Oct. 6, 1959 J. S. BRYAN 2,907,908

APPARATUS FOR PREVENTING DISTORTION IN PLURAL BEAM CATHODE RAY TUBES

Filed Sept. 1, 1955 2 Sheets-Sheet 1

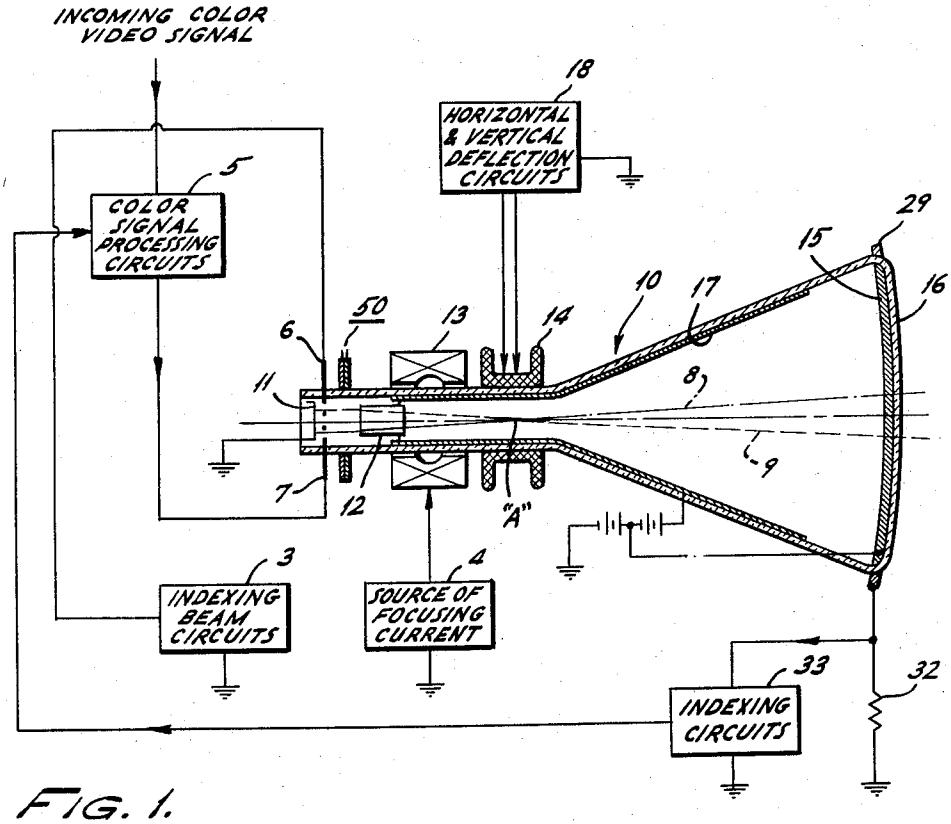


FIG. 1.

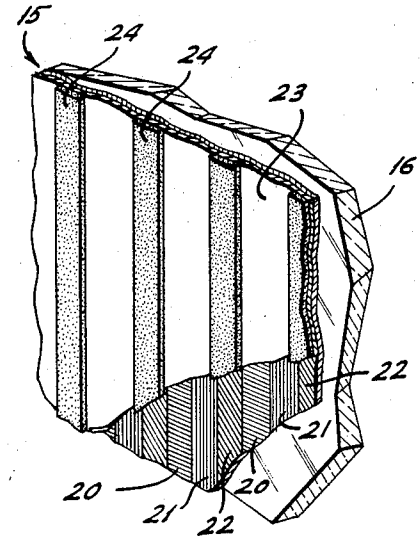
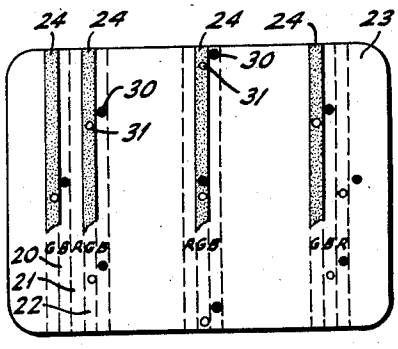


FIG. 2.

