Feb. 7, 1961 G. A. BURDICK 2,971,118

ELECTRON DISCHARGE DEVICE

Filed Nov. 10, 1958 2 Sheets-Sheet 1

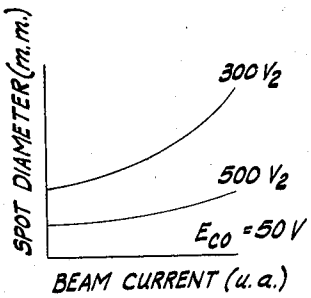


Fig. 4

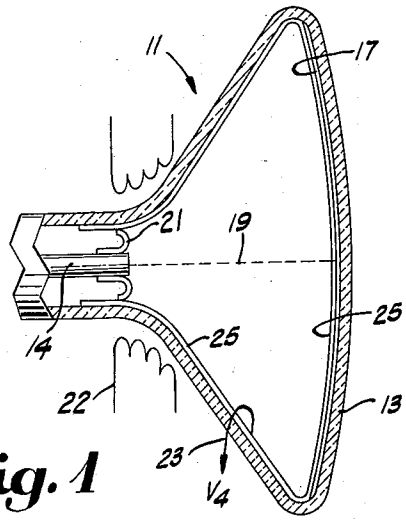


Fig. 1

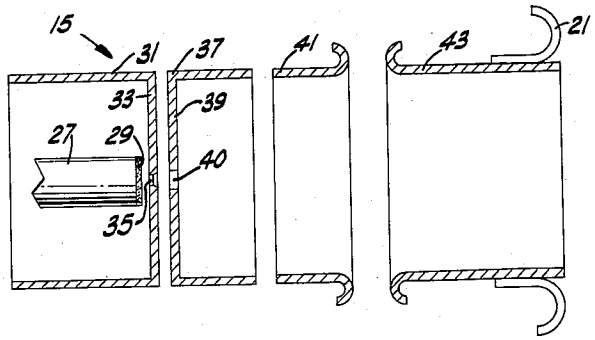


Fig. 2

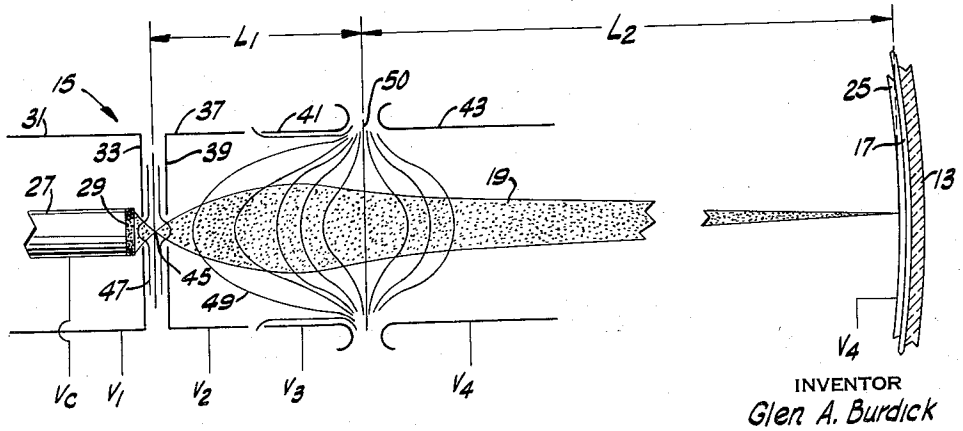


Fig. 3

INVENTOR
Glen A. Burdick
BY
Robert E. Strausser
ATTORNEY

Feb. 7, 1961 G. A. BURDICK 2,971,118

ELECTRON DISCHARGE DEVICE

Filed Nov. 10, 1958 2 Sheets-Sheet 2

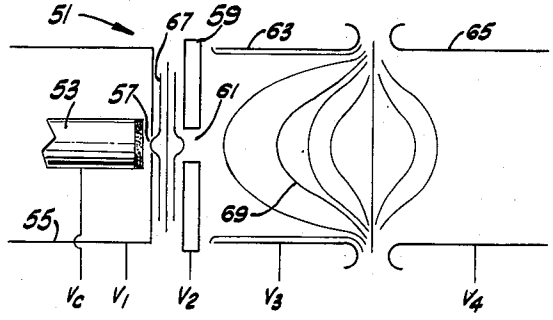


Fig. 5

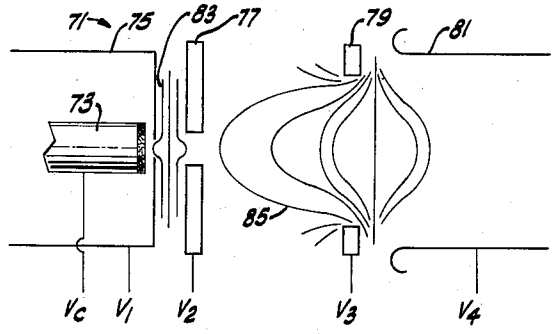


Fig. 6

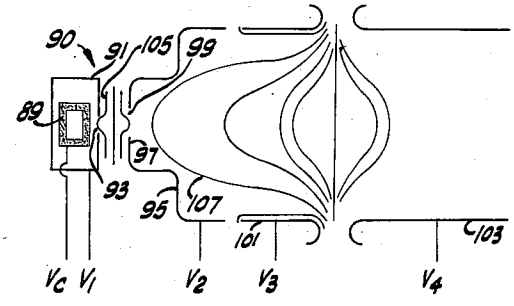


Fig. 7

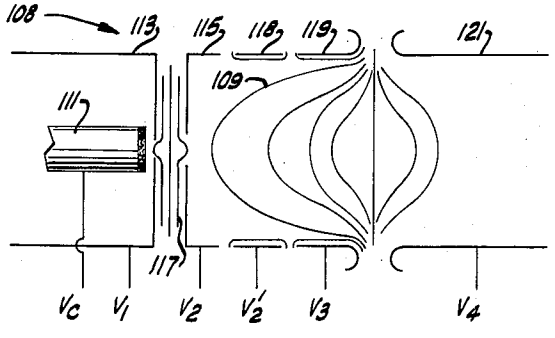


Fig. 8

INVENTOR
Glen A. Burdick
BY
Robert E. Strauser
ATTORNEY

United States Patent Office

2,971,118

Patented Feb. 7, 1961

2,971,118

ELECTRON DISCHARGE DEVICE

Glen A. Burdick, Waterloo, N.Y., assignor, by mesne assignments, to Sylvania Electric Products Inc., Wilmington, Del., a corporation of Delaware

Filed Nov. 10, 1958, Ser. No. 773,113

3 Claims. (Cl. 315—16)

This invention generally relates to electron discharge devices and more particularly to cathode ray tubes of the type employing electrostatic means for focusing the electron beam used to excite the image screen in the tube.

The majority of cathode ray tubes presently produced for image display purposes in electronic equipment such as television receivers conventionally use a uni-potential focusing lens system in the electron gun to provide final focusing of the electron beam. This type of lens is usually formed by an array of three aligned cylindrical electrodes mounted at the end of a tetrode electron gun located nearest the image screen. The first