Dec. 2, 1958 D. W. EPSTEIN ET AL 2,863,091

FLAT TRI-COLOR KINESCOPES

Filed March 7, 1956 2 Sheets-Sheet 1

Fig. 1.

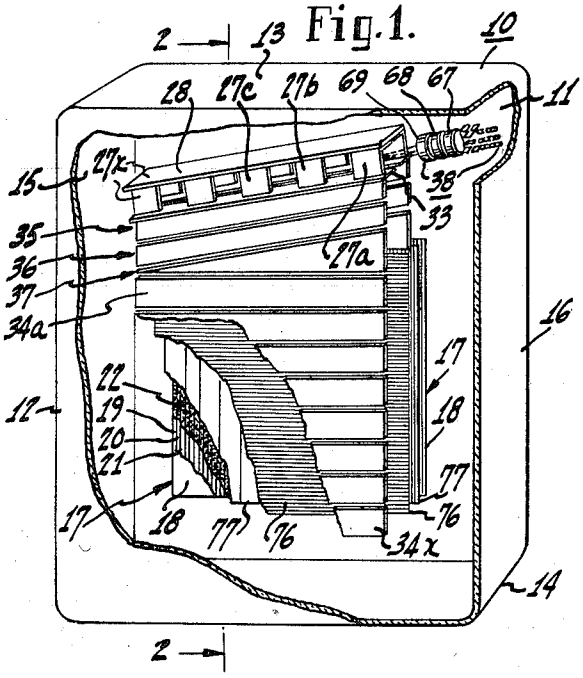


Fig. 2.

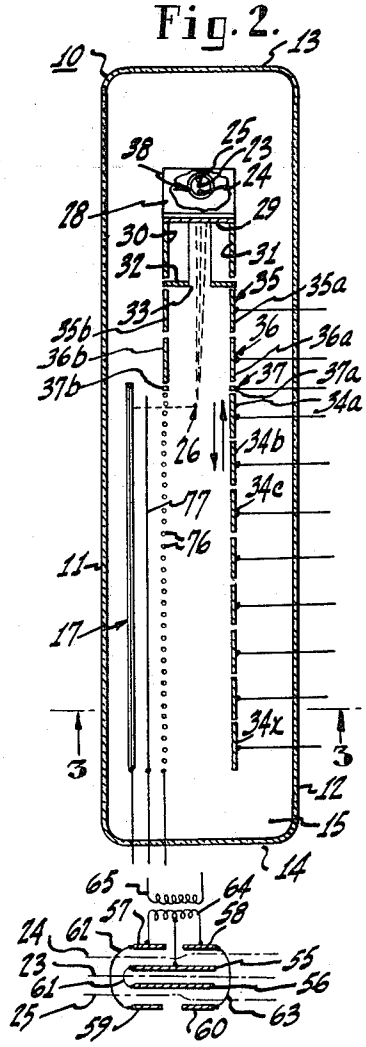


Fig. 3.

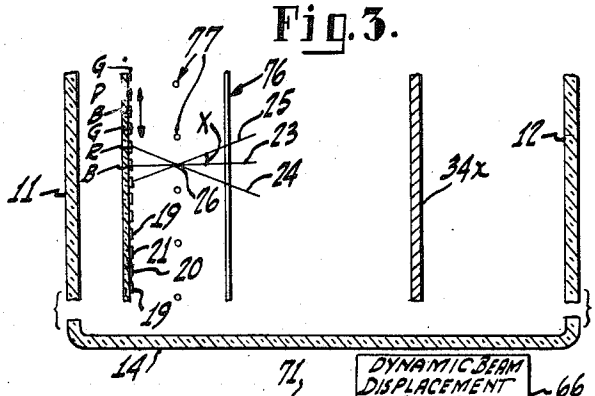
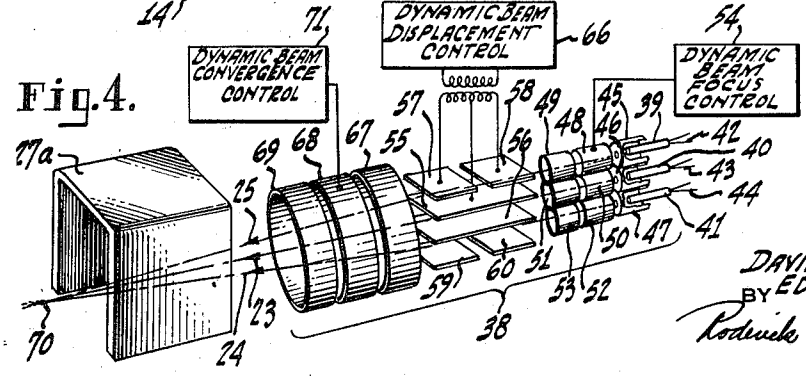


Fig. 5.

Fig. 4.



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Fig. 6.

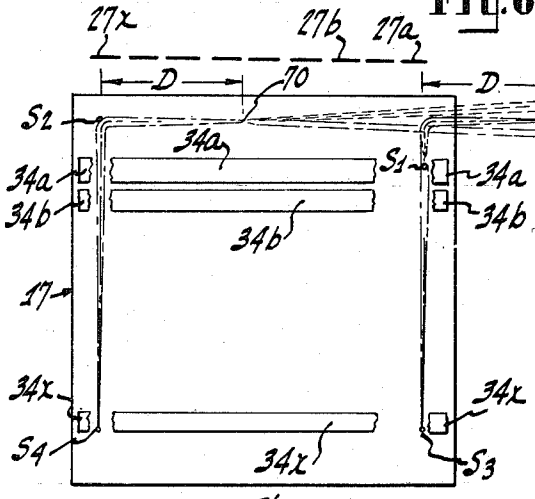




Fig. 11.