FIG. 3.



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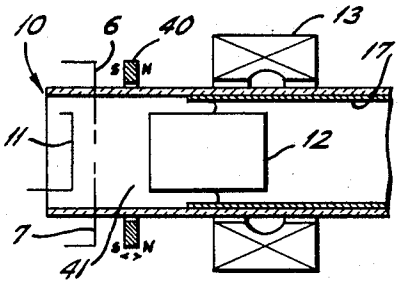


FIG. 4a.

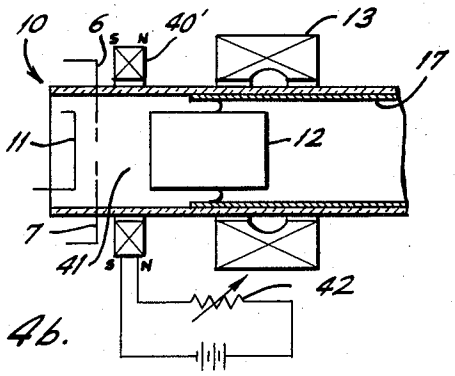


FIG. 4b.

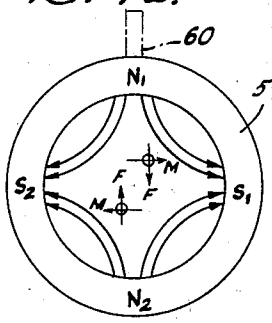


FIG. 7a.

CURRENT FLOWING TOWARD READER

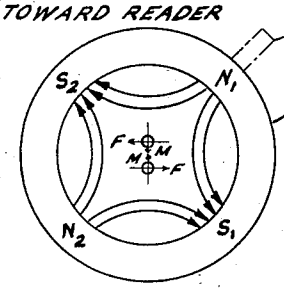


FIG. 7b.

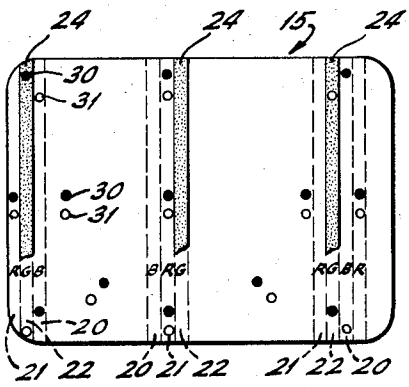


FIG. 5.

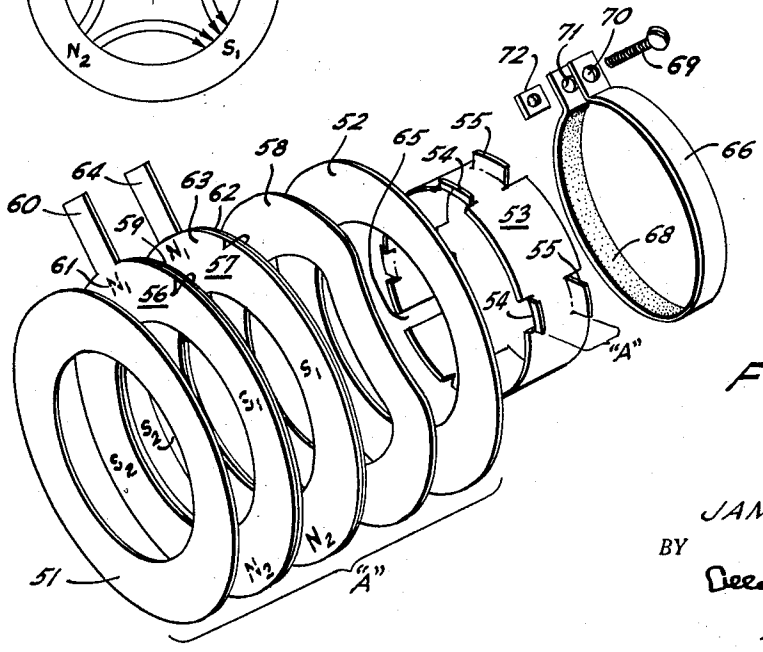


FIG. 6.