and third electrodes in a uni-potential focusing system, which are normally referred to as lens cups, are operated at the same potential, i.e., the anode or image screen potential. This anode voltage may range from 12 to 24 kv., depending upon the application. The intermediate second electrode or lens ring normally is operated at a potential which varies in accordance with the tube application from 300 volts negative to 500 volts positive. A lens of this type is net convergent so as to cause the diverging electron beam entering the lens from the "prefocusing" lens to converge or focus at the screen.

Although a uni-potential lens of the type described above performs satisfactorily, it requires a moderately long gun mount and thus a long tube neck, e.g., 5 inches. A cathode ray tube having a long neck is undesirable in light of the present trend in the television industry toward a reduction in axial tube length. At the present state of the art, a unipotential lens type gun can not be shortened beyond a given length without poor electron beam focusing which is manifested as poor picture resolution. This disadvantage seems, at present, to be inherent in a unipotential lens system due to its high magnification characteristics. Also, this type of lens has a high degree of spherical aberration, which causes distortion of the beam spot on the screen when the magnetic deflection fields are allowed to penetrate the lens electrode position. In order to make a minimum axial length tube, it is desirable to move the electron gun as far forward into the magnetic deflection field as possible, but this, as explained, increases aberration in the uni-potential electrostatic focus gun.

