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CATHODE RAY TUBE STRUCTURE INCLUDING COMBINED ELECTROSTATIC AND MAGNETIC CONVERGENCE SYSTEM

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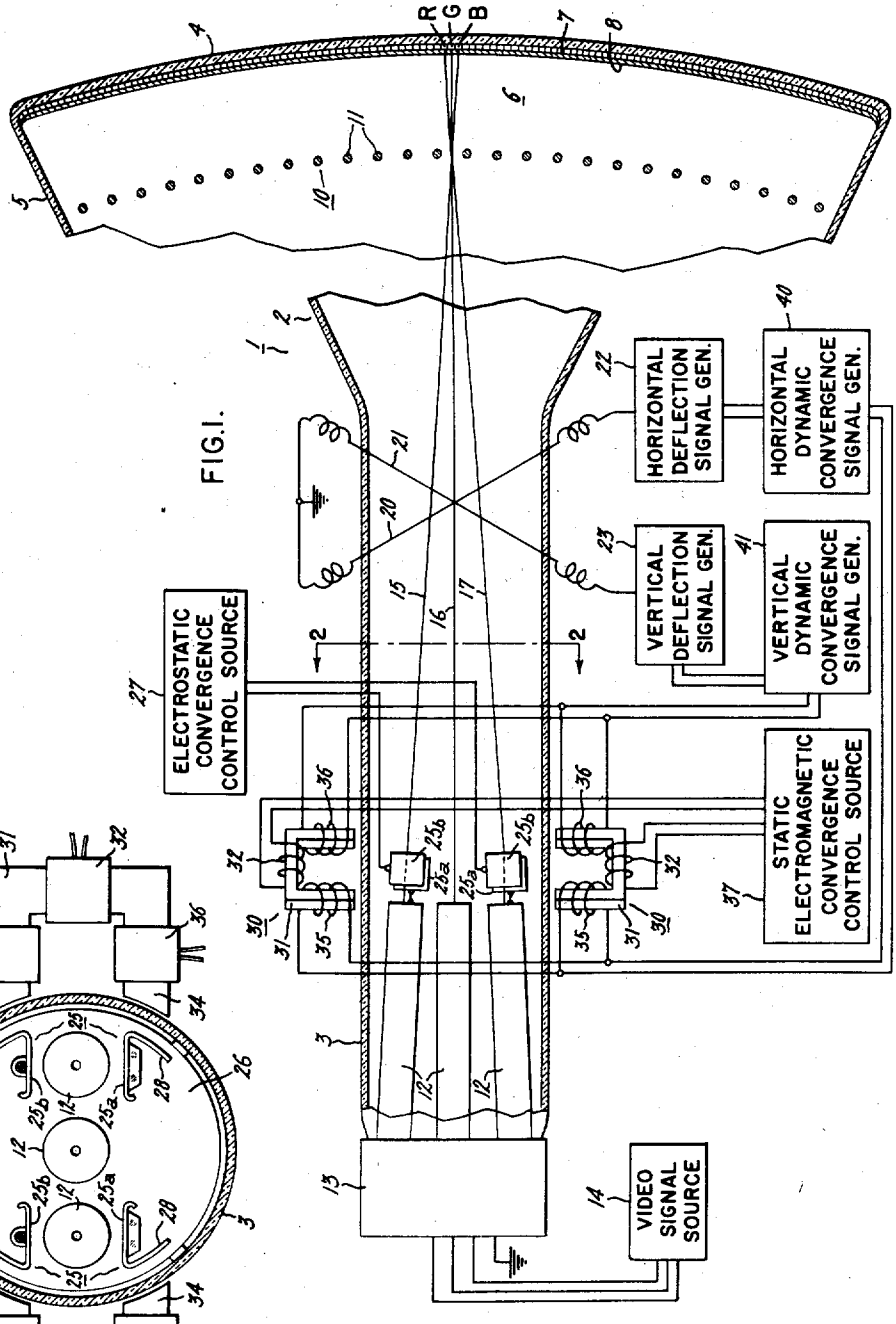


FIG. 1.

FIG. 2.

