Feb. 2, 1960 E. GUNDERT 2,923,844

CATHODE RAY TUBE STRUCTURE INCLUDING CONVERGENCE SYSTEM

Filed Jan. 11, 1957 2 Sheets-Sheet 1

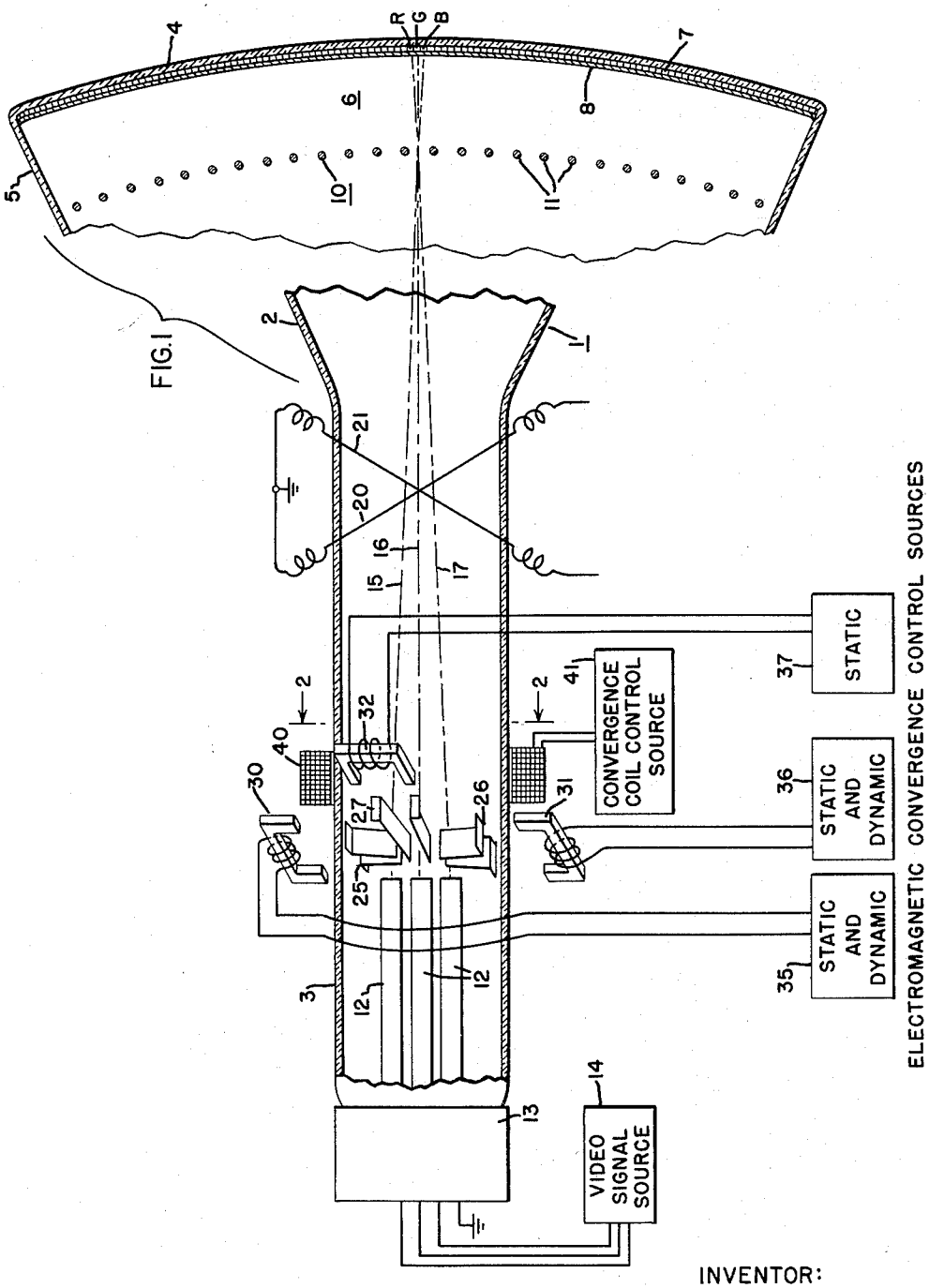


FIG. 1

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CATHODE RAY TUBE STRUCTURE INCLUDING CONVERGENCE SYSTEM

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FIG.2.