Another type of electron gun structure which has been proposed uses a bi-potential electrostatic collimating lens for focusing. This mount employs four spaced grids G_1, G_2, G_3 and G_4, respectively, arrayed from the cathode toward the screen. Voltages on the grids in this type of electron gun are so arranged that G_1 may be used for conventional electron control purposes, while G_2 may serve, in one aspect, to provide an immersion electrostatic field for forming the electron beam crossover point. G_3 is shaped with a restricted opening terminating in a surface defining a spherical opening to form a collimating convergent electrostatic field when operated at a low voltage relative to the potential applied to the open-ended cylindrical shaped G_4.

Under normal conditions, this collimating bi-potential focus mount has three lenses or lens fields. The first or immersion lens extends from G_2 to the cathode and aids in the production of the beam and formation of a crossover point. The second lens is positioned between G_2 and G_3 and serves to some degree as an isolating field and as a so-called "prefocusing" lens. The third or collimating lens formed by G_3 and G_4 provides final focusing of the beam. In this type of system, the limiting aperture in G_2 isolates the first lens from the second and the restricted opening and general configuration of G_3 isolates the second lens from the third lens.

A gun mount of the bi-potential type described above has a number of disadvantages. Due to the complex configuration of the parts, it is costly to produce and does not lend itself to automatic production techniques. Also, there is a tendency in this type of structure to cause beam de-focusing when there are variations in television receiver supplied voltages which result from incoming power line voltage fluctuations. Further, in a collimating lens, the action of the second focusing field operating in conjunction with the G_3 configuration produces a lens having a large amount of spherical aberation. When an electron beam passes through such a lens, poor focusing characteristics are experienced at wide deflection angles or at the edges of the screen even when the beam emerges from the center of the lens. This defocusing phenomenon is magnified when the conventional centering magnet normally positioned on the tube neck must be used. In other words, a lens having sufficient spherical aberration to cause undesirable beam spot distortion or defocusing when the beam emerges from the center of the focusing lens causes additional spot distortion when the beam is forced, by a centering magnet, to emerge from a position on the lens which is not located at the center.

Accordingly, an object of this invention is to reduce the aforementioned disadvantages in an ultra-short length cathode ray tube capable of reproducing satisfactory images.

A further object is to facilitate the utilization of low cost electrodes in a short electron gun mount which may easily be assembled and aligned by automatic production techniques.

Other objects of the invention are to reduce the spherical aberration of the electrostatic focus type short cathode ray tube mount so that it can be moved into the deflection region without causing defocusing or beam spot distortion; to reduce the magnification of a lens produced by a short focusing system so that proper beam focusing at the screen may be achieved; to utilize voltages for the electrodes in the focusing system which are readily available in a television receiver; and to produce a lens which is relatively insensitive, from a focusing viewpoint, to fluctuations in line voltage.

The foregoing objects are achieved in one aspect of the invention by the provision of a cathode ray tube having a relatively short electron gun which employs an electrostatic focusing lens system of a type wherein the object distance is relatively short and the net potential in the convergent region of the lens can be controlled without unduly affecting the immersion lens. In one embodiment of the invention, the focusing system is formed by three spaced electrodes which are operated at pre-selected, separately applied potentials to produce a unique tri-potential focusing lens.

For a better understanding of the invention, reference is made to the following description taken in conjunction with the accompanying drawings in which:

Fig. 1 is a sectional view of a cathode ray tube unitilizing the invention;

Fig. 2 illustrates a ring type electron gun structure

which is adapted for use in the cathode ray tube shown in Fig. 1;

Fig. 3 shows the electrostatic field configuration of the electrostatic lens system produced by the gun shown in Fig. 2 and its effect on the electron beam;

Fig. 4 is a graphical representation of certain characteristics of the gun structure shown in Fig. 2;

Fig. 5 illustrates another gun structure of the disc-ring type;

Fig. 6 illustrates another gun structure of the disc type;

Fig. 7 shows a Figure 2 type of gun modified primarily in the cathode and first grid regions; and

Fig. 8 shows another ring type gun structure employing a larger number of electrodes.