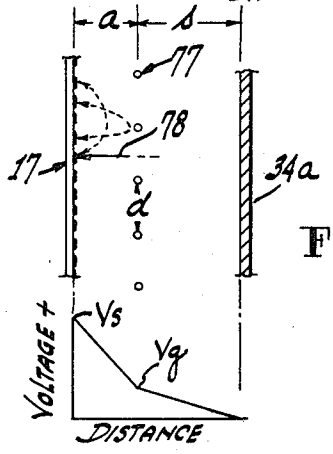


Fig. 7.

Fig. 8.

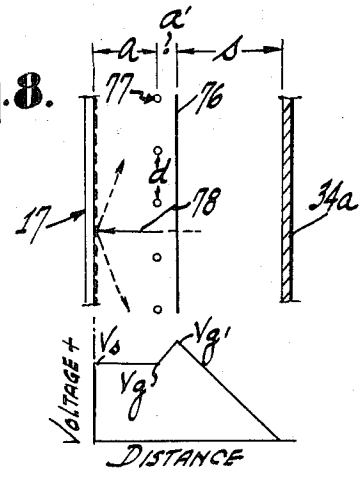
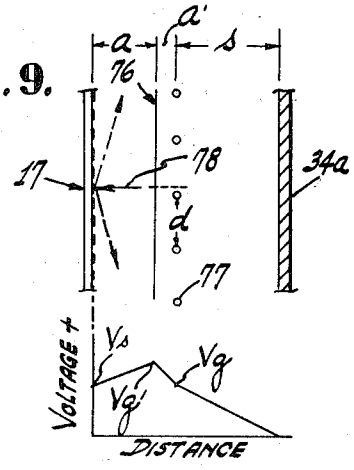


Fig. 9.



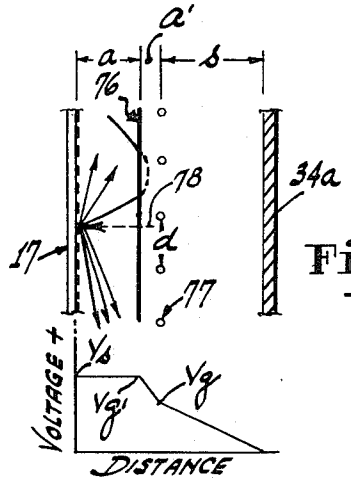


Fig. 10.

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FLAT TRI-COLOR KINESCOPES

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Application March 7, 1956, Serial No. 570,074

11 Claims. (Cl. 315—13)

This invention relates to electron beam tubes and more especially it relates to tubes of the flat bulb kind especially arranged for color television purposes.

A principal object of the invention is to provide a kinescope of the flat kind, having a novel combination of beam controls whereby color purity and sharpness of color images can be achieved in such tubes.

Another object is to provide a tricolor kinescope of the flat kind employing a triple electron beam generator, in conjunction with scanning means for bending the common trajectory of the beams in perpendicular directions to cause a tricolor raster to be scanned, while subjecting the beams to dynamic focusing and dynamic convergence control correlated respectively with the corresponding regions of the raster being scanned.

Another object is to provide a tricolor electron tube of the kind wherein a tricolor scanning beam has part of its trajectory substantially parallel to the tricolor screen and the final part of its trajectory substantially transverse to the tricolor screen, in conjunction with a beam focusing grill adjacent to the tricolor screen.

A feature of the invention relates to a tricolor electron tube of the kind wherein a tricolor scanning beam has part of its trajectory parallel to the color screen and part substantially normal to the screen, in conjunction with a system of grids adjacent to the screen, which system includes a focusing grill and an auxiliary grid for reducing the likelihood of color dilution by undesirable electron beam bombardment.

Another feature relates to a tricolor electron tube of the kind wherein a triple screen scanning beam has part of its trajectory substantially parallel to the color screen and its final part substantially transverse to the color screen, in conjunction with a focusing grill and an auxiliary grid adjacent to the screen for maintaining the beam at high velocity in the said final part of its trajectory, while at the same time reducing the likelihood of color dilution and the likelihood of reduction of image contrast from undesirable electron bombardment.

A further feature relates to an improved television tube of the kind having a flat bulb and electron gun means therein associated with respective scanning controls for causing the beam trajectory to have its initial part substantially parallel to the screen and the final part substantially transverse to the screen, in conjunction with a dynamic control beam-focusing system and a dynamic control beam convergence system.

A further feature relates to an improved television tube of the kind having a flat bulb and triple beam electron gun means associated with respective scanning controls for causing the beam trajectory to have its initial part substantially parallel to the screen and its final part substantially transverse to the screen, in conjunction with dynamically controlled convergence means for shifting the common convergence point of the three beams in accordance with the particular area of the screen which is being scanned.

A further feature relates to a tricolor tube of the kind having a flat bulb incorporating a triple beam electron gun with dynamically controlled beam focus means, means to control the relative spacing or displacement of the focused beams, to converge the beams; means for dynamically controlling the location of the common cross-over point of the converged beams in correlation with the particular region being scanned thereby; a series of beam deflectors extending substantially parallel to the screen for moving the initial part of the beam trajectory substantially parallel to the screen; and a second series of beam deflectors extending substantially parallel to the screen for moving the final part of the beam trajectory substantially transverse to the screen; in conjunction with a system of grids located in the path of said final trajectory, one of the grids being a focusing grill and the other an auxiliary grid for maintaining the elections in the final part of said trajectory at high velocity while at the same time reducing the likelihood of color dilution at the screen.

