Nov. 28, 1961 H. C. MOODEY 3,011,090

PLURAL BEAM TUBE

Original Filed June 6, 1950 3 Sheets-Sheet 1

Fig. 1.

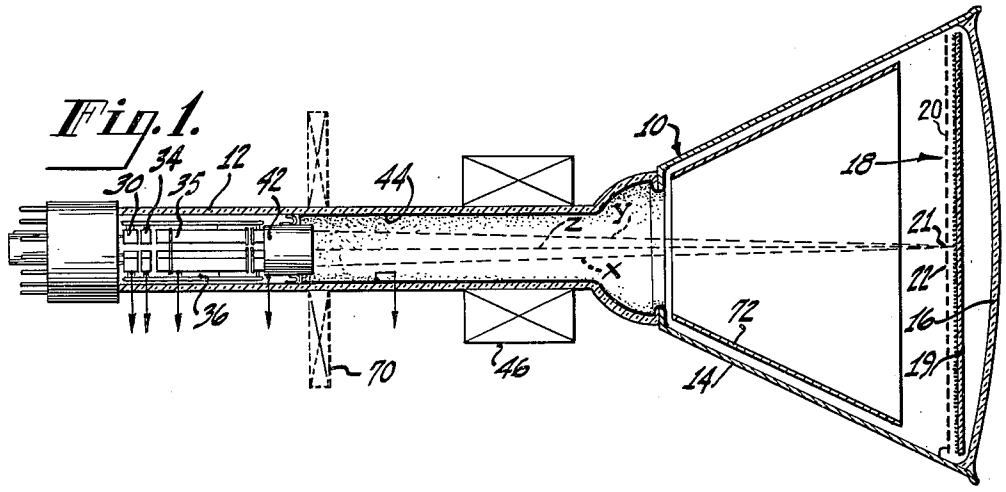
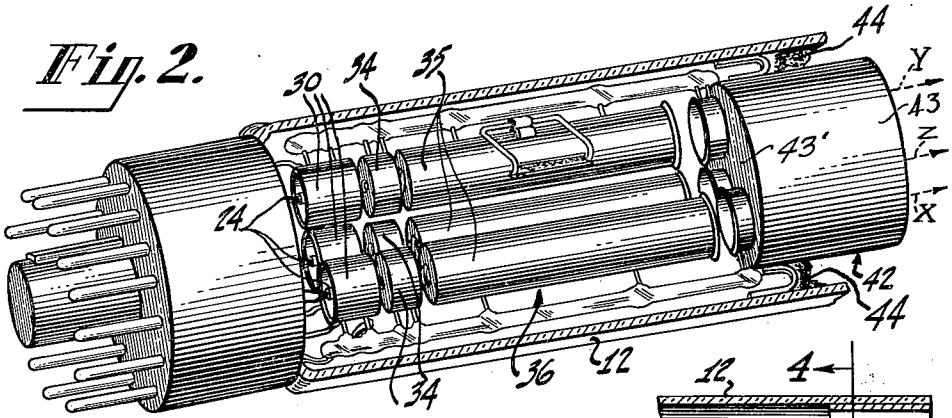


Fig. 2.



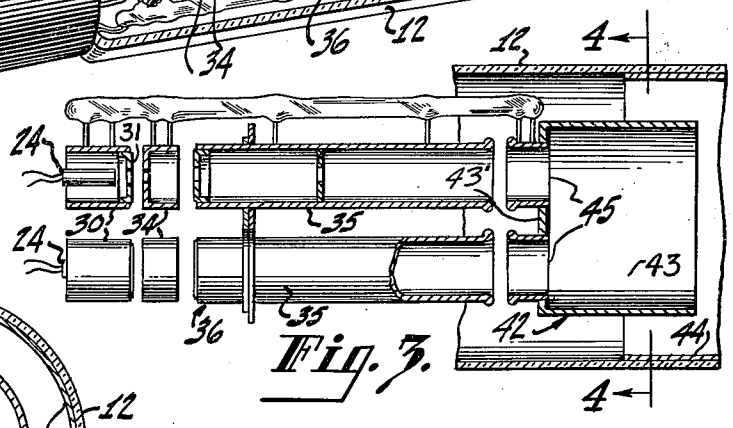


Fig. 3.

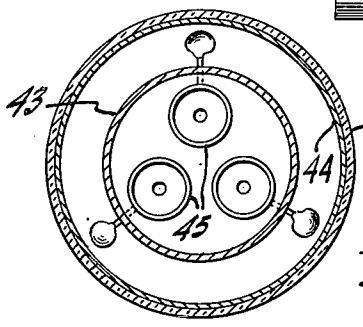


Fig. 4.

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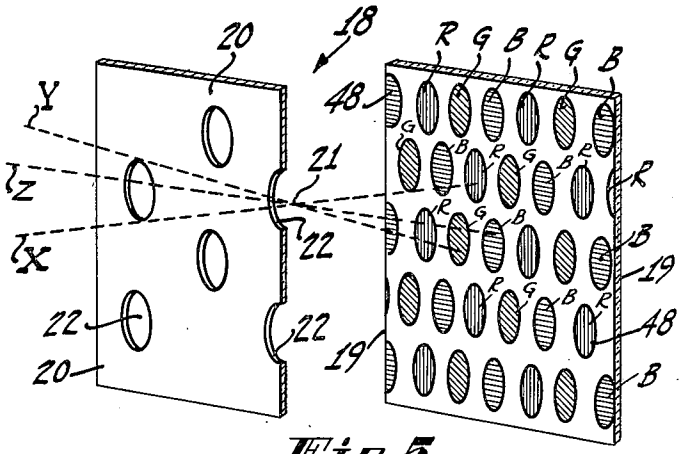
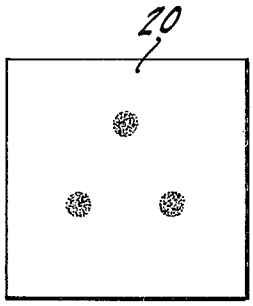
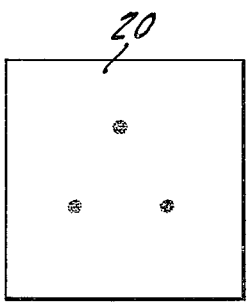


Fig. 5.