Referring to Fig. 1, a cathode ray tube **11** is shown comprising an envelope **13** hermetically enclosing an electron gun **14** spaced from a fluorescent image display screen **17**. The gun provides the source, control, acceleration and focusing of the electron beam **19**, which is directed toward the screen **17** and deflected by the magnetic field coils **22** to produce an image display raster. The screen, as well as the final electrode of gun **14**, are normally maintained at a potential V_4 ranging from about 12 to 24 kv., depending upon the application, to provide a constant potential deflection region through which the electrons pass at a high velocity to reach and impinge upon the screen. This high voltage V_4 is normally supplied to screen **17** and to snubbers **21** connected to the final gun electrode through a lead **23** and an internal conductive coating **25** such as an electron permeable film of aluminum. If desired, the internal neck portion of the tube contacting snubbers **21** and the interior region of the bulb around lead **23** may be coated with a layer of a graphite composition prior to aluminizing to insure electrical contact.

The electrostatic focus electron gun structure **15** shown in Fig. 2 is one form of gun structure of the present invention to be used in the cathode ray tube illustrated in Fig. 1. This structure, which will be referred to as a ring type mount, comprises an indirectly heated cathode sleeve **27** having electron emissive material **29** disposed on the end thereof. Spaced from the cathode in the direction of electron travel is a cylindrical first or control grid **31** formed to provide an end wall **33** having its central portion reduced in thickness adjacent the aperture **35** formed therein. The cylindrical second or screen grid **37**, which is spaced from grid **31**, also has an end wall **39** formed to provide an aperture **40** aligned with aperture **35**. The third grid **41** and fourth grid or anode **43** are formed as open-ended cylinders having internal diameters substantially equal to the diameter of grids **31** and **37**. The ends of grids **41** and **43** facing each other are curved to prevent arc-overs since there is a large potential difference existing between these electrodes during tube operation. Snubbers **21** on the fourth grid **43** provide electrical contact between conductive coating **25** and the high voltage lead **23**. These gun electrodes may be mounted relative to one another in the conventional manner by support pins or straps connected to an insulating rod (not shown). Thus, it can be seen from Fig. 2 that the gun structure **15** comprises a cathode and four aligned serially arrayed cylindrical grids. Apertured end walls are provided in grids **31** and **37** whereas grids **41** and **43** are open-ended cylinders.

Fig. 3 illustrates the electron optical system of gun **15** and the manner in which it operates upon the electron beam **19** to produce beam focus at screen **17** when the appropriate voltages are applied thereto as will be hereafter described. The optical system functions so that the electrons emitted from cathode **27** are formed into a beam which passes through aperture **35** to a minimum beam diameter position or crossover point **45**. This position appears to be located close to the control grid **31**. The first electrostatic field or immersion lens **47** causes the electrons to leave cathode **27** and converge at the electron crossover position **45**. As the electrons proceed through the immersion field **47**, they enter into grid **37** through aperture **40** in a moderately divergent manner. Upon entering grid **37**, the electrons in beam **19** are again converged by tri-potential lens **49** so that the beam is focused at screen **17**.

It can be seen from Fig. 3 that the lens system of gun **15** comprises an immersion field **47** with a tri-potential focusing field **49** located immediately adjacent thereto. Cylindrical grids **37** and **41** are constructed with open ends facing one another so that focusing field **49** extends back to end wall **39** of grid **37**. In addition, it can be seen that the electrons in beam **19** converge toward and diverge from crossover point **45** at moderate angles. As far as it can be determined, the beam, when properly focused, has essentially a conical envelope or outline extending from the grid **37** vicinity to screen **17** with the apex of the cone located at the screen.

Formation of the electrostatic lens system comprising immersion field **47** and tri-potential focusing field **49** is dependent, in part, upon the selected object distance L_1, the selected image distance L_2, and upon the voltages selected and applied to the various electrodes or grids in gun **15**. For purposes of description, the object distance L_1 may be defined as extending from crossover point **45** to the mid-point of the gap between grids **41** and **43**, which is essentially at the center **50** of lens **49**. Since it has been found that the crossover is located close to grid **31**, the distance L_1 can also be considered to extend from the forward surface of this grid to the center of lens **49** for all practical purposes. The image distance L_2 may be defined as the distance from the center of the lens **49** or the center of the grid **41**—grid **43** gap to the center of screen **17**.

It has been found that for a short axial length cathode ray tube **11**, the ratio of object distance to image distance, i.e., L_1/L_2, preferably is maintained within the range of from approximately .03 to .06. Above this range, the tube length is undesirably long and below this range the lens magnification is large and focusing becomes difficult with available receiver voltages. With a focusing lens system of this type, the object distance L_1 can range from about .250" to .640" when using grid cylinder diameters of the type hereinafter described. It is to be understood that the L_1/L_2 ratio and object distance range relates primarily to a 110° deflection tube. Accordingly, if the deflection angle is increased, these parameters as well as other interrelated parameters to be hereafter described may have to be altered in accordance with the concept described herein.