A further feature relates to a tricolor electron tube having a tricolor screen with recurrent sets of tricolor phosphor lines, a focusing grill adjacent to the screen comprised of a series of spaced grid wires extending substantially parallel to said phosphor lines, an auxiliary grid having spaced grid wires extending transversely to said grill wires, electron gun means for developing three converging scanning beams, horizontal and vertical deflecting systems for the three beams, for subjecting the initial trajectory of the beams to a deflection substantially parallel to the screen, and the final part of the trajectory substantially transverse to the said screen.

A still further feature relates to the novel organization, arrangement and relative location and interconnection of parts which cooperate to provide an improved tricolor image reproducing tube.

Other features and advantages will appear as the ensuing descriptions proceed.

In the drawing, which shows by way of example certain preferred embodiments.

Fig. 1 is a rear perspective view of a flattened or neckless tube embodying the invention;

Fig. 2 is an enlarged sectional view of Fig. 1 taken along the line 2—2 thereof and viewed in the direction of the arrows;

Fig.3 is an enlarged view of the lower end of Fig. 2 representing a section taken along the line 3—3 of Fig. 2 and viewed in the direction of the arrows;

Fig. 4 is an enlarged perspective view of the triple beam electron gun of Figs. 1 and 2;

Fig. 5 is a schematic diagram of the beam displacement control unit of the gun shown in Fig. 4;

Fig. 6 is a diagrammatic view explanatory of the beam convergence and beam bending of the triple beam and corresponding to different scanning regions of the tricolor screen;

Fig. 7 is a schematic diagram explanatory of one embodiment of the tube using only a focusing mask adjacent to the tricolor screen;

Fig. 8 is a schematic diagram explanatory of the embodiment of Figs. 1, 2 and 3, wherein there is employed adjacent to the tricolor screen a focusing grill and an auxiliary grid with certain relative potentials arranged to be applied thereto;

Fig. 9 is a schematic diagram of a modification of Figs. 1 to 3, wherein the positions of the focusing grill and the auxiliary grid are reversed as compared with those of Figs. 1 to 3;

Fig. 10 is a schematic diagram of an arrangement similar to that of Fig. 9 but with a different potential

relation as compared with Fig. 9 between the focusing mask, auxiliary grid and screen;

Fig. 11 is an enlarged schematic diagram to explain the color selecting action of the focusing grill.

The present invention is concerned primarily with the construction of a tricolor signal transducing picture tube of the flat or neckless kind, as distinguished from the more common kind of tube consisting of an elongated neck joined to a flared funnel portion, which latter is closed off by a flattened viewing window. Apart from the dimensional flattened construction of the neckless tube, is the fact that in order to scan the picture screen it is necessary to subject the scanning electron beam or beams in the case of a tricolor tube to two successive beam bending operations at right angles to each other. As a result of this double bending of the scanning beam or beams, it is possible to make the tube of very much shorter length than the conventional tube. In fact the height and width of the flattended tube may approximate the height and width of the picture screen, while the length of the tube need only be such as to accommodate the physical width of the electron gun and horizontal deflector elements. For a more detailed disclosure of such a tube reference may be had to application for patent of Harold B. Law et al., Serial No. 531,172, filed in the United States Patent Office on August 28, 1955. Reference can also be had to the magazine publication "Electronics," February 1955, page 7; "Electronics," March 1955, page 214D; and "Electronics," November 1955, page 186D. In fact the flattened tube can be made of two cylindrically arcuate glass sheets which are joined to each other directly or through the intermediary of a rigid metal frame, as disclosed for example in application Serial No. 529,790, filed August 22, 1955.

However, merely for illustrative purposes, the tube **10** according to the invention is shown in the accompanying drawings as being of glass and of rectangular shape (see Figs. 1 and 2). The tube comprises a front substantially flat or slightly curved viewing face **11**, a rear wall **12**, a top edge **13**, a bottom edge **14**, a left hand edge **15** and a right hand edge **16**. It will be understood, of course, that the tube **10** after all the elements have been suitably mounted therein is evacuated and sealed off in accordance with conventional picture tube evacuation and processing techniques.

Suitably mounted within the tube **10**, closely adjacent to the front or viewing face **11**, is a transducing screen **17** which may comprise a transparent rectangular plate **18** of thin glass, mica, or similar light transparent material. The surface of plate **18** on the side remote from the tube face **11** is coated with a phosphor or combination of phosphors which respond to electron bombardment by a scanning electron beam or beams, to produce visible light in the color determined by the spectral response of the phosphor or phosphors which at any given instant are being scanned by the beam or beams. It will be understood that instead of supporting the phosphors on a transparent backing which is a separate element, the window **11** may constitute the backing or foundation surface for the phosphors.

The present invention in certain of its aspects is peculiarly advantageous when the screen **17** is a tricolor transducing screen. For that purpose the phosphors may be applied in any well known manner in the form of stripes of elemental width, the stripes extending parallel to each other and, as shown in Fig. 1, they may extend parallel to the vertical dimension of the viewing face **11**. As is well known in the tricolor television art, the phosphors are arranged in tricolor groups, each group comprising a green responsive phosphor **19**, a blue responsive phosphor **20**, and a red responsive phosphor **21**. In accordance with the invention the tricolor screen is adapted to be biased to a positive potential and for that purpose a layer or coating **22** of electron transparent metal, such as aluminum, is deposited over the tricolor stripes.