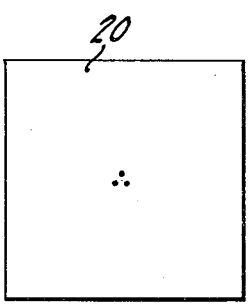
$E_{36} = E_{42} = E_{44}$

Fig. 6.



$E_{36} < E_{42} = E_{44}$

Fig. 7.



$E_{36} < E_{42} < E_{44}$

Fig. 8.

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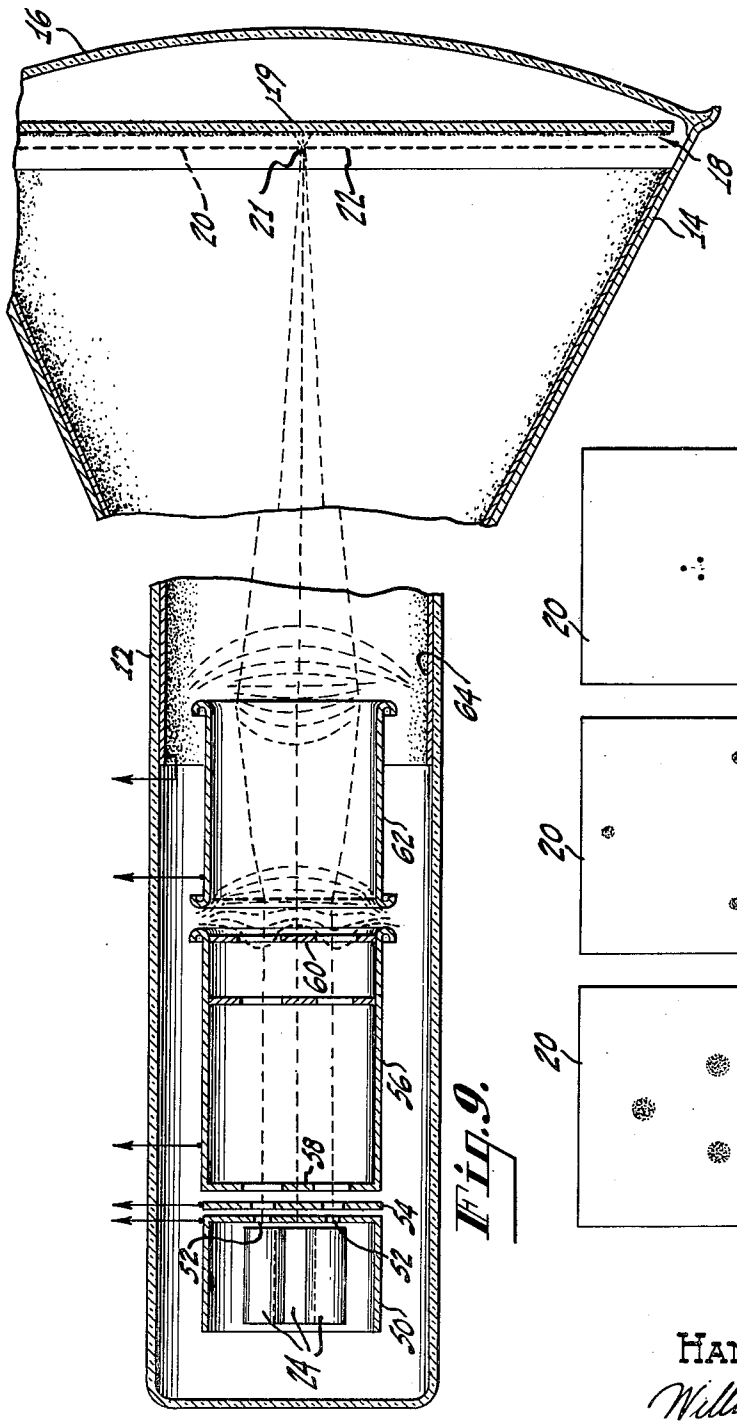


Fig. 9.

Fig. 12.

Fig. 11.

Fig. 10.

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3,011,090

PLURAL BEAM TUBE

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Continuation of abandoned application Ser. No. 166,416, June 6, 1950. This application June 24, 1952, Ser. No. 295,225

15 Claims. (Cl. 315—13)

This invention is directed to a cathode ray tube, and more particularly to an improved gun structure for producing a plurality of electron beams which may be converged toward each other or converged to a point. While not limited thereto, my invention is particularly suitable for use in a cathode ray tube for producing a visual picture in color.

This application is a continuation of my copending application Serial Number 166,416, filed on June 6, 1950, now abandoned.

