OF THE DISCLOSURE

A shadow mask type of three gun tri-color cathode-ray tube has a low focus voltage gun featuring a unipotential lens formed by the electrodes G_3 , G_4 and G_5 . Of these electrodes, G_3 and G_5 are maintained at ulior potential while G_4 is maintained at a very low potential. In order to avoid convergence drift and spot distortion the terminal portions of electrodes G_3 and G_5 which face electrode G_4 are turned back on themselves and the ends of electrode G_4 have projecting portions which are curved so that there is a uniform spacing between the facing ends of these three electrodes. The spacing of the electrodes from one another and the dimensioning of the terminal portions are proportioned so that the G_3 , G_4 and G_5 electrode spacings, as projected on the beam axis of the gun, is small compared with the height of the curved termination of electrode G_4 as projected on a plane normal to the beam axis.

BACKGROUND OF THE INVENTION

The present invention is addressed to cathode-ray tubes and, while useful in monochrome tubes, is especially advantageous for minimizing convergence drift in tri-color picture tubes and will, for convenience, be described in that environment. The usual tri-color picture tube has a delta array of three electron guns each of which has a series of electrodes aligned with the cathode and utilized for developing and accelerating an electron beam subject to modulation by control signals applied to the first grid and/or cathode. The acceleration of beam electrons is achieved by establishing a desired positive potential on other electrodes serving the function of an anode. Where the gun employs a unipotential focus lens, which is the specific type of structure under consideration, the requisite high potential is applied to the G_3 and G_5 electrodes while the intermediate electrode G_4 receives a relatively low potential. It is convenient to have the G_3 and G_5 electrodes conductively connected and energized by snubber springs which contact the graphite or aquadag coating deposited on the funnel of the tube envelope and extending into the contiguous portion of the glass neck which accommodates the gun assembly. The high voltage terminal of the tube projects into the coated funnel section so that voltage from the usual high voltage source is easily applied to the G_3 , G_5 electrodes. The G_4 electrode has a lead-in which extends to one of the terminal prongs of the tube base as a means for energizing this electrode. With the appropriate potentials applied to the three electrodes, an electrostatic lens is formed as required to focus an electron beam traversing the gun assembly upon the screen surface of the tube. As thus far described, the structure is exceedingly well known in the art and operates in a generally satisfactory manner in reproducing an image. For the tri-color tube employing three such gun assemblies to selectively energize deposits of red, green and blue phosphors on the image screen, the reproduction is in simulated natural color.

Some difficulty has been experienced, however, in this type of tri-color tube which is attributable to the potential distribution along the tube neck. It is found, for example,

that when the tube is first energized the end of the neck to which the aquadag coating extends is at a high anode potential whereas the other end is at essentially zero or ground potential, giving rise to a potential distribution which changes sharply in the region of the unipotential lens and resulting in a charge accumulation along the inner wall of the neck. As a consequence, a field is created which may penetrate the inter-electrode spaces of the electrostatic lens and may cause aberration of the electron spots, spurious electron emission, arcing and convergence drift. The nature and extent of that drift depend on the conditions of convergence adjustment.

If the receiver is adjusted with the three electron beams fully converged before stabilized operation has been obtained, and this is the usual case because stabilization customarily requires several hours of sustained operation, the ultimate effect of the field in the region of the focusing lens is a condition of misconvergence. This follows from the fact that as the tube is operated over an extended period of time, typically a minimum of three hours, the potential distribution along the neck undergoes a change because the charge accumulation dissipates as a condition of stability ensues. When this occurs, the potential gradient along the tube neck becomes less severe in the region of the focusing lens and the field attributable thereto decreases, causing the beams to shift from their initial condition of adjustment and thereby introducing convergence drift. The drift in convergence is, of course, undesirable and has been responsible for difficulty in successfully adapting the low focus voltage gun structure to a three color cathode-ray tube.