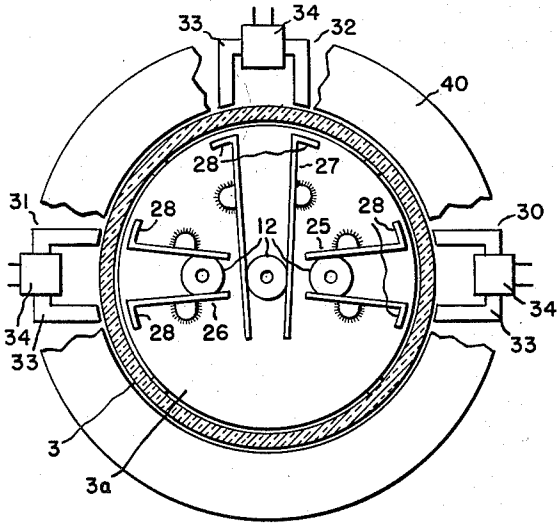


FIG.3.

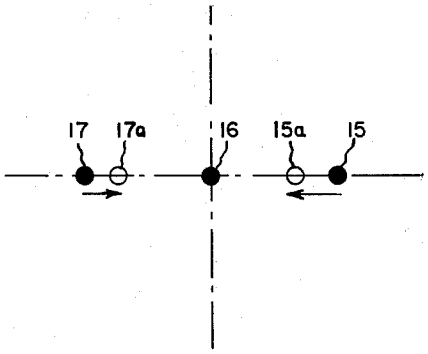
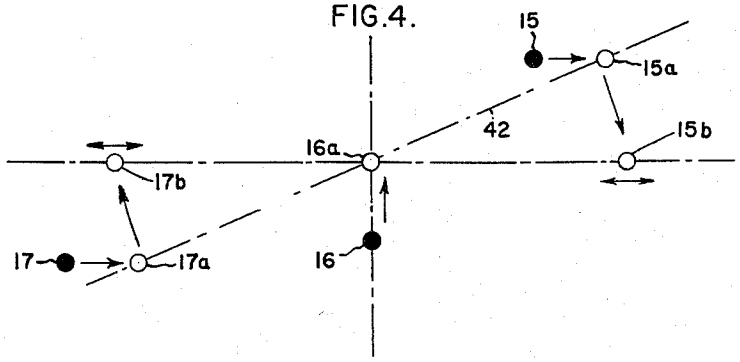


FIG.4.



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2,923,844

CATHODE RAY TUBE STRUCTURE INCLUDING CONVERGENCE SYSTEM

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Application January 11, 1957, Serial No. 633,568

Claims priority, application Germany February 4, 1956

1 Claim. (Cl. 313—70)

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

Color cathode ray tubes to which the present invention is particularly, although not exclusively, applicable generally include a luminescent screen comprising part of a target electrode structure 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 the target electrode structure, thereby to provide desired image rendition and color fidelity. Heretofore, various means have been resorted to in attempts to accomplish satisfactory beam convergence. However, many have been found generally unsatisfactory in that they resulted in complicated and expensive tube constructions, required considerable complicated control equipment, or had undesired effects on the operation of other tube components. Accordingly, the primary object of the present invention is to provide a new and improved cathode ray tube structure including new and improved electron-beam deflecting means.

Another object of the present invention is to provide a new and improved color cathode ray tube structure including new and improved means for effecting convergence of beam components therein.

Another object of the present invention is to provide a new and improved arrangement for magnetically effecting beam convergence.

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 operable with a minimum of control equipment.

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 an envelope containing a target electrode structure, and means for producing and directing several electron beam components toward the target electrode structure. Straddling each of the outer ones of the beam components is a spaced pair of magnetic pole pieces and straddling an intermediate beam component is a similar pair of pole pieces extending transverse to and through the planes of the others. Means are provided for establishing predetermined magnetic fields between the pole pieces to align substantially coplanarly the associated beam components. Other magnetic means is

provided for rotating the beam components about an axis of the tube for thus effecting direction of the beam components toward the target electrode in a predetermined plane. By means of the pole pieces the beam components are converged in the predetermined plane and at the target electrode. The pole pieces comprising each pair may be unequally spaced radially throughout the lengths thereof to effect a predetermined desired field distribution therebetween.

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 one embodiment of the present invention;

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

Figure 3 is a diagrammatic illustration of convergence effects attainable with the present invention;

Figure 4 is another diagrammatic illustration of other convergence effects attainable with the present invention.

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 structure generally designated 6. The structure 6 includes the face plate portion 4 of the envelope, a phosphorescent material coating or screen 7 on the inner surface of the face plate portion 4, which screen 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 and B.

Formed over the screen 7 is an electron permeable conductive layer 8 which can comprise 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 electrode 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 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 8 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 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 component 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**.

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 structure **6**. The operation of the horizontal and vertical deflection coils is controlled by conventional horizontal and vertical deflection signal generators, the construction and operation of which are well-known in the art and, therefore, are not shown or described. Additionally, the scanning operation can be conventional and will not be described hereinafter.

During assembly of the above-described tube structure, and as seen in Figures 1 and 2, the guns **12** are physically aligned for being substantially parallel to each other and for directing the beam components **15–17** toward the target electrode in substantially the same horizontal plane.