Likewise in accordance with well known television color theory, any desired color response at a given scanned elemental area can be produced in accordance with the particular combination of phosphors in each tricolor group that are energized by the electron scanning beams. For that purpose it is necessary to employ a triple beam or triple section electron beam, the three sections of which are designated, respectively, **23**, **24**, **25**. In any given static position of the tri-section beam, each section thereof terminates on a respective color stripe. Thus in the particular static position shown in Fig. 3, the center beam **23** is terminating on a blue stripe, the lateral beam **25** is terminating on a green stripe, and the other lateral beam **24** is terminating on a red stripe. In order to preserve the proper relation of the three beams they must have a common convergence point indicated schematically by the numeral **26** in Fig. 3. That convergence point is arranged to be moved in a linear path in the direction of the arrows (Fig. 3) and such linear movement for purpose of convenience will be referred to herein as the horizontal scan. In order to effect the vertical scan, namely to move the triple beam **23**, **24**, **25** parallel to the length of the color stripes, the convergence point **26** must be moved in a linear path in the direction of the arrows, as seen in Fig. 2, and this movement will be referred to herein as the vertical scan.

The horizontal scan is controlled by a series of horizontal beam reflector elements **27***a*, **27***b*, etc. which may be attached in adjacent slightly spaced relation to an insulator strip **28**. Each horizontal deflector element, as shown more clearly in Fig. 2, comprises a channel-shaped metal member having a horizontal top wall **29**, parallel side walls **30**, **31**, and a horizontal bottom wall **32** with a slit **33** for the emergence of the triple beams. Each such element **27***a*, **27***b*, etc. may be provided with a separate lead-in member (not shown) and sealed through the top wall **13** of the tube. Preferably the elements **27***a*, **27***b*, etc. are supported as a unit so that they are inclined somewhat with respect to the top wall **13**, as shown in Fig. 1. While the drawing shows only five such horizontal scan elements, it will be understood that a greater number may be employed and that they extend a horizontal distance commensurate with the horizontal width of screen **17**, as schematically illustrated in Fig. 6.

The vertical scan is controlled by a series of vertical deflector elements **34***a*, **34***b*, **34***c*, etc. While the drawing shows only eight such vertical scan control elements, a greater number may be employed. Each of the vertical deflector elements is in the form of a flat metal strip extending across the width of the tricolor screen and perpendicular to the length of the tricolor stripes, as indicated schematically in Fig. 6. The vertical deflectors **34***a*, **34***b*, etc. are suitably supported in coplanar array but insulated from each other and each is provided with a separate lead-in member sealed through the rear wall **12** of the tube.

The horizontal deflection elements **27***a*, **27***b*, etc. are arranged to be connected in timed sequence to any well known source of sawtooth scanning voltage. Likewise the vertical deflection elements **34***a*, **34***b*, etc. are arranged to be connected to any well known source of sawtooth scanning voltage. For a detailed description of the construction of the horizontal and deflector elements, and their respective sawtooth voltage sources reference may be had to application Serial No. 531,172, filed August 29, 1955 in the names of Harold B. Law, Harrison S. Allwine and Donald C. Darling.

Suitably mounted between the first vertical deflector element **34***a* and the horizontal deflector elements **27***a*, **27***b*, etc. are electron accelerating electrodes **35**, **36**, **37** each consisting of a pair of flat metal plates **35***a*, **35***b*, **36***a*, **36***b*, etc., each pair of plates being electrically connected by a suitable jumper wire (not shown) and also

connected to a respective lead-in 35c, 36c, etc., sealed through the rear wall 12 of the tube. As will be seen in Fig. 1, the accelerator plates are of tapered width so that when assembled in coplanar array the lower edges of accelerating electrode 37 are substantially perpendicular to the tricolor stripes.

Suitably supported within the tube 10, in alignment with the horizontal deflectors 27a, 27b, etc., is an electron gun 38 which is shown in enlarged perspective form in Fig. 4. This gun comprises three metal cathode sleeves 39, 40, 41, each having the usual heater element 42, 43, 44 on the interior thereof. The forward end or tip of each cathode sleeve is coated with suitable electron emissive material in the well known manner. Also mounted in closely spaced relation to each cathode emitter is a respective control electrode 45, 46, 47 each having a central opening in alignment with the respective cathode emitter so as to define the respective electron beam 23, 24, 25. In accordance with well known color television principles, the control electrodes have impressed thereon the color control signals for controlling the intensity of the associated beam. Also mounted in alignment with each control grid is a beam focusing system comprising, for each beam, a pair of axially aligned cylindrical electrodes through which each beam respectively passes for individual focusing action. Thus the beam 25 from cathode 39 passes through the pair of focusing electrodes 48, 49; the beam 23 from cathode 40 passes through its focusing electrodes 50, 51; and the beam 24 from cathode 41 passes through its focusing electrodes 52, 53. The three electrodes 48, 50 and 52 can be electrically connected together or in contact with each other and connected to a beam focus control circuit 54 which derives a dynamically variable focus control voltage from the sawtooth voltage source for the horizontal deflectors. For a detailed description of an arrangement for deriving such a dynamically variable control voltage reference may be had to U. S. Patent No. 2,714,176 and the article by A. W. Friend published in the Proceedings of the I. R. E., vol. 39, No. 10, October 1951. Likewise the focusing electrodes 49, 51, 53 can be connected together electrically or they can be in electrical contact with each other and connected to a suitable source of steady voltage by a steady focusing voltage.