The image distance L_2 should be selected to be larger in tubes with a larger screen area than in tubes with a smaller screen area. For instance, when employing gun **15** with a tube using a 14 inch diagonally measured screen, the image distance may be about 8.5 inches while a tube with a 24 inch diagonally measured screen may require an image distance of 12 inches.

The voltages applied to the electrodes of gun **15** are also basic parameters inter-related with the object and image distances which determine the action of immersion lens **47** and tri-potential focusing lens **49** as well as the electron beam cut-off or drive range characteristics of the tube. A factor to be considered regarding the drive range is the desired beam current, e.g., 1000 microamperes, which is required to provide an acceptable highlight brightness on the screen. It is advantageous to minimize the drive requirements in order to minimize the drive requirements in order to minimize motion of the crossover point **45** and thus minimize beam spot blooming. When desired, the drive characteristics of gun **15** can be altered either by changing the spacing between cathode **27** and grid **31**, the spacing from grid **31** to grid **37**, the diameter of aperture **35**, the thickness of the

material surrounding this aperture, or voltage V_2 applied to grid 37.

Regarding the focusing system, the immersion field 47 is formed by the potential difference existing between V_1 on grid 31 and V_2 on grid 37 and V_c. Assuming that tube 11 is cathode driven, although the inventive concept is not to be construed as being restricted thereto, the cathode voltage V_c represents the video signal derived from the video amplifier or second detector in the receiver and applied to the cathode. V_c may range from ground to approximately 50 volts positive. Under these conditions, V_1 is usually held at ground potential and V_2 is at a positive potential as will be hereinafter described.

Tri-potential focusing lens 49 is formed by the relatively low voltages V_2 and V_3 and the relatively high voltage V_4 applied to grids 37, 41 and 43 respectively. The potentials V_2 and V_3 preferably should neither exceed approximately 700 volts, nor be less than ground potential. At the upper part of this range, the focusing lens 49 becomes weaker and needs, for proper operation, a longer object distance and therefor a longer tube. In any event, V_2 and V_3 should preferably not exceed approximately 5% of the V_4 or screen potential, which may range from about 12 kv. to 24 kv. as stated above.

The voltage V_2 applied to screen grid 37 may be between approximately 250 and 700 volts and preferably in the upper part of this range. The graph shown in Fig. 4 illustrates an advantage to selecting a voltage V_2 near the B boost potential. Using a constant cathode drive range, E_{co}, of 50 volts, for example, the beam spot diameter at the screen is smaller at all beam currents when V_2 is at 500 volts than at 300 volts. Stated generally, the beam spot diameter decreases, and thus image resolution increases, as V_2 is increased, within limits.

The voltage V_3 supplied to grid 41 preferably is less than V_2 and in the vicinity of 300 volts since it has been found that there is a tendency for lens 49 to be less affected by line voltage fluctuations under these conditions. In practice, V_3 may be a variable voltage ranging from ground to B boost as stated above. Varying V_3 affects the focusing of tri-potential lens 49 but does not noticeably affect the immersion field 47. Therefor, varying V_3 does not appreciably change the beam cut-off or beam spot blooming characteristics of the tube.

The lengths of the various electrodes or cylinders in gun 15 determine in part some of the tube characteristics. Grid 31 is preferably long enough to substantially surround cathode 27, but otherwise as short as possible to minimize the length of mount 15. The total length of grids 37 and 41 taken together partially determine the object distance of lens 49. Individually, grid 37 may be slightly longer than grid 41. However, these lengths may be varied in order to stabilize the effects of fields 47 and 49 under conditions of line voltage fluctuations. Proper selection of the form of and spacing between grids 37 and 41 in conjunction with selection of V_2 and V_3 provides minimum variations in focusing or beam spot size when there are proportional variations in the receiver supplied voltages V_2 and V_3. The length of grid 43 is not of primary importance but is preferably substantially as long as it is wide.