In a type of cathode ray tube utilizing a plurality of electron beams, each beam is formed by an independent electron gun means, which focuses the beam on the target surface. Spacing the several gun means from each other and properly positioning the guns permits the directing of the respective beams toward the target surface from different directions in one proposed tube, a plurality of electron guns are spaced apart and inclined to each other in a manner to bring the several beams to a point of convergence at a target surface. With this structure, the beam paths of the respective electron beams are at all points converging. By this particular arrangement of electron guns, it is necessary to tilt the guns relative to each other, which requires an undue spacing of the guns within the tube neck. This arrangement also requires very accurate positioning to insure that the electron beams intersect precisely at the target. It is obvious that if the guns of the tube can't be nested together in parallel relationship, the use of a smaller diameter neck structure is permitted with resulting advantages.

Parallel electron beams resulting from an arrangement of parallel guns require either a magnetic or an electrostatic lens field to converge the beams toward a target or to a point near the screen surface. Difficulties arise in beam focusing with the introduction of a common converging field for several beams. However, a definite advantage is obtained in that the degree of convergence can be controlled by varying the strength of the converging field. In this manner, then, such adjustment can be made and control obtained within the finished tube which do not depend upon the mechanical alignment of the several guns relative to each other and to the tube axis.

It has been proposed to produce television pictures in color by the use of a single cathode ray tube. Such devices have been disclosed in the past, using either a single electron beam or a plurality of electron beams scanned over a fluorescent target structure. An example of a device utilizing a single beam cathode ray tube is that disclosed in the copending application of R. R. Law, Serial No. 143,405, filed February 10, 1950, now Patent No. 2,696,571, dated December 7, 1954. Also, a disclosure of a single television picture tube utilizing a plurality of electron beams is copending application of A. C. Schroeder, Serial No. 730,637, filed February 24, 1947, now Patent No. 2,595,548, dated May 6, 1952. Both of these applications are assigned to the assignee of the present application. Both of these types of color television picture tubes may utilize several types of target structure, as disclosed in these applications. These target structures are those which, for successful operation, require that the electron beam or beams approach the target structure from different directions so that all electrons approaching the target structure from any given direction

will strike a surface of the target structure coated with a phosphor material luminescing with a single colored light.

It is an object of my invention to provide an electron discharge device of the cathode ray type having a new and improved electron gun assembly.

It is a further object of my invention to provide a cathode ray tube using a plurality of electron beams with means providing a common converging field for the electron beams.

It is another object of my invention to provide a cathode ray tube using a plurality of electron beams and having common means for focusing and converging the beams.

It is a further object of my invention to provide a color television picture tube using a plurality of electron beams wherein said beams are focused and converged, and wherein the focusing effect may be adjusted independently of the converging effect.

Generally, my invention is directed to a cathode ray tube and a gun assembly for a cathode ray tube having a plurality of beam producing guns in which the beams can be separately controlled and focused as well as simultaneously deflected. By means of novel structure, the beams generated by the guns, which are mounted in parallel relationship, can be converged to a common point.

The specific invention is directed to a cathode ray tube having an electron gun for producing a plurality of electron beams, which are directed toward a target in a manner to approach the target, each from a different direction. If such a gun were used, for example, in a color television tube of the type disclosed in the above-cited application of Schroeder, the electron beam approaching the target from any given one direction will strike a phosphor coated target surface to produce a specific color of luminescence. The electron gun structure of my invention consists of closely arranged electrodes for producing a plurality of beams along parallel paths. The gun structure is designed to produce separate beam focusing fields for each beam, which do not affect the convergence of the several beams. Means are provided to produce a common converging field, which has the double function of bringing the several beams to a common point of convergence near the target and also that of completing the focusing of the electrons of each beam near the common point. The specific electron gun structure comprises an arrangement of positive electrodes, axially spaced along the beam paths between the cathode structure of the tube and the target screen. Tubular electrode structures provide separate focusing means for each electron beam. An electron lens producing means is used to provide a common converging field for bringing the electron beams to a common point of convergence near the target. The separate beam focusing fields are independent of and do not affect the converging effect of the common electron lens field. Thus, any adjustment of the independent focusing fields will not effectively change the convergence of the several beams at their common point. The beam converging lens means may consist of part of the electron gun structure to produce an electrostatic lens field or an external magnet means producing a magnetic lens field.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims, but the invention itself will best be understood by reference to the following description taken in connection with the accompanying drawings in which:

FIGURE 1 discloses a sectional view of a cathode ray tube utilizing a plurality of electron beams, in accordance with my invention;

FIGURES 2 and 3 are partial sectional views of a portion of a cathode ray tube similar to that shown in FIGURE 1;

FIGURE 4 is a cross-sectional view along lines 4—4 of FIGURE 3 of the gun structure of FIGURES 2 and 3;

FIGURE 5 is a schematic showing of a portion of the target structure of the tubes of FIGURE 1 and of FIGURES 2 to 4;

FIGURES 6, 7 and 8 are schematic showings of the effect of the electron beams of the tube of FIGURES 1, 2 and 3, as the operating potentials of the gun electrodes are varied;

FIGURE 9 is a partial sectional view of a cathode ray tube using a modified structure of the gun of FIGURES 2 and 3;

FIGURES 10, 11 and 12 are schematic showings of the effect of the electron beams of the tube of FIGURE 9, as the operating potentials of the gun electrodes are varied.