In attempting such an adaptation, it has been proposed that a conductive sleeve extend from the convergence cylinder which is customarily attached at the screen end of the gun cluster, and project in the direction of the cathode to shield the interelectrode spaces of the G_3 , G_4 and G_5 electrodes. This has the effect of minimizing misconvergence otherwise attributable to the charge phenomenon described above which takes place at the tube neck but it introduces a different problem. Specifically, with the sleeve in position, it is maintained at anode potential and causes the electric fields on either side of the beam axis of the individual guns to be asymmetrical and manifests itself in spot distortion.

Accordingly, it is an object of the invention to provide a cathode-ray tube which features a low focus voltage electron gun assembly and avoids the aforementioned difficulties of prior structures.

It is a specific object of the invention to provide a low focus voltage electron gun for color cathode-ray tubes which minimizes misconvergence as well as spot distortion of the electron beams of the tube.

SUMMARY ON THE INVENTION

An electron gun assembly constructed in accordance with the invention for use in a cathode-ray tube features an electrostatic lens for focusing an electron beam along a given path. The gun assembly comprises at least a pair of cylindrical electrodes spaced coaxially from one another along the beam path. Means are provided for applying to one of the electrodes an operating potential of a first value and for applying to the other of electrodes an operating potential of a second value so related to the first as to establish an electrostatic lens field for focusing an electron beam along the desired path. That terminal portion of the one electrode which is contiguous to the other is curved outwardly of the beam path and back upon itself while the adjacent end of the other electrode projects away from the beam path in substantially parallel relation to the terminal portion of the first-mentioned electrode. The separation of the electrodes along the

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path and the arcuate length of the projecting portion of the aforesaid other electrode are proportioned so that the spacing between these electrodes, as projected on the beam path, is small compared with the length of the projecting portion of the aforesaid other electrode as projected in a plane normal to the beam path.

Preferably, the electrostatic lens is of the unipotential type, having three electrodes coaxially aligned along the beam path. In that embodiment, the configuration and spacing of the terminal portions of the three electrodes which define the inter-electrode spaces and the lens field are arranged to be structurally the same and as described in the aforesaid paragraph which particularizes these features as to the facing ends of but a pair of the lens electrodes.

BRIEF DESCRIPTION OF THE DRAWING

The features of the present invention which are believed to be novel are set forth with particularity in the appended claims. The invention, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawing, in the several figures of which like reference numerals identify like elements, and in which:

FIGURE 1 represents a tri-color cathode-ray tube partially in cross section and featuring an electron gun assembly constructed in accordance with the invention; and

FIGURE 2 is an enlarged fragmentary view of the unipotential lens included in each of the three guns of the gun cluster included in the tube of FIGURE 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now more particularly to FIGURE 1, the cathode-ray tube there represented is a multibeam color picture tube of the three-gun shadow mask variety that is currently used in commercial television receivers. Its envelope is of glass and terminates at one end in a screen area 10 upon the internal surface of which is deposited an ordered array of phosphor elements. In the most popular version of this type structure, the phosphor screen has a myriad of dot triad elements with each triad containing a dot or deposit of red, a dot of blue and a dot of green phosphor. Usually, the screen is provided with an aluminum backing layer that is pervious to the electrons of the beams used to excite the phosphor and serves as a specular reflector to increase screen brightness. Screen 10 terminates a funnel section 11 of the envelope.

Normally, the cap of the tube including screen 10 is initially separate from funnel 11 which facilitates depositing the phosphor elements and after the screen has been formed, the cap is frit sealed or otherwise integrated with the funnel. They, of course, must be configured and dimensioned to match and usually are either round or rectangular in cross section. These details, however, form no part of the present invention and need not be considered in greater depth.