The spacings selected between electrodes in gun 15 also contribute to the desired tube characteristics. The cathode 27 to grid 31 spacing, and the grid 31 to grid 37 spacing are two of the several factors which determine the beam cutoff characteristics of the tube as mentioned above. With the voltages and dimensions enumerated for illustration of gun 15, the cathode to control grid 31 spacing may be from about .003 inch to .007 inch and the grid 31 to grid 37 spacing may be from approximately .010 inch to .025 inch.

The distance between grids 37 and 41 is inter-related with the lengths of these grids so that the proper object distance L_1 can be obtained. The grid 41 to grid 43 spacing also aids in determining L_1. Care must be taken not to make the grid 41 to grid 43 distance so small that arc-overs occur between these electrodes.

The diameters of the electrodes in gun 15 are dictated, in part, by the prescribed lens system. Generally, larger diameter cylinders for grids 37, 41 and 43 produce a lens field 49 which has less spherical aberration and is desirable from this point of view. However, smaller diameter cylinders require a shorter object distance for particular operating voltages and therefore are more desirably adapted to shorter gun mount applications. Therefore, any selection of electrode diameters is the result of a compromise between spherical aberration and gun length. The grids, especially grid 41 in mount 15, preferably have an inside diameter within the range of from about .20 to .60 inch, but the invention is not to be construed as being restricted thereto. It is advisable to use a ratio of object distance L_1 to cylinder diameter D, i.e., L/D ranging from approximately 1.0 to 1.5. Since the object distance is dependent in part upon the available grid diameters, this object distance L_1 may be shortened to an even greater extent if smaller diameter cylinders are employed. Grid 43 may have a smaller diameter than the other grids to enhance focusing, if desired.

The physical configurations of grids 31, 37, 41 and 43 are selected to aid in the achievement of desired tube characteristics as well as for their low cost and adaptability to automatic production techniques. The end wall 33 of control grid 31 is reduced in thickness around aperture 35 in order to obtain the desired beam cut-off characteristics without necessitating an unusually small and impractical cathode 27 to grid 31 spacing or grid 31 to grid 37 spacing. This feature, however, is not essential. A thickness ranging from about .002 inch to .010 inch has proven satisfactory. Regarding aperture 35, if the diameter is too small, the cathode is overloaded and poor cathode emission life characteristics are experienced, and if the diameter is too large, the beam crossover area 45 becomes too large to obtain a reasonably small beam spot diameter at screen 17. It has been found that aperture 35 is preferably between about .015 inch and .030 inch for gun 15.

The apertured end plate 39 of screen grid 37 serves to separate focusing field 49 from immersion field 47. When using a control grid aperture 35 of the type described above, it has been found preferable to use a diameter for aperture 40 ranging from approximately .025 inch to .060 inch. If aperture 40 is too small the alignment of the grids becomes very critical, if too large it will allow the field lines of lens 49 to undesirably affect field 47.

Grids 41 and 43 are formed as open-ended cylinders and the end of grid 37 facing grid 41 is also open so that the field lines of lens 49 may have normal symmetry and extend back to the end plate 39.

The structural features of any picture tube gun are dependent to some extent upon the operating voltages, type of drive, beam cut-off limits, deflection angle, overall envelop length and the image definition and brightness characteristics desired. Therefore, the present invention may be altered in accordance with these desires without departing from the spirit and scope of the invention.

Without limiting the generality of the foregoing description of one embodiment of the invention, a specific example of gun mount 15, when used in a 17 inch 110 degree deflection tube, may utilize an electrostatic focusing system wherein the object distance L_1 is about .426 inch and the image distance L_2 is approximately 8.64 inches. With the selected focus voltages, the inside diameters of the grids are approximately .375 inch.

With a cut-off drive range of about 60 volts, the spacing between cathode 27 and the internal surface of grid 31 is about .005 inch, the aperture 35 diameter is about .022 inch, the wall thickness of this aperture is about .004 inch, and the spacing between the edge of aperture

35 facing grid 37 and grid 37 is approximately .024 inch.

Aperture 40 in end wall 39 may have a diameter of about .036 inch to provide adequate separation of immersion field 47 from focusing field 49.

Acting in conjunction with the grid 31 to grid 37 spacing to provide the object distance recited above, grid 37 is about .165 inch long, grid 41 is about .135 inch long, the spacing between these grids is about .062 inch and the spacing from grid 41 to grid 43 is approximately .080 inch.

The length of grid 31 is about .250 inch and of grid 43 is approximately .345 inch.