It will be observed that the three beams as they emerge from their respective focusing systems are parallel to each other and are equally spaced, as indicated schematically in Fig. 5. It will be understood, of course, that the invention is not limited to the focusing of the three beams by electrostatic focusing electrodes and consequently the focusing may, if desired, be effected by any well known electromagnetic focusing means.

In accordance with the invention, the three beams have their trajectory spacings varied dynamically so as to vary the spacing between the center beam 23 and the two lateral beams 24, 25, while preserving their parallelism. For that purpose the center beam 23 passes centrally between two parallel metal plates 55, 56, the lateral beam 25 passes between the plate 55 and a pair of flat metal plates 57, 58. Likewise the lateral beam 24 passes between the plate 56 and a pair of flat metal plates 59, 60. The plate 55 is connected to plate 56 by a suitable strip or jumper wire 61 (Fig. 5). Likewise plate 57 is connected to plate 59 by a jumper wire 62 and plate 58 is connected to plate 60 by a jumper wire 63.

Plates 57, 58 are connected to the terminals of the secondary winding 64 of a suitable transformer, the electrical midpoint of that winding being connected to plate 55. The primary winding 65 of the transformer is connected to a beam displacement control cicuit 66 which derives a dynamically variable voltage from the sawtooth scanning voltage source. For a disclosure of such a beam displacement control circuit reference may be had to U. S. Patent 2,714,176 or U. S. Patent 2,687,493 and the I. R. E. publication referred to hereinabove.

The elements 55 to 60 constitute what is referred to herein as the beam displacement control unit. As will be seen in Fig. 5, the three beams as they emerge from their respective focusing systems are parallel, and the two lateral beams 24 and 25 are equally spaced from the center beam 23. By means of the displacement control unit, the displacement of the lateral beams from the center beam can be made greater or less while still preserving the parallelism of the emergent beams, as seen in Fig. 5. It will be understood, of course, that the invention is not limited to the use of three separate guns for producing the three beams. A single gun may be employed with suitable subdividing means for dividing the beam into a triple section beam wth the desired parallelism between the sections. It is understood, therefore, that the expression triple section beam as employed herein is intended to cover the arrangement in the form of a single gun or a set of three guns for producing the desired triple scanning beam.

The laterally displaced beams then pass through a unipotential convergent electronic lens system comprising, for example, three spaced cylindrical members 67, 68, 69 with member 68 suitably biased to a negative potential with respect to members 67, 69 so that the beams are converged towards each other and have a common cross-over point 70, the location of which can be varied by applying a dynamically variable potential to the element 68 from a suitable source 71 of beam convergence control which derives its convergence output signal from the vertical sawtooth scanning voltage applied to elements 34a, 34b, etc., as hereinabove referred to.

By means of the dynamically controlled beam displacement unit (elements 55—60) and the dynamically controlled beam convergence unit (elements 67—69), it is possible to have the three beams sharply converged, forming the same convergence angle with each other, at every point where they scan the screen 17. The simultaneous sharp focus of the individual beams is realized with the aid of the dynamically controlled focus unit (elements 48, 50 and 52). The voltage on the beam convergence unit is varied with the horizontal deflection so that the first point of convergence 70 maintains a constant distance from the instantaneous center of bending or deflection of the beams as a unit by the horizontal deflection elements 27a, 27b, etc. The voltage on the beam displacement unit is changed so as to keep the angle of convergence of the three beams at the first point of convergence 70 constant with horizontal deflection. However, as the vertical deflection is increased, the voltage difference in the dynamically controlled convergence unit is reduced so as to decrease the beam convergence and, at the same time, the magnitude of the voltages applied to the dynamically controlled beam deflection unit is changed so as to increase the beam separation. This is schematically illustrated in Fig. 6 of the drawing. Thus, if the beam is scanning a spot S_1 at the upper right corner of the screen, the converging action is a maximum and the beam displacement voltage applied to the displacement unit from the source 66 is such as to produce minimum beam separation, as schematically represented by the line 72. The cross-over point 70 is displaced a distance "D" from the center of the horizontal deflection of the beam. Similarly, when the triple beam is scanning a spot S_2 at the upper left corner of the screen, the beam displacement is increased with reduction in the voltage on the convergence unit, so that the cross-over point 70 is spaced from the center of the horizontal deflection approximately the same distance "D." The displacement condition under this situation is schematically represented by the line 73. Likewise if the scanned spot 53 is at the lower right corner of the screen, the beam displacement is represented by the line 74, the convergence voltage difference being re-

duced at the same time; and if the spot S_4 is at the lower left of the screen the displacement is represented by the line 75, with further reduction in the convergence voltage difference. It will be seen that the distance "D" between the location of the cross-over point 70 and the center of the horizontal deflection decreases with increasing vertical deflection. The dynamic focusing voltage applied to elements 48, 50 and 52 is such as to reduce the convergence of the individual beams as the total length of the scanning beam is increased.

It will be understood that the sawtooth voltage which is supplied from the focus control circuit 54 from the beam displacement control circuit 66 and from the beam convergence control unit 71, must have added thereto a vertical sawtooth signal component, eventually supplemented by cross-modulation terms to take care of the condition that the cross-over point 70 must approach the center of horizontal deflection as the vertical excursion of the scanning spot increases in distance from the top edge of the screen. In other words, the beam separation at the center of horizontal deflection, as viewed electro-optically from the same spot on the screen, and allowing for intervening electron accelerations, subtends the same angle for all points of the scanned raster. This, as pointed out above, is accomplished by increasing the beam separation under control of the beam displacement control unit (elements 55—60) with increasing horizontal and vertical excursions of the beam. It will be understood that the horizontal bending or scanning motion is controlled by applying to the horizontal deflection elements 27*a*, 27*b*, etc. a sawtooth voltage which is negative with respect to the beam accelerating voltage, thus causing the center of horizontal deflection to travel in the proper direction to cause the beams to execute the horizontal scans of the screen.