It is customary to coat the internal surface of funnel 11 and the contiguous end of glass neck 12 of the envelope with a conductive coating 13 of colloidal graphite such as that commercially available under the designation "Aquadag." A high voltage terminal 14 molded into a portion of funnel section 11 and arranged to receive a connector extending from a high voltage power supply (not shown) causes the aquadag coating to be maintained at a high potential usually of the order of 25,000 volts. The opposite end of neck 12 terminates in the usual base 15 which has terminal prongs 16 serving to apply operating potentials to the electrode structures of the guns of

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the tube as well as energizing voltages for the heaters of the cathodes of those guns.

For the most part, the guns of the picture tube are of conventional construction and it will suffice to enumerate the elements of one since they are all alike. Each gun has a cathode 20 followed by five electrodes G_1 - G_5 , inclusive. Of these, the electrode G_1 is the signal modulating grid while G_2 is included to provide a prefocus lens. Electrodes G_3 , G_4 and G_5 , collectively constitute an electrostatic lens of the unipotential type comprised of these three electrodes spaced from one another in coaxial alignment along the beam path of the gun. Their facing end portions, as such guns have been previously made, define unshielded interelectrode spaces which, unless protected suitably, are subject to the adverse field effects resulting from charge accumulations on the internal wall of tube neck 12, especially during that operating period of time which is required to achieve stabilized operation. Cathode 20 and electrodes G_1 - G_5 have support elements 22 which are embedded in beads or insulating pillars 23 to integrate the electrodes into a desired electron gun assembly.

At the end of the gun mount clear to screen 10, there is the usual convergence cylinder 25 which is secured to and supported by the several electrodes G_5 . This cylinder is a convenient means for shielding and for supporting three pairs of convergence pole pieces 25a. One pair of convergence pole pieces is disposed on opposite sides of the path of the beam issuing from one of the three guns of the gun mount and the remaining two pairs are similarly associated with the remaining two electron beams. A convergence system (not shown) causes magnetic fields to be established between the assigned pairs of convergence pole pieces in order to accomplish dynamic convergence of the three beams in a fashion that is well understood in the art and constitutes no part of the subject invention.

Snubber springs 26 of conductive material extend from convergence cylinder 25 into contact with aquadag coating 13. The springs mechanically position the gun mount within neck 12 and at the same time extend the final anode potential from high voltage terminal 14 and conductive coating 13 through conductive cylinder 25 to electrode G_5 . Since electrodes G_5 and G_3 operate at the same D.C. potential, the high voltage supply extends from electrode G_5 to electrode G_3 through any convenient conductive strap as indicated in the drawing by connection 19. Of course, it is necessary to apply to electrode G_4 an operating potential at a value suitably related to the potential of electrodes G_3 and G_5 to establish an electrostatic lens field for focusing on the image screen an electron beam traveling along the beam path. This is most conveniently accomplished by connecting electrode G_4 by means of a lead-in to one of the pins 16 in the base of the tube. It is also conventional to have a getter 27 supported from convergence cylinder 25 for the purpose of clearing up residual gas that may be trapped within the tube envelope.

A deflection yoke 28 is positioned about the end of funnel 11 which is contiguous to neck 12 and establishes deflection fields for deflecting the three beams generated in the gun mount across a shadow mask electrode 29 which is positioned across the paths of the beams immediately before the screen deposited on the internal surface of faceplate 10. Electrode 29 has a field of apertures corresponding in number to the triads of screen 10 and this mask, in conjunction with the geometry of the guns constituting the gun mount as well as the convergence system, permit each of the three electron beams to see only an assigned one of the three color phosphors deposited in triad form on screen 10. In this way, color selection is achieved; again, in a fashion well understood in the art. Since the invention is addressed most particularly to structural features of the unipotential lens which minimize misconvergence and spot distortion, considera-

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tion will be confined to this subject matter as distinguished from the control of the beams by luminance and chrominance information as required to synthesize images in simulated natural color.