In operation, gun 15 may have applied there a video signal V_c with V_1 at ground, V_2 at about 500 volts, V_3 variable and at approximately 300 volts and V_4 at about 16 kv.

The invention disclosed above in conjunction with the ring type gun mount 15 may be used to produce other types of guns such as those illustrated in Figs. 5, 6, 7 and 8. The basic gun structure parameters as well as the lens and voltage characteristics herebefore described are applicable to these mounts.

Fig. 5 illustrates a disc-ring type electrostatic tri-potential focus gun 51 employing a cathode 53 spaced from a cylindrical control grid 55 which has a limiting aperture 57 formed therein. A disc-shaped screen grid 59 is spaced from the control grid and is provided with an aperture 61. The open-ended cylindrical grids 63 and 65 are disposed in spaced relationship and arrayed toward the screen of the tube.

Electron gun 51 functions essentially in the same manner as gun 15 of Fig. 2. The immersion field 67 tends to form an electron crossover point and tri-potential field 69 operates to focus the beam at the screen. Voltages V_c, V_1, V_2, V_3 and V_4 may be of the magnitude described above, with V_3 preferably being variable.

Fig. 6 illustrates a disc-type electrostatic focus electron gun 71 employing in spaced array a cathode 73, cylindrical control grid 75, disc screen grid 77, disc grid 79 and cylindrical grid 81. The immersion field 83 is formed between cathode 73 and grids 75 and 77 and a tri-potential focusing lens 85 is formed by the potentials applied to grids 77, 79 and 81. The inside diameter of disc 79 may be slightly smaller than grid 81 in order to confine the field of lens 85. Here also, the voltages applied to the various grids may have the order of magnitude as described above.

The ring type gun mount 90 illustrated in Fig. 7 is modified from the gun 15 structure of Fig. 2 primarily in the cathode and control grid regions. In this embodiment of the invention, the cathode 89 and control grid 91 assembly is essentially constructed as a diode type receiving tube with an aperture 93 formed in member 91. The longitudinal axis of indirectly heated cathode 89 may be, in this instance, disposed transverse to the longitudinal axis of gun 90. Cylindrical grid 95 is formed with an end plate 97, which is provided with an aperture 99. That portion of grid 95 facing grid 91 is reduced in diameter to facilitate mounting to the previously fabricated cathode-control grid assembly. This reduced diameter does not appreciably affect the shape or action of the focusing lens. Serially arrayed in spaced relationship from grid 95 are the open-ended cylindrical grids 101 and 103. The immersion field 105 is formed between grids 91 and 95 and the tri-potential focusing field 107 is formed by the potentials applied to grids 95, 101 and 103. Voltages V_c, V_1, V_2, V_3 and V_4 are of magnitude described above.

The several embodiments of the invention heretofor described are directed to an ultra-short tri-potential electrostatic focus electron gun employing four grids. In each instance, the net convergent focusing field such as lens 49 of Fig. 3 has a convergent portion within the region of the second and third grids, e.g., electrodes 37 and 41, and a divergent portion within the fourth grid e.g., electrode 43. However, in accordance with this invention, it is to be understood that the number of grids used to form either the convergent or divergent portions of the focusing lens may be increased, if desired. For instance, Fig. 8 illustrates a gun structure 108 which employs four separately applied voltages in order to produce the focusing field 109. In this application, cathode 111 and control grid 113 are spaced from one another and from screen grid 115 to produce immersion field 117 when the voltages V_c, V_1 and V_2 respectively are applied thereto. The convergent portion of lens 109 lies substantially within the axially aligned and spaced cylindrical grids 115, 118 and 119. The divergent portion of lens 109 lies substantially within cylindrical grid 121. This type of gun structure may be considered to use a tetra-potential focusing lens 109 since voltages V_2, V_2', and V_3, all of which can be between ground and B boost, and the high potential V_4, may be separately applied to the designated grids. An advantage of such a structure resides in its adaptation to a more refined control over the shape of field 109 since the voltages V_2, V_2', and V_3 may be selected to arhieve this control after the V_4 value is selected. In this respect, grid 121 may also be formed as two or more grids, with separate high voltages applied to each. Although increasing the number of cylinders or discs may improve control of the field shape of lens 109, the cost of parts and the need for available power supplied will also increase over the tri-potential lens structures.