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2,907,908

APPARATUS FOR PREVENTING DISTORTION IN PLURAL BEAM CATHODE RAY TUBES

James S. Bryan, Philadelphia, Pa., assignor to Philco Corporation, Philadelphia, Pa., a corporation of Pennsylvania

Application September 1, 1955, Serial No. 531,972

10 Claims. (Cl. 313—84)

This invention relates to improvements in cathode ray tube systems and in particular to apparatus for preventing certain types of distortion which arise in cathode ray tubes in which a plurality of electron beams are produced.

While not limited thereto, my invention is particularly applicable to certain forms of cathode ray tubes suitable for use as the image reproducing devices in color television receivers, and it is with reference to this application that the invention will be described. Such cathode ray tubes may include means for generating two or more independent electron beams which are shaped by an axial focussing magnetic field produced either by permanent or electro-magnetic means which are generally external to the tube itself. The beams are accelerated toward a beam intercepting structure by appropriate anode structures. The two beams may be positioned very close to one another and aligned so that one is positioned just above the other.

The beam intercepting structure may be constituted in part of a screen having a plurality of groups of parallel strips of phosphor materials, each of which emits light of a particular primary color when bombarded by an electron beam. Between the phosphor strips and the beam generating means are a plurality of strip-like indexing elements, each of which is disposed in a predetermined geometrical relation to a corresponding one (or ones) of the phosphor strips. In one illustrative form these indexing elements may consist of a material such as MgO having a secondary emission characteristic which differs from that of the rest of the beam intercepting structure. One of the electron beams (hereinafter called the "video beam") is modulated in intensity by video signals corresponding to the color components of a televised scene. The other electron beam (hereinafter called the "indexing beam") is generally modulated in intensity at a single frequency which is well above the video frequencies to assist in isolating the indexing frequency components from the video signal components. Both beams are usually deflected in unison by electro-magnetic deflection means which cause the beams to scan the beam intercepting structure, in a direction transverse to the phosphor strips, in a plurality of substantially parallel paths.

The video beam impinges on the phosphor strips, thereby producing a luminous multi-colored reproduction of the televised scene. The indexing beam impinges on the indexing elements (and incidentally on the phosphor strips) thereby producing indexing signals as a result of the emission of secondary electrons from the indexing elements. These indexing signals may be employed in certain circuits to coordinate the position on the phosphor screen of the video beam with the modulation of the latter, so that when the video beam strikes a red color-emissive phosphor strip, for example, its intensity will be modulated by a video signal whose amplitude corresponds to the red color content of the element of the televised scene which is being scanned. To insure precise co-

ordination between impingement of the video beam on the different color light-emissive strips and the modulation of the video beams in accordance with the intelligence representative of these colors, it may be desirable for both the video beam and the indexing beam to traverse simultaneously the same phosphor strip at all points of the scanning raster although the beams may be displaced from each other slightly in the direction of the phosphor strips.

However, it may be difficult to attain perfect coordination between the position of the video beam and the modulation thereof because of a number of distortions which arise in such cathode ray tubes as a result of magnetic fields produced therein. As a result of these distortions, the indexing beam may not impinge on a predetermined phosphor strip, say the green phosphor strip, at the same time as the video beam does at all points in the scanned raster. When this occurs the "tracking" of the two beams is said to be imperfect.