My invention is described in relation to a television tube for producing pictures in color. This is by way of example only, and the invention should not be considered as limited to only this example. FIGURE 1 discloses one type of cathode ray tube for which my gun is suitable and comprising a color television picture tube having an evacuated envelope structure **10** formed with a tubular neck portion **12** and a conical bulb portion **14**. The large end of the conical bulb portion **14** is closed by a relatively flat wall portion or face plate **16**. Spaced from the face plate **16** is a target structure **18** comprising a transparent target sheet **19** coated on one surface thereof with a plurality of phosphor materials, in the arrangement described below, and an apertured masking electrode **20** adjacent to the target sheet **19** and having a plurality of apertures **22** for the passage therethrough of a plurality of electron beams. The masking electrode **20** is electrically connected to the metal cone **14**.

Within the tubular neck portion **12** of envelope **10** is mounted means for producing a plurality of electron beams. Such means includes electron gun structure for directing and focusing a plurality of electron beams at a common point near the surface of the masking electrode **20**.

The gun structure, shown in greater detail in FIGURES 2, 3 and 4, comprises three cathode electrodes **24**, consisting of tubular members axially aligned parallel to each other and to the axis of the tubular envelope portion **12**. Within each cathode electrode is, as is well known in the art, a heater filament for maintaining the temperature of the cathode **24** at an appropriate temperature for thermionic emission. The target end of each cathode electrode **24** is closed and coated by a mixture of barium and strontium oxides to provide a source of electron emission during tube operation. Each cathode electrode **24** is surrounded by a tubular control grid member **30**, which is closed at the target end by an apertured plate **31** (FIGURE 3). Closely spaced along the tubular envelope portion **12** and coaxial to each grid member **30**, is a short cup-like screen grid electrode **34**. As shown, the bottom of each cup member **34** is apertured to provide passage therethrough of a beam of electrons from one of the cathodes **24**. A first accelerating electrode structure **36** is provided for the three electron beams shown. The first accelerating electrode structure **36**, as shown in FIGURES 2 and 3, consists essentially of a unit of three tubular accelerating electrode members **35**, arranged with their axes parallel to each other and aligned each with one set of gun electrodes **24**, **31** and **34**. The electrode members **35** may be either insulated from each other as shown in FIGURE 2, or connected as shown in FIGURE 3. As shown best in FIGURE 3, each of the first accelerating electrode members **35** is partially closed at the cathode end with an apertured plate and open at the other end.

A second accelerating electrode structure **42**, provided as is shown in FIGURES 2 and 3, comprises a tubular member **43** common to the three beams. However, the cathode end of tubular member **43** is partially closed by a plate structure or wall **43'** in which are mounted three short tubular members **45**, each of which is aligned with one of the members **35**. A tubular third accelerating electrode consists of a conductive coating **44** formed on the inner surface of the tubular neck portion **12** of the envelope. The conductive coating extends into the conical tube portion **14** to a point making contact therewith, to prevent the accumulation of charges on the glass portion of the envelope wall during tube operation.

Each set of aligned electrodes **24**, **31**, **34**, **35** and **45** constitutes, in effect, a separate electron gun for producing and focusing an electron beam at a point near the target surface. The three sets of electrodes shown in FIGURES 1, 2 and 3 provides means for producing three electron beams along respective paths initially parallel to each other and the tube axis. As will be described below, the electrode structure also provides means for simultaneous convergence of the three beams along paths X, Y and Z to a common point near the target surface. Thus, the electron beams are caused to always approach the surface of masking electrode **20** from different directions, the direction of approach of each beam being substantially the same over all portions of the surface of the masking electrode **20**.

FIGURE 5 discloses a greatly enlarged view of a small segment of the target structure **18**, so as to diagrammatically illustrate how the color is produced by the several electron beams striking target structure **18**. The apertured masking plate **20** has a plurality of regularly arranged apertures **22** for the passage therethrough of electrons from beams X, Y and Z. The electron beams may be brought to a common point **21** of convergence near the surface of the masking electrode **20**. During tube operation, the three beams are simultaneously scanned over the surface of the masking electrode **20** by scanning fields produced by two pairs of deflecting coils contained in a yoke structure indicated at **46** in FIGURE 1. Each pair of coils is adapted to produce a field transverse to the axis of the envelope neck portion **12** and perpendicular to the field of the other pair of deflecting coils. The coils of each pair are connected in series and to an appropriate circuit including a source for producing saw-tooth current pulses, to provide line and frame scansion of the electron beams over the surface of the masking electrode **20**. The conventional scanning pattern is rectangular, in which the scansion lines are horizontally arranged running from top to the bottom of the raster. Such scansion of electron beam over a target surface is well known and is not a part of my invention.

As shown in FIGURE 5, when the common point **21** of convergence of the electron beams X, Y and Z falls on an aperture **22** of the masking electrode **20**, the beam paths pass through the masking aperture **22** and diverge to strike spaced portions **48** of the adjacent surface of the transparent target sheet **19**. These spaced surface portions are coated, each with a different phosphor material providing a characteristic colored luminescence. For example, it may be arranged that all of the phosphor coated portions struck by the electrons of the beam following path X will luminesce with a red colored light, while those electrons following beam paths Y and Z will strike phosphor areas which will only luminesce with a greeen and blue light respectively. The phosphor coated portions are each arranged, with respect to apertures **22**, of the masking electrode **20**, so that electrons passing through apertured electrode **20** and from the direction of the beam path X will cause only red luminescence, while those electrons striking the phosphor coated surface of the target sheet **19** from directions Y and Z will produce only green and blue luminescence, respectively. The arrangement of the phosphor coated areas **48** upon the surface of plate **19** are de-

termined by simple geometric relationship. It is obvious that for each aperture 22, there are three phosphor coated areas 48, one producing red luminescence, and the other two, green and blue luminescence respectively. The arrangement of the apertures 22 may be in any order desired and, as is shown in FIGURE 2, may consist of horizontal rows of apertures parallel to the line scansion of the electron beams. It is desirable, of course, to coat as much as possible of the surface of plate 19 with phosphor material to provide more light output. Accordingly, the dispersion of the beams X, Y and Z after passing through apertures 22 should not be too great but only sufficient to separate the electrons of the beam that they may strike separate phosphor coated areas. In a successfully operated tube of the type described, the several electron beams X, Y and Z have an angle of incidence with respect to masking electrode 20 of substantially between 1 to 3 degrees.