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CATHODE RAY TUBE STRUCTURE INCLUDING COMBINED ELECTROSTATIC AND MAGNETIC CONVERGENCE SYSTEM

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7 Claims. (Cl. 315—13)

My invention relates to cathode ray tubes and pertains more particularly to a new and improved cathode ray tube structure including improved means adapted for effecting convergence of electron beam components therein.

Color cathode ray tubes to which the present invention is particularly applicable generally include a luminescent screen comprising part of a target electrode in which different phosphor areas produce differently colored light when excited by electron beam components impinging thereupon, means for producing and directing a plurality of electron beam components toward the target electrode and means for deflecting the beam components thereby to scan a raster at the target electrode. In such tubes it is generally necessary to provide means for effecting substantial convergence of the different electron beam components at all points of the raster scanned thereby at the target electrode. Heretofore, various means have been resorted to in an attempt to accomplish satisfactory beam convergence. However, they have been found generally unsatisfactory in that they resulted in complicated and expensive tube constructions, required considerable complicated control equipment, or effected undesirable distortion of the beam components with resultant color impurities. Accordingly, the primary object of the present invention is to provide a new and improved color cathode ray tube structure.

Another object of the present invention is to provide a new and improved color cathode ray tube structure including new and improved means adapted for effecting convergence of beam components at all points of a raster scanned by such components.

Another object of the present invention is to provide a new and improved arrangement adapted for effecting both static and dynamic beam convergence.

Another object of the present invention is to provide a new and improved color cathode ray tube including a single convergence system adapted for both electrostatic and magnetic convergence control of electron beam components therein.

Still another object of the present invention is to provide a new and improved beam-convergence arrangement which is simple and less expensive in construction, provides improved color quality and is controllable without the complicated control equipment heretofore required.

Further objects and advantages of my invention will become apparent as the following description proceeds and the features of novelty which characterize my invention will be pointed out with particularity in the claims annexed to and forming part of this specification.

In carrying out the objects of my invention, I provide a cathode ray tube including a target electrode, means for producing and directing several substantially coplanar electron beam components toward the target electrode and means for deflecting the components to effect scanning thereof at the target electrode. Also included in the tube structure and straddling outer components are pairs of elements adapted for electrostatically deflecting and thus converging the outer beam components on a plane of deflection determined by an inner beam component. These elements are further adapted to serve as internal magnetic pole pieces adapted for having magnetic fields established therebetween thereby magnetically to deflect and thus effect convergence of the electron beam components in a plane perpendicular to the one determined by the inner component. Magnetic field producing means located externally of the tube are adapted for being energized to effect both a static magnetic convergence of the beam components and a dynamic magnetic convergence in accordance with the raster positions of the scanning components.

For a better understanding of my invention, reference may be had to the accompanying drawing in which:

Figure 1 is a schematic fragmentary illustration of a preferred form of the present invention; and

Figure 2 is a sectional view taken along the line 2—2 in Figure 1 and looking in the direction of the arrows.

Referring to Figure 1, there is shown a color cathode ray tube structure generally designated **1** including an envelope **2** having a cylindrical neck portion **3**, a transparent viewing end or face plate portion **4** and a substantially conical transitional portion **5**.

Located at the viewing end of the envelope **2** is a target electrode generally designated **6**. The target electrode **6** includes a phosphorescent material coating or screen **7**. The screen **7** is supported on the inner surface of the face plate portion **4** and preferably comprises phosphors capable of producing light of different colors in response to any impingement thereon by charged particles or electrons. The screen **7** preferably comprises red, green and blue light-producing phosphors deposited or arranged on the inner surface of the face plate in repeated triades of vertical red, green and blue phosphor stripes in the manner illustrated exaggeratedly in Figure 1 at R, G, B.

Formed over the screen **7** is an electron permeable conductive layer **8** which may be of aluminum or any other suitable conductive material and constitutes what shall hereinafter be referred to as the first electrode in the target electrode structure **6**. Also included in the target electrode structure **6** and provided for cooperating with the first electrode **8** is a second electrode in the form of a grille generally designated **10**. The grille **10** comprises a plurality of closely spaced wires **11** extending substantially parallel to each other and to the stripes of phosphorescent material comprising the screen **7**. The size and spacing of the grille wires **11** are also illustrated exaggeratedly in the drawing.