There are several types of distortion which occur in cathode ray tubes of the type described, one of these being known as "bull's-eye error." If it is desired to have both beams impinge on the same phosphor strip at all points on the raster, bull's-eye error is manifested in the displacement, at most points, of the video beam laterally with respect to the indexing beam. As a result, the video and indexing beams do not simultaneously impinge upon the same phosphor strip so that the indexing signals do not accurately reflect the position of the video beam. I have found, after an intensive investigation of the phenomenon, that one cause of bull's-eye error is the "skew" in the video and indexing beams. By "skew" I mean that the central rays of the two electron beams, as they enter the magnetic deflection field, do not lie in the same plane, but rather have a finite angular velocity about the longitudinal axis of the cathode ray tube. Skew may arise because of several factors. One factor is improper construction of the electron gun resulting in an initial misalignment of the centers of the beams and a consequent skewed relation of the two beams. Another factor is the influence of part of the magnetic field produced by the focussing magnet in the grid-anode acceleration gap in a manner to be explained below.

There is also another type of distortion which arises in cathode ray tubes having plural beams which are deflected in unison by electro-magnetic deflection means. This distortion is known as "corner-twist" error and is manifested by a change in the relative angular positions of the video and indexing beams at various points on the scanned raster, and especially at the four corners thereof. At the upper right and left hand corners of the raster the spot produced by the video beam is closer to the corresponding edge of the raster than is the spot of the indexing beam. However, at the lower left and right corners the converse is true, i.e., the indexing beam spot is closer to the corresponding edges of the raster than the video beam spot. At other points on the raster there is a varying angular displacement between the two spots, the amount of displacement increasing as a function of the distance from both the vertical and horizontal axes of the raster. If the phosphor strips are rectilinear it is possible, for example, because of corner twist error, that at one point on the screen the indexing beam may impinge on a blue emissive strip while the video beam impinges on the red emissive strip adjacent thereto instead of impinging on the same blue strip. At another point on the screen the indexing beam may impinge on a green emissive strip while the video beam impinges on a red emissive strip. Hence the indexing signal generated by the indexing beam as it impinges on the indexing elements will not accurately indicate the position of the video beam, making it very difficult to

coordinate the position of the video beam with the intensity modulation thereof. As a result the quality of the reproduced image will be noticeably degraded.

I have found that corner twist error is a function of the separation of the centers of the two beams as they pass through the deflection yoke, and is also a function of the distribution of the windings of the yoke. Since the distribution of the windings varies from one yoke to another of the same general class, the degree and direction of the particular corner twist error produced by each yoke will be affected accordingly unless narrow tolerances are specified and maintained during their manufacture which would increase the cost of yokes considerably. On the other hand, if narrow tolerances are not maintained, the distribution of the windings (and hence the corner twist error pattern due thereto) will vary from yoke to yoke, and extensive and delicate adjustments will be required to position the yoke at precisely the right place for each cathode ray tube during the manufacture of receivers employing such yokes. As a consequence many costly man-hours will be expended to the detriment of efficient production.

It is therefore a principal object of this invention to provide apparatus for eliminating or overcoming certain types of distortion which occur in plural-beam cathode ray tubes.

Another object of the invention is to provide apparatus for assisting in insuring that the several beams of a plural-beam cathode ray tube track in a predetermined manner.

Another object of the invention is to provide apparatus for use with plural-beam cathode ray tubes which prevents bull's-eye distortion in the scanning of the raster by the several beams thereof.

Still another object of the invention is to provide apparatus for use with plural-beam cathode ray tubes which assists in overcoming the effects of corner-twist error.

Another object of the invention is to provide apparatus which assists in improving the color fidelity of images produced by certain type of color television receivers.