The fragmentary representation of FIGURE 2 illustrates the configuration and geometrical relation, especially of the facing terminal portions of electrodes G_2 and G_4 on one hand and electrodes G_4 and G_5 on the other to permit effective use of a low focus voltage gun while avoiding any material effects of misconvergence, spot distortion and the voltage breakdown or arcing. More particularly, and with reference to electrode pair G_3 and G_4 , the terminal portion of electrode G_3 that is contiguous to electrode G_4 is curved outwardly of the beam path designated by construction line L. Viewed on an incremental basis and as indicated in FIGURE 2, this terminal portion of electrode G_3 is an arc of radius r_1 and the arc length is sufficient that the electrode is re-entrant or curves back upon itself. The adjacent end of electrode G_4 projects away from beam path L in substantially parallel relation to the curved termination of electrode G_3 . Preferably, the projecting portion 30 of electrode G_4 is a sector of an arc which, again on an incremental basis and as illustrated in FIGURE 2, has the same center as the radius of return portion 31 of electrode G_3 and it has a radial dimension r_2 . The separation of electrodes G_3 and G_4 along the beam path and the arcuate length of projecting portion 30 are proportioned so that the spacing s_1 between electrodes G_3 and G_4 as projected on beam path L is small compared with the length s_2 of the projecting portion 30 of electrode G_4 as projected in a plane normal to path L. The adjacent terminations of electrodes G_4 and G_5 are similarly arranged both as to configuration and spacing.

The described unipotential lens differs from prior art structures not only with respect to the configuration of the electrodes but also their spacing. Particularly, spacing s_1 has been reduced and that may require a reduction in the diameter d_1 of the lens electrodes or an increase in length of electrode G_4 in order to attain the same lens effect but the proportioning of the electrode elements in order to achieve a given lens field is well known in the art. It will be observed that the physical separation between portions 30 and 31 of electrodes G_3 and G_4 is uniform since on an incremental basis they are concentric arcs. As a consequence, the field intensity of surface 30, which may be likened to a cathode in that its operating voltage is very low compared with that of electrode G_3 , is reduced and, therefore, any tendency toward emission is likewise reduced giving the important result that the possibility of arcing has been diminished. Where the described proportioning and spacing are satisfied, an electron beam traversing path L is effectively shielded from any electric field associated with the internal wall of tube neck 12.

While the projecting portion 30, as shown, does not constitute a complete physical barrier interposed between the facing ends of electrodes G_3 and G_4 on the one hand and the internal neck surface of the tube on the other, the spacing s_1 is so small in comparison with the other dimensions of the lens elements, that the beam path is effectively shielded, as stated. Of course, lens elements G_3 and G_4 may be moved together so that dimension s_1 approaches zero or even becomes negative, in the sense that electrode G_3 may extend within projection 30 of G_4 , but it is preferred that the spacing s_1 have a positive value, as shown, since this affords the best protection against arcing between elements of the lens.

Because of the shielding effect, changes in the charges along the neck surface of the tube or the pillars 23 which, in previous structures produce an undesired misconvergence, is for the described arrangement of little or no effect. Additionally, the lens field of the unipotential arrangement has no asymmetry and, therefore, spot distortion is also obviated. While the invention has been specifi-

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cally described in connection with a unipotential lens, it is not limited to that application and may, for example, be employed in a two-elemental bipotential lens.

A unipotential lens structure that has been successfully employed in a 25 inch rectangular color picture tube had the following significant dimensions:

Electrodes G_5 and electrode G_3 of the blue gun—.010" stainless steel having an inner diameter in the section contiguous to G_4 of .290" and a return or re-entrant section having a radius of curvature of 0.20" and an arc of at least 180°.

Electrodes G_4 and electrode G_3 of the red and green— #4750 or #52 alloy I.D. of 0.29" and an overall length of 0.143. Radius of curvature of projecting portion 30 of .093".

Dimension s_1 —.048".

Dimension s_2 —0.075".