By means not shown the second electrode **10** is supported for conforming substantially to the curvature of the face plate **4** so as to provide substantially uniform spacing between the first and second electrodes **8** and **10**, respectively, across the target electrode. In the just-described target electrode structure the first electrode **8** is adapted for being maintained at a potential higher than that of the second electrode **10**, thereby to set up and maintain a predetermined electric field in the inter-electrode region defined by the electrodes. By virtue of its construction, the second electrode **10** is permeable to charged particles or electrons directed toward the screen. Thus, during the operation of the tube **1**, electron beams or beam components directed toward the target electrode by beam producing means, which will be described hereinafter, are admitted into the inter-electrode region through the spaces between the wires **11** and travel through this region for striking or impinging upon the phosphorescent material screen **7**. In the inter-electrode region the higher potential of the conductive layer or first electrode **7** is effective for attracting and thereby accelerating the movement of the electrons comprising the

beam components toward the screen thereby to increase the striking force of the electrons on the screen whereby color brightness is increased. Additionally, the second electrode **10** serves properly to focus the electron beam components entering the inter-electrode region and to direct them onto the phosphor stripes in a predetermined desired manner.

Provided for producing the electron beams or beam components for impinging on the screen and located in the neck portion **3** of the tube envelope is a plurality of electron beam or beam component producing means or guns **12**. The guns **12** are preferably substantially coplanar or arranged in a substantial planar array extending perpendicular to the phosphor stripes of the screen **7** and the wires of the grille **10**. Additionally, the guns **12** are equal in number to the number of primary colors in which an image is to be reproduced on the screen **6**; and, therefore, in the illustrated embodiment three guns are provided. Each of the guns **12** may be of the conventional type, consisting of a cathode, a control grid, one or more accelerating electrodes and a focusing electrode, none of which elements need be specifically illustrated or described. The three guns **12** are suitably connected through an insulative tube base **13** to a conventional video signal source generally designated **14**; and, in accordance with color intelligence received from the source **14**, the guns **12** produce and direct toward the target electrode **6** schematically represented beam components **15**, **16** and **17** which extend in a substantially coplanar array.

It will be seen that, while I have shown and described the beam component producing means as constituting a plurality of individual electron gun structures, any means may be employed for producing and directing toward the target electrode a plurality of "beam components" which should be understood herein to denote individual electron beams formed by separate means or separate portions of a stream of electrons emanating from a single means.

By means of horizontal and vertical deflection coils schematically illustrated and designated **20** and **21**, respectively, the beam components emanating from the guns **12** are deflected in both horizontal and vertical planes of deflection thereby to scan a raster at the target electrode **6**. The operation of the horizontal and vertical deflection coils is controlled by conventional horizontal and vertical deflection signal generators generally designated **22** and **23**, respectively, the construction and operation of which are well-known in the art.

In a tube structure such as that described above, and as seen in Figure 1, the guns **12** are physically aligned or aimed in assembly for ideal convergence and cross-over of the beam components **15**, **16** and **17** in substantially the same vertical plane as the plane of the grille **10** and for ideal impingement upon the screen **7** in substantially the same horizontal plane where the center component is directed along the longitudinal axis of the tube.

However, as a practical matter, and due to difficulties in obtaining satisfactorily accurate gun alignment by known manufacturing and assembling methods, the described ideal convergence and impingement are not obtained without providing some form of beam-convergence means or means for initially or statically converging the beam components in both vertical and horizontal planes to correct for any inaccuracies in physical alignment. That is, without some form of initial or static beam-convergence means the beam components **15**, **16** and **17** would tend to impinge upon the screen **6** in different horizontal planes and the outer components would tend to follow trajectories resulting in reduced and unsatisfactory resolution and in excitation of other than respective phosphor stripes of particular triads.

In order to obtain the necessary static convergence on a horizontal plane at the screen I have provided beam

component convergence means which includes a pair of vertically spaced horizontal metal or otherwise electrically conductive plates or electrode elements **25** disposed for straddling each of the outer beam components **15** and **17** adjacent the emitting ends of the corresponding electron guns **12**.