Mounted in spaced relation to the vertical deflection elements 34*a*, 34*b*, etc. is a grid electrode 76. Preferably, although not necessarily, the grid 76 is coplanar with the sides 35*b*, 36*b*, etc. of the accelerating electrodes so as to present a unipotential plane and to define a deflection chamber with respect to the vertical deflection elements 34*a*, 34*b*, etc. These vertical deflection elements are arranged to be biased negatively with respect to the grid 76, thus causing the triple beam to be bent towards the grid 76. Located between the auxiliary grid 76 and the screen 17 is another grid 77 which acts as a color selection and beam focusing grill and for that purpose grid 77 may consist of a series of parallel spaced fine wires extending parallel to the length of the color stripes 19—21. The focusing grill 77 may be constituted of one-third the number of spaced parallel wires as there are phosphor stripes. In other words, the spacing between successive focusing grill wires is approximately equal to the width of three adjacent phosphor stripes, as indicated in enlarged form in Fig. 3 of the drawing. In that case the auxiliary grid 76 may be formed of a series of spaced parallel wires of closer spacing than the wires of the focusing grill 77 and with the wires of grid 76 extending transversely or perpendicularly to the wires of the focusing grill. With such arrangement of the wires in the auxiliary grid 76, the electric fields around the wires of that grid effect no displacement of the electrons in the triple beam in a direction transverse to the length of the color stripes, and, therefore, can produce no color dilution. The only effect of the wires of grid 76 so far as the triple scanning beam is concerned is a certain amount of elongation of the scanning spot in the direction of the length of the color stripes. The manner in which the focusing grill 77 also effects the color selection is schematically illustrated in Fig. 11. In that figure one of the three beams or beam sections, namely the red beam section 24 alone is shown. Merely for purposes of illustration, the red beam section may be large enough to span three or more successive grill wires so that the grill in effect divides each beam, for example the red beam, into two or more segments, for example 24*a*, 24*b*, and each adjacent pair of grill wires focuses its respective beam segment on the particular color allotted to that particular beam.

In the particular construction shown in Figs. 1–3, the focusing grill 77 is nearest to the tricolor screen, and is arranged to be maintained at the same potential as the screen, as indicated schematically by the graph immediately beneath the electrodes schematically shown in Fig. 8. As will be seen from Fig. 8, the trajectory of one of the three components of the focused triple beam is represented by the arrowed line 78; the focusing grill 77 is spaced a distance "*a*" from the screen 17; the auxiliary grid 76 is spaced a distance *a'* from the focusing mask, and the auxiliary grid 76 is spaced a distance *s* from the plane of the vertical deflection elements, one of which is shown in Fig. 8, namely vertical deflection element 34*a*. As indicated in the graph in Fig. 8, the screen 17 and focusing grill 77 are at the same potential, which potential is positive with respect to the vertical deflection element. The auxiliary grid 76 is at a slightly higher positive potential both with respect to the screen and the focusing grill.

When the triple scanning beam impinges upon the phosphor stripes it causes high speed electrons to be released from the phosphor. However, since the auxiliary grid 76 is positive with respect to the screen, these high speed electrons are prevented from returning to the screen where they would tend to cause color distortion and color dilution. The same is true of the slow moving secondary electrons which may be released when either of the grids 76, 77 is bombarded by the primary electrons in the triple scanning beam. These relatively slow moving secondary electrons are also subjected to the more positive potential of the grid 76 and are prevented from reaching the screen. If only a single grid is used between the vertical deflection elements and the screen, for example if only the focusing grill 77 is used, as schematically illustrated in Fig. 7, it will have the advantage of increasing the efficiency of beam electron transmission by the color-selecting grill 77. The combination of this focusing grill in the particular flat tube illustrated has the advantage over the conventional tricolor kinescope that the angle of incidence of the scanning beam on the screen remains substantially constant over the entire raster. Furthermore, the relatively large value of that angle of incidence enables the voltage ratio between the screen voltage and the focusing grill voltage to be smaller and permits a smaller operation between the screen and the focusing grill.

As is schematically illustrated in Fig. 7, the focusing grill 77 is negative with respect to the screen, and the electrons released by the screen can return thereto. While, therefore, the use of a single grid in the form of a focusing grill has improved advantages in a flattened tube of the type described as compared with the conventional tricolor kinescope, it is possible even further to increase this advantage by the use of the auxiliary grid 76. There are several possible combinations of the auxiliary grid with the focusing grill. One of these combinations is described hereinabove in connection with Fig. 8. Another illustration is schematically shown in Fig. 9 wherein the focusing grill 77 and the auxiliary grid 76 are reversed positionally compared with their positions in the embodiment of Fig. 8. In Fig. 9 the auxiliary grid 76 is located between the focusing grill and the screen and is biased positively both with respect to the screen and to the focusing grill. However the focusing grill is at approximately the same potential as the screen. This embodiment has the advantage of the embodiment of Figs. 1–3 and 8 in so far as preventing color dilution by secondary electrons is concerned and the secondaries released from their auxiliary grid 76 do not reach the screen with sufficient velocity to excite luminescence therein. Furthermore, a considerable fraction of the high

velocity electrons emitted from the screen, as represented by the arrowed dotted lines, do not return to the screen.