Since the focal length of the unipotential lens varies inversely with the voltage of grid G_4 , it is desirable to use a low voltage for this lens element. As this voltage is decreased, a condition of infinite focal length is approached which would relieve the focus from variations in operating voltage, that is, from voltage regulation. The described lens has been satisfactorily operated with a voltage of 21.5 kv. for electrodes G_3 , G_5 and any voltage from zero to 900 volts for electrode G_4 making focus regulation unnecessary.

It is frequently desirable to locate what is known in the art as a "blue lateral magnet" over the center of electrode G_3 of the so-called blue gun, that is to say, the gun emitting the beam that is to impinge upon the blue phosphor deposits of the image screen. The purpose of the blue lateral magnet is to give another degree of freedom in attaining beam convergence and for optimum results it should affect only the position of the blue gun. This result is aided if the G_3 electrodes of the red and green guns are formed of mu metal or otherwise provided with a permeability which is very high compared with that of the G_3 electrode of the blue gun. Where this is done, the G_3 electrodes of the red and green guns serve effectively as magnetic shunts to protect the beams traversing these guns from any influence of the blue lateral magnet. It is also desirable to shield the electron lens area from stray magnetic fields that may cause electron spot distortions and for this reason the G_4 electrodes are made of high magnetic permeability material.

While a particular embodiment of the invention has been shown and described, it will be obvious to those skilled in the art that changes and modifications may be made without departing from the invention in its broader aspects, and, therefore, the aim in the appended claims is to cover all such changes and modifications as fall within the true spirit and scope of the invention.

I claim:

1. An electron gun assembly for a cathode-ray tube having an electrostatic lens for focusing an electron beam along a given path comprising:

a pair of cylindrical electrodes spaced coaxially from one another along said path;

means for applying to one of said electrodes an operating potential of a first value and for applying to the other of said electrodes an operating potential of a second value related to the first to establish an electrostatic lens field for focusing an electron beam along said path;

the terminal portion of said one electrode contiguous to said other electrode being curved outwardly of said path and back upon itself and the adjacent end portion of said other electrode projecting away from said path in substantially parallel relation to said terminal portion of said one electrode, and the separation of said electrodes along said path and the arcuate length of said projecting portion of said other

electrode being proportioned so that the spacing between said electrodes, projected on said path, is small compared with the length of said projecting portion of said other electrode projected in a plane normal to said path.

2. An electron gun assembly in accordance with claim 1 in which incremental sections of the terminal portion of said one electrode and the projecting portion of said other electrode are arcs of concentric circles.

3. An electron gun assembly in accordance with claim 1 including a third cylindrical electrode positioned coaxially of said path on the side of said other electrode opposite said one electrode and in which said third electrode is maintained at the same operating potential as said one electrode to constitute therewith, in conjunction with said other electrode, a unipotential lens for focusing an electron beam.

4. An electron gun assembly in accordance with claim 3 in which the terminal portions of both end electrodes contiguous to the center electrode have the same configuration and spacing relative to the respective adjacent end portions of the center electrode.

5. An electron gun assembly for a color cathode-ray tube having three electron guns, individually constructed in accordance with claim 4, arranged in a delta pattern centered on said path.

6. An electron gun assembly for a color cathode-ray tube in accordance with claim 5 in which for two of the three electron guns the electrode of the unipotential lens which is closest to the electron source is formed of a metal having a permeability which is high compared with

that of the corresponding electrode of the third electron gun.

7. An electron gun assembly for a color cathode-ray tube in accordance with claim 5 in which the center electrode of the unipotential lens is maintained at a lower operating potential than the end electrodes of the unipotential lens.

8. An electron gun assembly for a color cathode-ray tube in accordance with claim 7 in which the center electrode of each gun is formed of a metal having high magnetic permeability.

9. An electron gun assembly for a cathode-ray tube having a unipotential electrostatic lens for focusing an electron beam along a given path comprising:

a cylindrical lens electrode including a central portion of a predetermined internal radius and having a curved termination at each end thereof which extends generally outwardly and away from said central portion and which, on an incremental basis, has a radius of curvature small compared to said predetermined radius.

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