As seen in Figure 2 the lower plates designated **25***a* are conductively mounted as by welding on a conductive diaphragm **26** adapted for extending transversely in the neck of the tube and having the emitting ends of the guns **12** extend therethrough and in conductive connection therewith. Thus, the lower plates **25***a* are adapted for being maintained at gun potential. The diaphragm **26** is not shown in Figure 1 for purposes of simplified illustration. The upper plates designated **25***b* are mounted on the diaphragm **26** in any suitable manner whereby they are insulated from the diaphragm and electrically isolated from effects of electric potentials applied to other components of the tube, as for example, those of the guns **12** and the target electrode **6**.

As seen in Figure 1, each pair of plates **25***b* is adapted for being suitably electrically connected to an electrostatic convergence control source generally designated **27**. For example, electrical connections between the plates **25***b* and the control source **27** may be made through terminal pins (not shown) in the tube base **13**. The source **27** may be one of any of a number of suitable generally available circuit arrangements and is adapted for electrostatically and independently controlling each pair of plates **25** thereby to effect any desired amount of vertical deflection of corresponding ones of the outer beam components. Thus, the two pairs of plates **25** are adapted for effecting static convergence of the outer beam components **15** and **17** on substantially the same horizontal plane at the screen **7** as the center beam component **16** or on any plane of deflection that might be determined by the physical alignment of the center gun and the resultant impingement of the center beam component.

It is also necessary to effect static convergence of the outer beam componnents **15** and **17** on the inner beam component **16** in a horizontal plane in the manner illustrated by solid lines **15**, **16**, **17** in Figure 1, thereby to provide for cross-over of the beams in the plane of the grille **10** and satisfactory impingement of phosphor stripes at desired points or at substantially the central portions thereof. The static convergence in the horizontal plane is accomplished by magnetic deflection and to this end the pairs of plates **25** are formed of any suitable soft-magnetic material or any material which has high magnetic permeability and low magnetic retentivity, such as soft iron. The plates **25** are thus adapted for serving as internal pole pieces in the static magnetic convergence arrangement including externally disposed magnetic field producing means.

As seen in Figure 2 each of the plates **25***a* and **25***b* is formed with an arcuate portion **28** disposed in close proximity to and conforming substantially to the internal surface of the neck **3** of the tube. In this manner each vertically spaced pair of plates **25** is adapted for cooperating with one of a pair of electromagnets each of which is generally designated **30**. The electromagnets **30** are disposed externally of the tube neck in diametrically opposite positions with each being in close proximity to the associated pair of plates **25**. Each of the electromagnets **30** includes a substantially U-shaped soft-magnetic material core **31** which may be formed of ferrite or the like. The core **31** is adapted for carrying a coil or winding **32** on the center portion thereof. The coil **32** is utilized in the static convergence control of the beam components and will hereinafter be referred to as the static magnetic coil. Additionally, as shown in Figure 2, the core **31** includes upper and lower leg portions **33** and **34**, respectively, the ends of which constitute external magnetic pole pieces which are shaped for conforming substantially to the external surface of the tube neck and are disposed

for cooperating magnetically with a corresponding pair of the plates **25** to establish magnet fields between pairs of vertically spaced plates **25**. The conformance of the ends of the core leg portions **33** and **34** and the arcuate portions **28** of the internal pole pieces **25***a* and **25***b* afford the establishment of fields or greater strength between the pole pieces for a given energizing current. The upper and lower leg portions of the core **31** carry coils **35** and **36**, respectively. The coils **35** and **36** are adapted for utilization in a dynamic convergence control arrangement the purpose, structure and function of which will be brought out in detail hereinafter; and the coils **35** and **36** will be referred to as the dynamic magnetic coils.

The static magnetic coils **32** are each suitably electrically connected to a static electromagnetic convergence control source generally designated **37** in Figure 1. The source **37** may be any suitable arrangement adapted for unidirectionally energizing each of the electromagnets **30** through its respective coil **32** and for energizing the electromagnets in opposite polarity. When the magnets **30** are thus energized magnetic fields at the pole pieces **33** and **34** are caused to extend through the tube envelopes to the elements **25***a* and **25***b* for establishing transverse magnetic fields between each pair **25** thereof, whereby the outer beams **15** and **17** are caused to shift inwardly and converge on the inner beam **16**. The static electromagnetic convergence control source **37** is adjustably controllable so that the convergence of each outer component is such as to provide for cross-over in the plane of the grille **11**. Thus, the beam components are statically electromagnetically converged for impinging respective phosphor stripes of an individual triad of stripes in the desired manner.