In order to appreciate the marked advance toward shorter axial length tubes which this invention provides, it is only necessary to compare the overall lengths of the shortest previously available tubes of a given type such as a 17 inch, 110 degree deflection tube, with a 17 inch 110 degree deflection tube employing one of the gun structures of this invention. It is to be noted that the dimensions fo the envelope or bulb in both instances from the yoke reference line forward to the screen are identical. The prior short tubes had an overall length from the base of the tube to screen 17 which was approximately 13 inches whereas the overall dimension of tube 11 is approximately 10 inches. The difference in these two lengths is in the neck portion of the tube and is brought about primarily by the ultra-short gun structures.

A cathode ray tube constructed in accordance with the invention meets the operating requirements of television manufacturers and has satisfactory electrical and image brightness and definition characteristics. The focusing lens produces minimum spherical aberration and can be controlled without undesirably affecting the immersion field. Accordingly, with these features, the picture tube has universality in that the range of manufacturing tolerances need not be unusually restrictive and that the electron beam in the tube can be focused under all circumstances where the voltages normally available for application to the focusing system electrodes are different from one television receiver to another.

Although several embodiments of the invention have been shown and described, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the scope of the invention as defined by the appended claims.

What is claimed is:

1. A gun structure adapted for use in a cathode ray tube employing an electron beam comprising in sequence a cathode, a first grid having an apertured end wall, a second grid formed to provide an apertured wall, a third grid having a given diameter and a fourth high voltage grid, said grids being mounted in spaced relationship with one another and formed to provide an electrostatic immersion lens and a tri-potential electrostatic beam focusing lens separated directly by said second grid apertured wall, said focusing lens having an object distance which is substantial but less than approximately .64

inch, an object distance to image distance ratio ranging from approximately .03 to .06, and a ratio of said given object distance to said given diameter ranging from about 1.0 to 1.5, said tri-potential lens providing focusing of the beam when the voltage applied to said second grid ranges from approximately 250 to 700 volts, the voltage applied to said third grid is less than approximately 700 volts, and the voltage applied to said fourth grid exceeds approximately 12,000 volts.

2. A gun structure adapted for use in a cathode ray tube employing an electron beam comprising in sequence a cathode, a first grid having an apertured end wall, a second grid formed to provide an apertured wall, a cylindrical third grid, a cylindrical fourth grid having a given diameter, and a fifth high voltage grid, said grids being mounted in spaced relationship with one another and formed to provide an electrostatic immersion lens and a tetra-potential electrostatic beam focusing lens separated directly by said second grid apertured wall, said focusing lens having an object distance which is substantial but less than approximately .64 inch, an object distance to image distance ratio ranging from approximately .03 to .06, and a ratio of said given object distance to said given diameter ranging from about 1.0 to 1.5, said tetra-potential lens providing focusing of the beam when the voltage applied to said second grid ranges from approximately 250 to 700 volts, the voltages applied to said third grid and fourth grids are less than approximately 700 volts, and the voltage applied to said fifth grid exceeds approximately 12,000 volts.

3. A gun structure adapted for use in a cathode ray tube employing an electron beam including in sequence a cathode, a first grid having an apertured end wall, a second grid formed to provide an apertured wall, at least a third grid having a given diameter, and a final high voltage grid, said grids being mounted in spaced relationship with one another and formed to provide an electrostatic immersion lens and an electrostatic beam focusing lens separated directly by said second grid apertured wall, said focusing lens having an object distance which is substantial but less than approximately .64 inch, an object distance to image distance ratio ranging from approximately .03 to .06, and a ratio of said given object distance to said given diameter ranging from about 1.0 to 1.5, said focusing lens providing focusing of the beam when the voltage applied to said second grid ranges from approximately 250 to 700 volts, the voltage applied to said third grid is less than approximately 700 volts, and the voltage applied to said final grid exceeds approximately 12,000 volts.

References Cited in the file of this patent

UNITED STATES PATENTS

2,139,678	Glass	Dec. 13, 1938
2,227,033	Schlesinger	Dec. 31, 1940
2,806,163	Benway	Sept. 10, 1957
2,825,837	Dudley	Mar. 4, 1958
2,839,703	Niklas	June 17, 1958
2,859,366	Squier	Nov. 4, 1958

OTHER REFERENCES

Pearce: "The Return of Electrostatic Focusing," Journal of the Television Society, vol. 8, No. 6, Apr.–June, 1957, pp. 237 to 248.