In order to obtain the necessary convergence of the beam components **15–17** at the target electrode, and as perhaps better seen in Figure 2, I have provided beam component convergence means which includes two pairs of vertically spaced elongated plates or pole pieces **25** and **26**. The pole pieces **25** and **26** extend transverse to the longitudinal axis of the tube **1** and are disposed for straddling each of the outer beam components **15** and **17** adjacent the exit ends of the corresponding electron guns **12**. Also included in the convergence means is a pair of similar but longer pole pieces **27** straddling the inner beam component **16** and preferably extending substantially perpendicular to the pairs of pole pieces **25** and **26**. While the pole pieces **27** preferably extend perpendicular to the pole pieces **25** and **26** in the presently disclosed embodiment, it will be seen from the following that it is sufficient if the pole pieces **27** extend transversely to and through the planes of the pole pieces **25** and **26**.

As seen in Figure 2, the pole pieces **25–27** are mounted in the neck **3** of the tube envelope **2** on a transversely extending diaphragm **3***a* in any suitable manner whereby they are maintained at the same potential as the diaphragm and the exit ends of the guns **12**. For example, each of the pole pieces may be formed with an ear spot-welded to the diaphragm, in the manner illustrated in Figure 2. For simplification of illustration, the diaphragm **3***a* has not been shown in Figure 1.

The above-mentioned convergence of the components **15–17** at the target electrode is accomplished by magnetic deflection and to this end the pairs of pole pieces **25–27** are formed of any suitable soft-magnetic material, such as soft iron.

Additionally, the individual pole pieces of each pair thereof include arcuate portions **28** disposed in close proximity and conforming substantially to the internal surface of the neck of the tube. Still further, the pole pieces of each pair are mutually inclined or unequally spaced radially or outwardly throuhgout their lengths with the innermost edges of each pair being most closely spaced. The purpose for this will be brought out in detail hereinafter.

Thus, each spaced pair of pole pieces **25–27** is adapted for cooperating with a corresponding one of three electromagnets **30–32**. The electromagnets **30–32** are disposed externally of the tube neck and are spaced 90° apart thereabout for thus locating each in close proximity to its associated pair of pole pieces. Each of the electromagnets includes a substantially U-shaped soft-magnetic material core **33** which may be formed of ferrite or the like. The cores **33** are adapted each for carrying a coil or winding **34** on the center portion thereof. Additionally, as shown in Figure 2, the cores **33** include upper and lower leg portions, 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 **25–27** to establish magnet fields therebetween. The conformance of the ends of the core leg portions and the arcuate portions **28** of the internal pole pieces **25–27** afford better coupling therebetween and thus the establishment of fields of greater strength between the pole pieces for a given energizing current. Additionally, the mutual inclination of the pole pieces of each pair enables wider spacing of the legs of the cores. This, minimizes the concentration of magnetic fields between the outer ends of the pole pieces for thus affording a predetermined more uniform field distribution between the pole pieces of each pair and resultant more uniform beam-deflection effects.

The coils of the electromagnets **30–32** are suitably electrically connected to adjustable electromagnetic convergence control sources generally designated **35–37**, respectively in Figure 1. These adjustable control sources may be any suitable arrangement adapted for independently, variably energizing each of the electromagnets **30–32** through its respective coil and in accordance with a preselected polarity. When the magnets **30–32** are thus energized magnetic fields at the pole pieces thereof are caused to couple through the tube envelopes to the spaced internal pole pieces for establishing transverse magnetic fields between each pair thereof, whereby the outer beams **15** and **17** can be caused to be deflected or shifted horizontally in either direction and the inner beam **16** can be deflected or shifted vertically in either direction in Figure 1.

As seen in Figure 1, the control sources **35** and **36** may be both static and dynamic. That is, each of these sources may be adapted for energizing the related coils of the magnets **30** and **31** with a predetermined D.C. current in order thereby to correct for static misconvergence, or misconvergence due generally to gun misalignment; and, additionally, the sources may be such as to energize the magnets **30** and **31** with an A.C. signal of a predetermined parabolic wave form, thereby to correct for dynamic misconvergence, or misconvergence generally encountered as a result of scanning. It will be evident from the foregoing that, for the purpose of effecting dynamic convergence, the sources **35** and **36** can be

associated with the scanning means including the deflection coils **20** and **21**.

Also included in the convergence system is an electromagnetic convergence coil or yoke **40**. The coil **40** is mounted concentrically on the neck of the tube envelope immediately adjacent the pole pieces **25–27**. As illustrated in Figure 1, the coil **40** is preferably disposed between the internal pole pieces and the target electrode. However, it will be clear from the following that in some forms of the present invention the coil **40** may be located on the gun side of the internal pole pieces.