It will be understood that in effecting this initial or static convergence of the beam components, the components may be in any desired one of their different deflected positions. For example, they may be initially converged at the center of the raster to be scanned in the manner illustrated in solid lines in Figure 1. Alternatively they may be initially converged at any corner of the raster. It will be understood further that while I have illustrated and described electromagnetic means for static magnetic beam component convergence other magnetic means such as arrangements including permanent magnets located either internally or externally of the tube envelope may be alternatively employed as the magnetic field producing means. Furthermore, if desired, the plates **25***a* and **25***b* serving as the internal pole pieces may each be formed of suitable material for being permanently magnetized predetermined degrees to provide for predetermined magnetic deflection of the components.

As seen in Figure 1, the screen **7** is arcuate in the horizontal plane. It is similarly arcuate in a vertical plane. Thus, it will be seen that in scanning of the beam components, the trajectory of each component impinging upon the screen will vary in length in accordance with the raster position. In the vicinity of the axis of the tube and difference between the lengths of components is negligible but such differences increase progressively outwardly from the tube axis and the static convergence obtained in the above-described manner becomes progressively less effective as the components scan outwardly.

The differences in lengths of the component trajectories has no appreciable effect on the convergence obtained electrostatically, or the relative vertical points of impingement on the screen **7**, since the component sources or electron guns **12** are coplanar. However, the differences in lengths of the trajectories at various raster positions results in undesired variations in horizontal convergence and color impurities. Thus, dynamic convergence means is required in order to obtain desired horizontal beam component convergence at all raster positions. In the present embodiment I have provided a dynamic convergence arrangement which includes the above-mentioned dynamic magnetic coils **35** and **36** and operates in accordance with predetermined functions of the deflection of the components.

The coils **35** are oppositely wound and suitably electrically connected to a horizontal dynamic convergence signal generator **40** which may be of any suitable conventional type adapted for generating signals of a sinusoidal wave form having clipped upper crests. The signal generator **40** is coupled to the horizontal deflection signal generator **22**. Thus, in accordance with the function of the horizontal deflection signal generator **22**, the convergence signal generator **40** is adapted for generating a wave form effective for so energizing the coils **35** as to affect predetermined variations in the strengths of the fields produced thereby between the pairs of plates or internal pole pieces **25**. These field strength variations effect corresponding variations in the paths or trajectories of the outer electron beam components **15** and **17** relative to the longitudinal axis of the tube and the inner or center component **16** as the beam components are traced horizontally across the target electrode. In this manner suitable variations in accordance with the horizontal deflection of the beam components are made in the horizontal convergence angles of the outer components as a step toward producing the desired horizontal convergence of the beam components substantially in the plane of the grille **10** at all points of the raster.

The mentioned desired horizontal convergence at all points of the raster is fully obtained when the paths or trajectories of the outer beam components **15** and **17** are also suitably varied in accordance with the vertical deflection of the beam components. This type of variation is accomplished through the agency of the coils **36**. The coils **36** are also oppositely wound and are suitably electrically connected to a vertical dynamic convergence signal generator **41**. The generator **41** may be of any suitable conventional type adapted for generating signals of parabolic wave forms and is suitably coupled to the vertical deflection signal generator **23**. By this arrangement and in accordance with the function of the vertical deflection signal generator **23** there is impressed on the coils **36** a signal which is effective for so varying the strengths of the magnetic fields between the pairs of internal pole pieces **25** as suitably to vary the pre-deflection paths of the outer beam components **15** and **17** in accordance with the vertical deflection thereof.

It will be seen that, while the static magnetic convergence means, the dynamic magnetic convergence means operating in accordance with horizontal component deflection and the dynamic magnetic convergence means operating in accordance with vertical component deflection have each been described separately for the purpose of elucidation, these means function or operate concurrently for determining the strengths of the fields existing between the pairs of pole pieces **25** at any particular time or raster position of the beam components and together cooperate to provide the desired horizontal convergence of the components at each raster position.