The electron guns of FIGURES 1 to 4 are indicated as grouped about the axis of the tubular envelope portion 12 in a triangular spacing of 120 angular degrees. However, such an arrangement of electron guns is not strictly necessary as the several guns may be placed in any arrangement as long as the beams are spaced and pass through apertures 22 with sufficient dispersion to not interfere with each other upon striking the phosphor coated portions 48. For example, the guns may also have a straight line arrangement such as indicated in the above-cited co-pending application of Schroeder.

It is proposed to utilize a common field for converging the beams to a common point 21 near the target surface. However, it has been found that such an expediency cannot be easily accomplished in a practical sense, since the beams can be converged to the common point 21 by a much lower field strength than that needed for focusing the electrons of each beam to a fine spot at point 21. It is therefore a feature of my invention to provide additional focusing means for each electron beam independent of the converging field, to bring each beam to a sharp focus near the point 21 of beam convergence.

FIGURE 3 shows schematically in partial section the gun structure of a tube designed according to my invention. As described above, the electrons emitted by the cathodes 24 are urged along their respective beam paths by the positive accelerating voltages of electrodes 34, 36 and 42. The first accelerating electrode structure 36 consists of restricted portions comprising the tubular members 35, each of which surrounds a respective beam path. The second accelerating electrode 42 comprises the cylindrical member 43 common to and surrounding all of the three beam paths. However, the end of the tubular member 43 adjacent to the tubular first accelerating electrode members 35 is partially closed by the plate 43' through which are mounted the short tubular members 45, each one in alignment with the adjacent first accelerating electrode tubular member 35.

When the three accelerating electrodes 36, 42 and 44 are maintained at different potentials during tube operation, there are formed in the regions between these electrodes, electron lens fields, as is well known in the art. By adjustment of the relative strengths of these fields the three beams themselves can be made to converge to a common point 21 near the surface of the masking electrode 20, and the electrons in each beam can simultaneously be brought to a focus near the common point of beam convergence. The action of these lens fields on the three electron beams is well illustrated in FIGURES 6, 7, and 8. When the voltage E_{36}, of the first accelerating electrode 36, is equal to the potential or voltage of E_{42} and E_{44} respectively of second and third accelerating electrodes 42 and 44, then the electrons of the several beams will pass through the electrodes of the gun structure and impinge upon the masking electrode 20 in three relatively widely spaced unfocused spots as shown in FIGURE 6. If, now, the voltages of the second accelerating electrode 42 and the third accelerating electrode 44 are simultaneously increased the same amount, the electron beams individually will become focused and will strike the masking electrode 20 in relatively small spots but still spaced to substantially the same degree as shown in FIGURE 6. This second result is shown in FIGURE 7 and indicates that the beams, although not brought to a complete focus on masking electrode 20, are, however, more completely focused than under the conditions shown in FIGURE 6. The effect of maintaining the potential of first accelerating electrode 36 lower than the potential of electrode 42 sets up a separate focusing electron lens between each of the respective tubular members 35 and 45. These electron lenses act separately to bring the electrons of each beam to focus at a point. That is, the effect of each lens field between tubular electrode members 35 and 45 is to focus the beam passing through it substantially independently of the focus of the other beams.

If, now, the voltage on the third accelerating electrode 44 is alone raised to a higher potential than that of the second accelerating electrode 42, a common converging electrostatic field is set up between the tubular member 43 of the second accelerating electrode 42 and the third accelerating electrode coating 44. This common converging lens field will act upon the three beams simultaneously to cause them to converge toward each other until the three beams strike the masking electrode 20 in three small spots closely spaced and as graphically illustrated in FIGURE 8. This common converging field between the second and third accelerating electrodes 42 and 44 also provides a partial focusing of the electrons in each beam so that each beam will strike the surface of masking electrode 20 in a much smaller area than that under the conditions shown in FIGURE 7. The voltage of second accelerating electrode 42 may now be varied to produce convergence of the three beams at a common point. What changes in the second accelerating electrode voltage are necessary for final beam convergence are sufficiently small that the main focusing field between accelerating electrode 36 and 42 is little affected. Thus, bringing the beams to a common point of convergence from the conditions of FIGURE 8 changes very little the degree of focus of each beam. If, however, the second accelerating electrode voltage is too high, there will be insufficient convergence of the beams, and if too low, the beams will be over-converged so that they pass through a cross-over point before reaching the masking electrode 20. Thus, by adjusting the relative values of the three accelerating electrode voltages, it is possible to produce beam focus and beam convergence simultaneously with a common means.