In the embodiment of Fig. 10 the positional relations of the focusing grill and auxiliary grid are the same as in the embodiment of Fig. 9. However, in Fig. 10 the auxiliary grid **76** is at the same potential as the screen and the focusing grill is negative to the screen and auxiliary grid, as represented in the graph at the lower part of Fig. 10. In the embodiment of Fig. 10 the secondaries released from the focusing grill only, are accelerated towards the screen and bombard it with only a fraction of the energy of the primary electrons in the tricolor beam. The high velocity electrons released from the screen quite generally return to the screen again but mainly at a considerable distance from their point of origin, as schematically represented by the arrowed dotted lines. However, the embodiment of Fig. 10 has the advantage, as compared with the preceding embodiments in that the screen **17** is at the highest potential in the tube structure. Thus the beam is incident on the screen with the maximum voltage provided by the voltage supply, resulting in maximum light output for given beam current.

The ratio of the tricolor screen voltage (V_s) to the focusing grill voltage (V_g) or the auxiliary grid voltage ($V_{g'}$), as well as the distance "a," are determined by the convergence angle "x" (see Fig. 3) between the incident beams and also by the wire spacing d between the adjacent wires of the focusing grill, the spacing d' between the adjacent wires of the auxiliary grid, and θ the angle of incidence of the beams on whichever grid is nearest to the vertical deflection plate under consideration. In the embodiments of Figs. 7, 9 and 10 the ratio of the two voltages (V_s) and (V_g) or ($V_{g'}$) also depends upon the field between the vertical deflection plates and the grid nearest thereto. This latter field may be written V_g/s or $V_{g'}/s$, where "s" is the distance between the vertical deflection plate under consideration and the grid nearest thereto.

In the embodiment of Figs. 1–3 and 8, the ratio $V_{g'}/s$ only serves to increase the spot broadening in a direction parallel to the length of the phosphor stripes, resulting from the electric fields around the auxiliary grid wires. In the embodiments of Figs. 8, 9 and 10 the distance a' between the two grids is an additional determining factor for the voltage ratio and for the value of "a." The following are the formulae for the voltage ratios; wherein δy represents the spot broadening in a direction parallel to the length of the phosphor stripes; d represents the spacing between the wires of the focusing grill; d' represents the spacing between the wires of the auxiliary grid; and D' is the thickness of the wires of the auxiliary grid.

Embodiment of Fig. 7:

$$V_s/V_g=1+3\cos^2\theta+\frac{2d}{3xs}\cos\theta+\frac{d^2}{36x^2s^2}$$

$$a=\frac{d}{2x}\cos\theta+\frac{d^2}{36x^2s}$$

Embodiment of Fig. 8:

$$V_{g'}/V_s=1+\frac{2a'\cos^2\theta}{\sqrt{\frac{d^2\cos^2\theta}{9x^2}+a'^2-a'\cos(2\theta)}}$$

$$a=\sqrt{\frac{d^2\cos^2\theta}{9x^2}+a'^2}-a'$$

$$\delta y=(d'-D')\cos^2\theta\left\{1+\frac{a'}{s}\frac{V_{g'}}{V_{g'}-V_s}\right\}$$

Embodiment of Fig. 9:

$$V_{g'}/V_s=1+\frac{a'}{s}+\frac{6a'x}{d}\cos\theta$$

$$a=\frac{d}{6x}\left(\cos\theta+\sqrt{\cos^2\theta+\frac{a'}{s}+\frac{6a'x}{d}\cos\theta}\right)-a'$$

$$\delta y=(d'-D')\frac{V_{g'}-V_s}{V_{g'}}\frac{\cos\theta\sqrt{V_{g'}/V_s-\sin^2\theta}}{V_{g'}/V_s-1-a'/s}$$

Embodiment of Fig. 10:

$$V_s/V_g=1+\frac{a'}{s}+\frac{6a'x}{d}\cos\theta$$

$$a=\left\{\frac{d}{3x}-\frac{2a'}{\cos\theta+\sqrt{\cos^2\theta+\frac{a'}{s}+\frac{6a'x}{d}\cos\theta}}\right\}\sqrt{\cos^2\theta+\frac{a'}{s}+\frac{6a'x}{d}\cos\theta}$$

$$\delta y=(d'-D')\frac{a}{2a'}\frac{V_s-V_g}{V_s}$$

Below these formulae have been evaluated for characteristic parameter values, namely d=0.030, x=1°, s=1", a'=0.125", and θ=45°. This value of θ corresponds to a height of incidence on the vertical deflection fields equal to about 0.6 the separation between the vertical deflection plates and the grid facing them, measured from the grid plane. For this height of incidence strong vertical focusing is obtained.

	Fig. 7	Fig. 8	Fig. 9	Fig. 10
$\frac{V_s}{V_g}$ or $\frac{V_{g'}}{V_s}$	3.391	1.295	1.434	1.434
a inches	0.69	0.299	0.354	0.409
$\delta y/(d'-D')$		0.776	0.665	0.494

As compared with its application to a conventional tricolor kinescope, the use of the focusing mask principle in the flat tube tricolor kinescope has the advantage that the angle of incidence θ is essentially constant for the entire picture field. The relatively large value of θ causes both the voltage ratio and the value of a a to be smaller, for given convergence angle, than for a conventional tricolor kinescope with focusing mask. In the embodiments of Figs. 7, 9 and 10 the effect on the voltage ratio is in large part compensated by the effect of the vertical deflecting field.