It will be seen that while I have illustrated and described the elements **25** as plates, these elements may have any suitable configuration. For example, the opposed surfaces of each pair of plates may be parallel as shown to serve best in the electrostatic convergence of the beam components while the remaining portions may have any suitable configuration for best concentrating the magnetic fields established therebetween for the dynamic convergence operation above-described.

While I have shown and described a specific embodiment of my invention I do not desire my invention to be limited to the particular form shown and described and I intend by the appended claims to cover all modifications within the spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A cathode ray tube comprising an envelope, a target electrode, means for directing toward said target electrode

a plurality of electron beam components one of which constitutes a reference beam component, means including a pair of magnetic pole pieces straddling at least the others of said beam components and forming in the path thereof magnetic deflection fields, means for supplying different potentials to the pole pieces of each pair of said pole pieces to form therebetween an electrostatic deflection field, whereby said electrostatic and magnetic fields provide predetermined deflections of each of said other beam components in mutually perpendicular directions and relative to said reference beam component.

2. A cathode ray tube comprising an envelope, a target electrode, means for directing several substantially coplanar electron beam components toward said target electrode, a pair of magnetic pole pieces associated with each of outer ones of said beam components in said envelope, said pole pieces being adapted for magnetic convergence of said outer beam components on a plane determined by an inner one of said beam components, and means for supplying a potential difference between each pair of said pole pieces to form therebetween an electrostatic field for electrostatic convergence of said outer beam components on said inner beam component in said plane determined by said inner beam component.

3. A cathode ray tube comprising an envelope, a target electrode, a plurality of electron beam producing means adapted for directing beams toward said target electrodes, a pair of plates of soft-magnetic-material forming magnetic pole pieces straddling one of said beams and insulated from said beam producing means, means for supplying a potential difference between said pole pieces to form therebetween an electrostatic field, electrostatic convergence of said one beam on a plane determined by another of said beams, and said pole pieces being adapted for having a magnetic field established therebetween for magnetic convergence of said one beam on said other beam in said plane determined by said other beam.

4. In combination a cathode ray tube including an envelope, a target electrode, means for directing toward said target electrode a plurality of electron beam components one of which constitutes a reference beam component, means for deflecting said beam components to scan a raster at said target electrode, electrostatic deflection means in the path of at least the other ones of said beam components for deflecting said other beam components in one direction, said electrostatic deflection means including common magnetic pole pieces for deflecting said other beam components in a direction perpendicular to said one direction.

5. In combination a cathode ray tube including an envelope, a target electrode, means for directing several electron beam components toward said target electrode, means for deflecting said beam components to scan a raster at said target electrode, means adapted for electrostatically converging outer ones of said beam components on a plane determined by an inner one of said beam components, means adapted for effecting static magnetic convergence of said outer beam components on said inner beam component in said plane and means adapted for effecting dynamic magnetic convergence of said outer beam components on said inner beam component in said plane in accordance with the raster position thereof.

6. In combination a cathod ray tube including an envelope, a target electrode, means for directing several substantially coplanar electron beam components toward said target electrode, means for deflecting said beam components to scan a raster at said target electrode, a pair of soft-magnetic material elements straddling each of the outer ones of said beam components in said envelope, said elements being adapted for effecting electrostatic convergence of said outer beam components on a plane determined by an inner one of said beam components, magnetic field producing means disposed externally of said envelope and adapted for establishing magnetic fields between said elements, said field producing means being energizable to establish magnetic fields between said elements effective for magnetically converging said outer beam components in said plane determined by said inner beam component.

7. In combination a cathode ray tube including an envelope, a target electrode, several substantially planar beam producing means adapted for directing electron beams toward said target electrode, means for deflecting said beams to scan a raster at said target electrode, a pair of soft-magnetic-material elements straddling each of the outer ones of said beams in said envelope and insulated from said beam producing means, said elements being adapted for effecting electrostatic convergence of said outer beams on a plane determined by an inner one of said beams, magnetic field producing means disposed externally of said envelope and adapted for establishing magnetic fields between said elements, said field producing means being energizable to establish magnetic fields between said elements effective for both static and dynamic convergence of said outer beams in said plane determined by said beam.

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