In a tube similar to that described above, which has been successfully operated, the first accelerating electrode voltage was maintained at approximately 4500 volts. The second and third accelerating electrodes were operated at potentials around 9000 and 18,000 volts respectively. The potentials of the first accelerating electrode 36 and second accelerating electrode 42 were adjusted back and forth to provide the optimum beam focus and beam convergence for successful tube operation.

For color television picture reproduction, the tube described above may be operated in the following illustrative manner. Color television signals can be transmitted, with signals corresponding to the primary color to be reproduced on the screen 18. The signals may be received either simultaneously or in any time sequence, as is known in the art. Each one of the electron beams is caused to strike all portions of the target sheet 19 coated with a single phosphor, which will have one color of luminescence. Accordingly, then, each beam must be modulated with the incoming signals corresponding to the color to be reproduced by that beam at the target. Thus, the signals corresponding to one color of the televised screen are applied to each cathode 24 to appropriately

modulate the respective electron beam. The control grids 30 are maintained at a common ground potential to provide cut-off of the beam, when the cathodes are biased to a positive cut-off voltage at any time during tube operation.

The screen grids 34 are arranged to have separate leads so that they can be biased at positive potentials relative to ground independently of each other. This permits adjustment of the potentials of the screen grids 34 to provide similar modulation characteristics for each cathode grid unit, so that the same voltage applied to each cathode 24 will produce substantially the same density of beam on all of the guns. This is necessary to provide a balanced color effect in the final pictures. For example, if a modulation voltage of 50 volts is applied at the same moment to all of the cathodes 24, there will be reproduced on the fluorescent screen the three colors in the proper propotrion of light output to produce white light.

The above described mode of tube operation is illustrative only. For example, the incoming video signals may be applied to the control grids 30 of the electron guns with the control grids negatively biased to cut-off, relative to cathode potential at ground.

With the tube structure described above, color video signals can be applied, as described, to produce a color television picture on the target plate 19. It has been found that during the scanning of the electron beams over the surface of the target, there should be less converging action of the beams as they approach the edges of the scanned raster than in the central portions. This is due primarily to the increased distance of the edges of the target surface from the center of beam deflection. To provide this result compensating changes in the second accelerating electrode voltage are made, to weaken the converging field in synchronism with the scanning fields applied to the electron beams.

The above description has been confined to a type of first accelerating electrode having separate tubular members for each beam. However, to provide a more compact electron gun arrangement, the several electrodes of the tube of FIGURES 1 to 4 may be modified in a manner described and shown in FIGURE 9. In FIGURE 9 the control grid comprises a single cup-shaped member 50 having three grid openings 52 therein, aligned with the coated ends of three cathodes 24. The shield grid comprises an apertured plate electrode 54, also having three apertures aligned respectively with the apertures 52 in control grid 50. The first accelerating electrode consists of a single tubular member 56 partially closed at both ends respectively with plates 58 and 60, each of which have three apertures aligned respectively with the apertures in electrodes 50 and 54. The second accelerating electrode consists of an open-ended tubular member 62, coaxial to first accelerating electrode 56 and spaced axially therefrom along tubular envelope portion 12. The third accelerating electrode may comprise a coating 64 similar to anode coating 44 of FIGURE 1. The operation of the tube of FIGURE 9 is somewhat similar to that described above for the two FIGURES 1 and 4. The electrons emitted from the indirectly heated cathodes 24 are formed into beams passing down the tubular envelope portion 12 substantially along parallel paths. If the three accelerating electrodes 56, 62 and 64 are maintained at a common potential, the electron beams will pass through the apertured electrode structure and strike target plate 20 in relatively widely spaced unfocused spots, as graphically indicated in FIGURE 10, as in FIGURE 6. If now, the voltages of the second accelerating electrode 62 and the third accelerating electrode 64 are simultaneously increased the same amount, the spots of FIGURE 10 tend to move outwardly or diverge and at the same time each spot will grow smaller, indicating that the electrons in each beam are being brought to partial focus. The reason that the beams are caused to diverge, however, is due to the field configuration between the first and second accelerating electrodes 56 and 62 respectively. The equipotential lines shown in FIGURE 9 between electrodes 56 and 62 represent the lens field between these electrodes. This lens field is such that the equipotential surfaces dip into tubular electrode 56 through the apertures of the plate 60 to provide a converging portion of the lens field for each of the electron beams. Also, the equipotential field surfaces dip into the open end of tubular electrode 62 which is adjacent to the end of electrode 56. The electrons of the several beams first contact the convergent portions of the lens field as they approach the apertures of first accelerating electrode plate 60. The convergent portions of the lens field cause the electrons of each beam to converge or be brought to a focus independently of the convergence of the beams.

As the beams pass between electrodes 56 and 62, they then pass into a common diverging portion of the lens field represented by the equipotential lines of FIGURE 9. Due to this portion of the lens fields, the beams diverge from each other and strike the target plate 20 at more widely spaced points than under the conditions described for FIGURE 10, as shown in FIGURE 11.

Next, if the voltage on the third accelerating electrode 64 is alone raised to a point above that of the voltage on the second accelerating electrode 62, a common converging field is set up between electrodes 62 and 64. The potential of 64 can be raised until the beams are brought to substantially a common point of convergence near the surface of masking electrode 20. Furthermore, the focusing of the electrons in each beam is completed by the converging action of the lens between electrodes 62 and 64 so that the beams will strike at relatively sharp points closely spaced together on the surface of electrode 20 and as shown in FIGURE 12. Again, as described above, the voltage of the several accelerating electrodes 56, 62 and 64 respectively, may be adjusted until the optimum convergence of the three beams, together with the optimum focus of each beam is obtained at a common point near the surface of the masking electrode 20.