It may be noted that the convergence angle x=1° corresponds to a maximum beam separation of the order of 0.1" after leaving the horizontal deflection field for e. g. a 12" x 16" raster.

It will be understood that various changes and modifications may be made in the disclosed embodiments without departing from the invention as consonant with the appended claims. For example, while the drawing shows the screen and focusing grills as flat planar construction, they can, if desired, be of curved contour. This curved arrangement of the screen and focusing grill is particularly advantageous in the embodiment of Fig. 7 wherein only a single grid, namely the focusing grill is employed adjacent the screen.

It should be noted that the above-mentioned dynamic controls for attaining simultaneously sharp focus, convergence and color purity at the screen, may be replaced in whole or in part by other measures such as (*a*) the three beams instead of being parallel at their source can be tilted equi-angularly or triangularly with respect to each other so that the lens action of the horizontal field is reduced as the horizontal excursion of the cross-over point **70** increases; (*b*) giving the horizontal deflection electrodes a slight negative bias with the same objec-

tive; (c) increasing the separation between the screen 17 and the focusing grill, with increasing vertical deflection, and decreasing that separation between the screen and the focusing grill with increasing horizontal deflection or by tilting the screen about a 45° axis for example, through the points of minimum and maximum deflection. In the case of the tilted screen that would also in general necessitate varying the separation between the focusing grill and the auxiliary grid and eventually between the vertical deflecting plates and the grid nearest to them.

What is claimed is:

1. An electron beam tube comprising an electron responsive light transducing screen, means to develop a tri-section electron scanning beam with the sections variably displaceable with respect to an axis of symmetry, means to focus the beam sections, means to control the relative displacements of said beam sections with respect to said axis, means to converge the displaced sections to a common cross-over point which is movable in accordance with the regions of the screen being scanned by said beam sections, means to bend the initial part of the focused beams with the point of bending being signal controlable, which point is movable in a scanning direction substantially parallel to one dimension of the screen, means to bend a final section of the focused beams in a direction substantially transverse to the screen, and means to move the second mentioned bending point in a scanning direction substantially perpendicular to the first mentioned dimension of the screen.

2. An electron beam tube according to claim 1 in which there is mounted adjacent the screen an electrode system comprising a beam focusing grill and an auxiliary grid for reducing the likelihood of undesirable bombardment of the screen by electrons outside the screen area at which the scanning beam is being focused.

3. An electron beam tube according to claim 1 in which there is mounted adjacent to the screen a beam accelerating system comprising a beam focusing grill and an auxiliary grid, both of which are arranged to be biased with respect to the screen to reduce the likelihood of undesirable bombardment of the screen except by the primary signal controlled electrons in the focused beam.

4. An electron beam tube comprising an electron responsive light transducing target having respective sets of tricolor phosphor elements, means to develope a tri-section electron scanning beam, means to focus the beam sections, means to converge the beam sections to a first cross-over point, horizontal deflection scanning means for bending the initial part of the beam with the bending point variably movable in a direction parallel to the horizontal dimension of the target, means to image the beam on said target elements as the beam exists at said cross-over point, vertical deflection scanning means to bend the final part of the beam at substantially right angles to the first part to scan the target vertically, and means to shift the said cross-over point to maintain a substantially uniform distance between said cross-over point and the instantaneous center of deflection of the beam by said horizontal deflection scanning means.

5. An electron tube according to claim 4 in which the means for imaging said first cross-over point on said target includes said horizontal deflection scanning means.

6. An electron tube according to claim 4 in which said horizontal deflection scanning means comprises a series of discrete serially arranged beam deflection elements each having a cross-sectional configuration to converge the beam to a second convergent point.

7. An electron beam tube comprising an electron responsive light transducing target having recurrent sets of tricolor phosphor elements, means to develop a tri-section electron scanning beam, means to focus the beam sections, means to converge the beam sections to a first cross-over point, means to image on said target elements respective sections of the beam as they exist at said cross-over points, first scanning deflection means for bending the beam in one direction to cause the said imaged sections to scan the target in one direction, second scanning deflection means for bending the beam in a direction transverse to the first direction to cause the imaged beam sections to scan the target in a direction transverse to said first-mentioned direction; and electron acceleration control means located adjacent to the target and including a foraminous focusing grill and an auxiliary grid arranged to be biased with respect to the target to protect each target area as it is being scanned by the primary beam electrons from being bombarded by electrons not constituting part of said primary beam electrons.

8. An electron beam tube according to claim 7, in which said phosphor elements are in the form of linear strips of elemental width, and said focusing grill comprises a series of spaced parallel grid wires extending parallel to said phosphor elements.

9. An electron beam tube according to claim 7, in which said phosphor elements are in the form of linear strips of elemental width, said focusing grill comprises a series of spaced parallel grid wires extending parallel to said phosphor elements, and said auxiliary grid has a series of grid wires extending substantially transverse to said focusing grill wires.

10. An electron beam tube according to claim 7, in which said focusing grill is located between said auxiliary grid and the screen.

11. An electron beam tube according to claim 7, in which said auxiliary grid is located between said focusing grill and said screen.

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UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

December 2, 1958

Patent No. 2,863,091

David W. Epstein et al.

It is hereby certified that error appears in the printed specification of the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 2, line 18, for "elections" read -- electrons --; column 6, line 16, for "wth" read -- with --; column 8, line 48, for "operation" read -- separation --.

Signed and sealed this 19th day of May 1959.

(SEAL)
Attest:

KARL H. AXLINE
Attesting Officer

ROBERT C. WATSON
Commissioner of Patents

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