Additionally, the coil **40** is suitably electrically connected to a control source generally designated **41**. The control source **41** may be of any suitable generally available type adapted for adjustably controlling the energization of the electromagnetic coil **40** to produce a magnetic field of adjustable intensity and polarity. As is well known to those skilled in the art, the shape of such a magnetic field is generally toroidal, with the lines of force extending generally axially through the tube neck and flaring outwardly from the neck axis on both sides of the coil **40**. As is also well known, the effect of such a magnetic field on an electron beam travelling down the neck of the tube generally parallel to the neck axis but radially displaced therefrom is to converge the beam toward the neck axis by a somewhat helical or spiral deflection of the beam. Thus, in accordance with the energization of the coil **40** the beam components **15–17** may be deflected so as to effect a rotational movement of the beam components about the longitudinal axis of the tube. The purpose for this feature will be brought out in detail hereinafter.

If the guns **12** are accurately aligned in assembly the beam components **15–17** emanating therefrom will be directed toward the target in a horizontal plane with the inner component substantially coaxial with the longitudinal axis of the tube, in the manner indicated diagrammatically in Figure 3. Thus, convergence of the three beam components at the target electrode can be accomplished simply by operating the D.C. or static feature of the control sources **35** and **36** for shifting or deflecting the outer components inwardly or outwardly relative to the center component, as for example, to the positions **15***a* and **17***a* and until desired convergence is obtained. Subsequently, during operation of the tube and scanning of the beam components, the A.C. signals provided by the sources **35** and **36** will effect energization of the related magnets and pole pieces whereby dynamic convergence will be effected.

As a practical matter, however, and due, among other reasons, to difficulties in obtaining satisfactorily accurate gun alignment by known manufacturing and assembling methods, the guns are not generally effective for directing the beam components toward the target electrode in the manner indicated at **15–17** in Figure 3. Instead, and even after the guns are physically aligned as well as humanly possible, the components often emanate from the guns somewhat irregularly, such as in the manner illustrated exaggeratedly at **15–17** in Figure 4, resulting in the beam components impinging upon the screen **6** in different horizontal planes and thus causing misconvergence with resultant reduced and unsatisfactory image rendition and color fidelity. To overcome this condition the control source **37** can be operated for establishing a predetermined magnetic field between the pair of pole pieces **27** effective for deflecting the center component **16** upwardly to position **16***a* in Figure 4. Then the control sources **35** and **36** can be operated for establishing suitable static electromagnetic fields between the outer pairs of pole pieces **25** and **26** for deflecting

the outer beam components horizontally until they assume positions such as **15***a* and **17***a* and lie in a substantially common plane with the center beam, such as that indicated at **42** in Figure 4. In this plane, however, suitable convergence is not generally attainable and to overcome this the coil control source **41** can be operated for energizing the coil **40** sufficiently to effect rotation of the outer beam components about the position **16***a* for causing them to assume the positions **15***b*—**17***b* and to lie and be directed toward the target electrode in the same horizontal plane. Subsequently, the control sources **35** and **36** can be further operated for causing the outer beam components to converge satisfactorily on the inner component, as at the target electrode **6** and specifically in the plane of the grille **10** in the manner shown in Figure 1.

The just-described convergence of the beam components is facilitated to a high degree by the above-referred-to mutual outward inclination of the pole pieces comprising the pairs **25–27**. This inclination of the pole pieces results in a predetermined substantially uniform field distribution across the region between the poles and thus provides more uniform beam deflections for given changes in energization currents as effected by the control sources **35—36**.

While a specific embodiment of the invention has been shown and described, it is not desired that the invention be limited to the particular form shown and described, and it is intended by the appended claim to cover all modifications within the spirit and scope of the invention.

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

A cathode ray tube including an envelope, a target electrode, three substantially coplanar electron guns for directing three electron beam components toward said target electrode, and means for converging said three beam components into equally spaced relation in a plane parallel to said electron guns comprising a pair of first magnetic pole piece straddling each of the outer ones of said beam components in said envelope, said first pole pieces being adapted for magnetic field displacement of said outer beam components in a plane parallel to the plane of said electron guns, a pair of second magnetic pole pieces straddling the inner one of said beam components, said second pole pieces being substantially perpendicular to said first pole pieces and being adapted for magnetic convergence of said inner beam component to a position midway between said outer beam components on the plane determined by the outer ones of said beam components, the pole pieces of each of said pairs of pole pieces including mutually inclined portions for generating a uniform magnetic field throughout the space between said mutually inclined portions, an electromagnetic coil surrounding the paths of said beam components and positioned to generate a magnetic field having an axis substantially parallel to the paths of said beam components for effecting rotational displacement of at least the outer ones of said beam components about the axis of said tube, and respective magnet means for establishing predetermined magnetic fields between said respective pairs of pole pieces.

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