These objectives, as well as others which will appear, are attained, according to the present invention, by employing apparatus which produces auxiliary magnetic fields to adjust the position of the several beams of plural-beam cathode ray tubes. The nature of the auxiliary magnetic field produced depends upon the nature of the distortion to be corrected. To prevent bull's-eye error, apparatus is provided, according to my invention, which produces an auxiliary and compensatory magnetic field in the grid-anode acceleration gap. This is achieved by placing an adjustable magnetic device which produces an auxiliary axial magnetic field in proximity to the grid-anode gap to correct for the skewed condition of the beams. In another form of my invention, the position of skewed beams is corrected by positioning near the grid-anode gap or at other desired points along the neck of the cathode ray tube apparatus which produces a transverse magnetic field.

In still another form of the invention apparatus is provided for helping to overcome the effects of corner-twist error by adjusting the position of the region in which the beams of plural beam cathode ray tubes cross over one another. I have discovered that if the beams of plural-beam cathode ray tubes are caused to cross over in the "center of the deflection yoke," as defined hereinafter, the mass production of certain types of cathode ray tubes for color television may be considerably facilitated. In this form of my invention apparatus is provided for adjusting the position of the cross-over region to coincide with the center of the yoke by producing a transverse magnetic field in a selected region of the cathode ray tube.

Figure 1 is a schematic and partially sectional view of a cathode ray tube used in certain color television receiving systems;

Figure 2 is a perspective and sectional view of the beam-intercepting structure of the cathode ray tube shown in Figure 1;

Figure 3 shows schematically the distortion known as bull's-eye error as it appears in a color television reproducing tube of the type shown in Fig. 1;

Figures 4*a* and 4*b* are enlarged views of a part of the cathode ray tube shown in Fig. 1 showing apparatus embodying my invention for the production of an auxiliary axial magnetic field in the grid-anode acceleration gap;

Figure 5 is a schematic representation of the distortion known as corner-twist error in a color television reproducing tube of the type shown in Fig. 1;

Figure 6 is an exploded view of a skew and convergence correcting apparatus constructed according to the present invention; and

Figures 7*a* and 7*b* are schematic representations of two of the active parts of the skew and convergence correcting apparatus illustrated in Figure 6.

Referring to Figure 1, a cathode ray tube **10** is shown having a cathode **11** and apertured control grids **6** and **7**. The incoming color signals are processed in color signal processing circuits **5** and applied to control grid **7** to form the video beam **8**. Signals produced by indexing beam circuits **3** are applied to control grid **6** to form the indexing beam **9**. The beams **8** and **9** are very close to one another in a direction transverse to the direction in which they are scanned. These beams are accelerated by an anode structure **12** which makes contact with coating **17** and are focussed by the focuser **13** which is energized from a source **4** of current. The focuser **13** produces an axial magnetic field whose magnetic lines of force are mainly parallel to the longitudinal axis of the cathode ray tube **10**. As a result of the action of the focuser **13**, the video beam **8** and the indexing beam **9** are caused to cross over one another at point "A." Point "A" is preferably within the space enclosed by the deflection yoke **14** which deflects the video beam **8** and the indexing beam **9** in unison in response to signals from horizontal and vertical deflection circuits **18** over a beam intercepting structure **15**. The latter structure may be located in contact with the face plate **16** of the cathode ray tube **10** or may be spaced therefrom. Ordinarily, the current in the indexing beam **9** is much smaller than the current in the video beam **8** for reasons that will be explained later. A coating **17** of an electrically conductive material is deposited on the inner surface of the bulb portion of the cathode ray tube **10** as shown. A high positive electrical potential of approximately 30 kv. is usually applied to coating **17** which helps to accelerate the beams **8** and **9** toward the beam intercepting structure **15**, establishes a field-free region in the tube, and attracts secondary electrons emitted in response to the impingement of the electron beam **9** on the elements **24** (Fig. 2).

A conductive strip **29** encircles the bulb portion of tube **10** near the face plate **16**. This strip may be painted on or may consist of a metallic mounting member used to support that end of the tube. In either case, the strip **29** is disposed close to the coating **23** so that a capacitive relation exists between them. The strip **29** is connected to indexing circuits **33** and to a load resistor **32** whose other end is grounded.