It also has been demonstrated that similar results of beam focus and convergence can be obtained by an electron gun structure in which the second accelerating electrode 62 is much shorter than shown in FIGURE 9. In such a modification the lens field between accelerating electrodes 62 and 64 can be made to extend completely through the second accelerating electrode 62 and destroy the divergent effect of the lens field between accelerating electrodes 56 and 62. In such a gun structure, then, the paths of the electron beams are only convergent from their original parallel direction, and such a gun structure will operate more like that of the gun structure shown in FIGURES 1 through 4.

The above description has been confined to an electrostatic lens field for providing convergence of the several electron beams. However, the invention is not confined to electrostatic convergence. It is obvious that a magnetic lens field may be produced in the region between the second and third accelerating electrodes to cause the several beams to converge at a common point near the surface of the masking electrode 20. For example, in FIGURE 1, there is shown in dotted outline, a coil 70, similar to those used for magnetic focusing of single beams. The coil 70 produces a magnetic electron lens field which will cause the three electron beams from the gun structure 36, 42 to converge along paths X, Y and Z to a common point near the masking electrode 20. When such a magnetic converging coil 70 is used, then the third accelerating electrode is eliminated by connecting the coating 44 to the second accelerating electrode 42. Thus, the electrostatic converging field between these accelerating electrodes is eliminated and the magnetic converging field of coil 70 is substituted therefor. As shown in FIG. 1, the coil 70 is symmetrical with respect to the gun structure to establish a converging magnetic

field which is symmetrical with respect to the group of beam paths in the tube. It has been found that magnetic coil 70 cannot be used without either providing a bucking coil to eliminate rotation of the beams or by sealing the gun mount into the tube with a required rotation to compensate for the beam rotation.

In the tube of FIGURE 1, there is also shown in the bulb section 14 of the tube envelope, a metallic shield 72, extending over a substantial part of the electron beam paths. This shield 72 is made of metal of "soft" magnetic material to prevent any disturbance of the electron beams by external fields. The metal shield 72 has been formed from No. 4750 alloy, which comprises 47–50% nickel and the balance iron. Because of the rather small angle of incidence of each beam at the target surface, slight disturbances of the beam in passing to the screen structure has a tendency to cause the beam to strike phosphor areas of the target screen other than the intended ones. This then introduces reproduction of the televised picture in the wrong color.

The above described invention is one in which the electron gun structures of the tube can be assembled in parallel relationship. This feature simplifies the assembling of the device by the use of mandrels. It is obvious that such electron gun structure mounted at critical angles to each other are much more difficult to assemble and to maintain in their specific spaced relationship. However, in the structure disclosed above, parallel mandrels can be inserted into the tubular portions of the guns and easily withdrawn when the unit has been assembled. This feature alone is vital for mass assembly of these structures.

Furthermore, the application of separate focusing fields for each beam in combination with a common converging lens provides an electrical control of the convergence substantially independent of the major focusing action. Such electrical control of convergence has distinct advantages over mechanical convergence obtained by tilting of the guns relative to each other and to the axis of the tube. Electrical convergence control can be established after the gun has been mounted within the tube and the tube sealed off, whereas any inaccuracies in mechanical arrangement of the gun structure within the tube cannot be easily determined until after the tube has been sealed off and tested. At this point, misarrangement of the gun structures relative to each other in a mechanically converging gun unit necessitates reopening of the tube and applying a mechanical correction to the gun arrangements.

Another advantage of the use of electrical convergence as set forth in the above described invention is the ability to modulate the converging lens or field in synchronism with beam scanning so that accurate beam convergence can be obtained over all portions of the screen even though the common point of convergence varies in distance from the point of beam deflection.

While certain specific embodiments have been illustrated and described, it will be understood that various changes and modifications may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. A cathode ray tube comprising an envelope containing means for producing a plurality of electron beams along respective paths having a common general direction, a target electrode mounted transversely to said beam paths, focusing means located along said paths adjacent to said beam producing means for providing a separate focusing action on the electrons of each beam, and means surrounding said beam paths adjacent to said focusing means for converging said electron beams to a common point near said target electrode, said beam converging means comprising a unitary structure surrounding said beam paths and mounted within said envelope in a region remote from said target electrode and adjacent to said focusing means.

2. A cathode ray tube as in claim 1, further comprising deflecting means, located along said beam paths between said converging means and said target electrode, for scanning said beams over said target electrode.

3. A cathode ray tube for color television comprising an envelope containing a plurality of electrodes including electron emitting cathode means for producing a plurality of electron beams along respective paths having a common general direction, a target electrode mounted transversely to said beam paths, focusing means located along said paths adjacent to said beam producing electrodes for providing a separate focusing action on the electrons of each beam, said target electrode including a fluorescent screen portion and a multi-apertured masking electrode spaced from said screen portion toward said cathode means, and means surrounding said beam paths adjacent to said focusing means for bringing said beams to convergence near said target electrode, said beam converging means comprising a unitary structure surrounding said beam paths and mounted within said envelope in a region remote from said target electrode and adjacent to said focusing means.

4. A cathode ray tube comprising a plurality of electrodes for producing a plurality of electron beams along respective paths having a common general direction, a target electrode mounted transversely to said beam paths, said beam producing electrodes including a plurality of cathode electrodes, focusing means located along said paths adjacent to said beam producing electrodes for providing a separate focusing action on the electrons of each beam, and a magnetic coil symmetrically disposed around said beam paths adjacent to said focusing means for establishing a common converging field for bringing said beams to convergence near said target electrode.

5. An electron gun structure for a cathode ray tube, said structure comprising electrode means for producing a plurality of electron beams along respective paths having a common general direction, a first accelerating electrode adjacent to said electrode means, a second accelerating electrode adjacent to said first accelerating electrode and having a portion thereof surrounding said beam paths, said first accelerating electrode portion including a plurality of apertures, each of said apertures surrounding one of said beam paths for producing a separate focusing field for each beam between said first and second accelerating electrodes, and a third accelerating electrode surrounding said beam paths adjacent to said second accelerating electrode portion for establishing a common converging field for said electron beams between said second and third accelerating electrodes.

6. An electron discharge device comprising means for producing a plurality of electron beams along respective paths, a target electrode mounted transversely to said electron beam paths, said target electrode including fluorescent means and responsive to electrons from different directions of approach, first and second accelerating electrode means adjacent to said beam producing means and spaced along said beam paths from each other, said first accelerating electrode means having a restricted portion surrounding each beam path adjacent to said second accelerating electrode means for producing a separate focusing field for each beam between said first and second accelerating electrode means, and a third accelerating electrode means adjacent to said second accelerating electrode means, said second and third accelerating electrode means each having an aperture therethrough surrounding said beam paths for producing a field common to said electron beams between said second and third accelerating electrode means for converging said beams to a point near said target electrode.

7. A cathode ray tube for color television comprising electrode means for producing a plurality of electron beams along parallel paths, a target electrode mounted transversely to and intersecting said beam paths, said target electrode including a fluorescent screen portion and a multi-apertured masking electrode mounted adjacent

to said screen portion and between said electrode means and said screen portion, a first accelerating electrode adjacent to said electrode means, a second accelerating electrode adjacent to a portion of said first accelerating electrode and including a tubular member surrounding said beam paths, said first accelerating electrode portion including a plurality of restricted portions, each of said restricted portions surrounding one of said beam paths for producing a separate focusing field for each beam between said first and second accelerating electrodes, and electron lens producing means adjacent to said second accelerating electrode for establishing a field common to said electron beams for bringing said beams to convergence near said masking target electrode.

8. A cathode ray tube for color television comprising electrode means for producing a plurality of electron beams along spaced parallel paths, a target electrode mounted transversely to and intersecting said parallel beam paths, said target electrode including a transparent support, a fluorescent material coating portions of said transparent support and a multi-apertured masking electrode adjacent to the coated portion of said target support and between said support and said electrode means, a first accelerating electrode adjacent to said electrode means, a second accelerating electrode including a tubular member surrounding said beam paths and a portion thereof adjacent to a portion of said first accelerating electrode, said first accelerating electrode portion having a plurality of apertures therethrough, each of said apertures surrounding one of said beam paths for producing a separate focusing field for each beam between said first and second accelerating electrodes, and a third accelerating electrode including a tubular member surrounding said beam paths adjacent to said tubular member for establishing a common converging field for said electron beams between said second and third accelerating electrodes, whereby said beams may be converged to a point near said apertured masking electrode.

9. Beam forming structure for a cathode ray tube, said structure comprising, a plurality of electron guns arranged along parallel axes respectively, each of said electron guns including a control electrode and a tubular first accelerating electrode adjacent to and insulatingly spaced from each other along the gun axis in the order named, each of said control electrodes being insulatingly spaced from each other, a common second accelerating electrode having a tubular portion surrounding said parallel gun axes and another portion adjacent to each of said tubular first accelerating electrodes, said other second accelerating electrode portion including a plurality of tubular members each enclosing one of said parallel axes and spaced from one end of a tubular first accelerating electrode to form a separate beam focusing field for each beam, a tubular third accelerating electrode surrounding said parallel gun axes and having one end adjacent to and coaxial with said tubular second accelerating electrode portion whereby a common converging field may be established therebetween to converge the electron beams of said guns to a common point.

10. An electron gun structure for a cathode ray tube, said structure comprising: means for producing a plurality of electron beams along respective paths having a common general direction; and first, second and third accelerating electrode means adjacent to each other and said beam producing means and spaced along said beam paths from said beam producing means in the order named; said first accelerating electrode means including means defining a plurality of apertures adjacent to said second accelerating electrode means, each aperture surrounding one of said beam paths for cooperating with said second accelerating electrode means to establish a separate focusing field for each beam, each of said second and third accelerating electrode means including a tubular member surrounding all of said beam paths for establishing a common converging field for said beams between said tubular members.

11. An electron gun structure as in claim 10, wherein said first accelerating electrode means comprises a plurality of separate tubular elements, each surrounding one of said beam paths, and defining said apertures.

12. An electron gun structure as in claim 11, wherein said second accelerating electrode means comprises a plurality of tubular elements, each surrounding one of said beam paths and aligned with one of the tubular elements of said first accelerating electrode means.

13. An electron gun structure as in claim 10, wherein said first accelerating electrode means comprises a tubular member surrounding said beam paths and having an end plate containing said apertures.

14. An electron gun structure as in claim 10, wherein the tubular member of said second accelerating member has an axial length which is substantially equal to its diameter.

15. An electron gun structure as in claim 10, wherein the tubular member of said second accelerating electrode is partially closed at the end next to said first accelerating electrode by a transverse wall having apertures aligned with said first-named apertures.

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