In Figure 2 the face plate **16** is shown in section as are the elements which comprise the beam intercepting structure **15**. The beam intercepting structure **15** includes a plurality of phosphor strips **20**, **21** and **22** respectively, deposited in contiguous groups of three on the faceplate **16**. Strips **20**, **21** and **22** emit light of blue, red and green color respectively when they are impinged upon by an electron beam. The video beam **8** is modulated in intensity so that, when it strikes a red color emissive strip **21**, for example, its intensity corresponds to that of the red component of the element of the scene

being televised. In front of the strips **20**, **21** and **22**, a coating **23** of an electron-permeable and light reflecting material such as aluminum is deposited to which a relatively high potential of about 25 kv. is applied. The coating **23** helps to enhance the brightness of the image produced by the tube **20** and assists in producing indexing signals in a manner explained below. On the back surface of the coating **23** a number of indexing elements **24** having a strip-like configuration are deposited in a predetermined geometrical relationship to selected ones of the strips **20**, **21** and **22**. In Figure 2 a typical relationship is shown in which the indexing strips **24** coincide with the green strips **22**. The indexing strips **24** are composed of a material having a secondary-electron emission characteristic differing from that of the rest of the beam intercepting structure **15**. The strips **24** are struck by the indexing beam **9** which causes them to emit a secondary-electron current which is collected by coating **17**. When secondary electrons are emitted from elements **24**, the charge on coating **23** varies correspondingly. These variations are transmitted to the indexing circuits **33** which are coupled across the load resistor **32**. The circuits **33** are connected to the processing circuits **5** so that the indexing signals can be used to coordinate the position of the video beam **8** with the intensity modulation thereof.

In one mode of operation the video beam **8** and the indexing beam **9** should be directly over one another so that when the video beam **8** traverses the green-emissive phosphor strips **22** the indexing beam **9** traverses the respective indexing strips **24** coincident therewith. Since the strips **24** and the coating **23** are electron-permeable, the indexing beam **9** will also impinge upon the phosphor strips **20**, **21** and **22**. To avoid desaturation of the image produced by the video beam **8**, the current of the indexing beam **9** is therefore kept low relative to the current of the video beam **8**.

In Figure 3 there is represented the distortion known as bull's-eye error. The beam intercepting structure **15** of the cathode ray tube **10** is shown as seen from the cathode end of the tube. The structure **15** contains rectilinear phosphor strips **20**, **21** and **22** disposed in a recurrent sequence from left to right (although only certain ones of them are shown as indicated by the vertical broken lines). The aluminum coating **23** is deposited on the back of the phosphor strips **20**, **21** and **22** and the indexing strips **24** are disposed on the back surface of the aluminum coating **23**. The phosphor strips **20**, **21** and **22** are appropriately lettered to denote the color of the light emitted thereby.

The area of impingement of the video beam **8** on the structure **15** is indicated in Fig. 3 by the filled-in circle **30**, whereas that of the indexing beam **9** is indicated by the unfilled circle **31**. As inspection of Figure 3 reveals, the video beam **8** and the indexing beam **9** do not impinge on the same phosphor strip at all points on the structure **15**. Instead, the position of the area **30** with respect to the position of the area **31** indicates that at most points on the structure **15** the video beam is displaced to the right of the indexing beam. Thus, at the various points of the raster shown in Fig. 3, the impingement of the indexing beam **9** on the indexing elements **24** produces indexing signals which are utilized by the indexing circuits to control the intensity of the video beam **8** in accordance with the green color content of the scene being televised. If the scene televised has a pure green color throughout, the impingement of the indexing beam **9** on elements **24** will cause the video beam **8** to be modulated in intensity corresponding to the green content, but since the video beam is displaced to the right by the width of one phosphor strip, blue light will be emitted in response to the impingement of the latter beam. Thus a circular ring of blue will be formed. If the amount of lateral displacement between the beams varies at other points on the raster, rings of colors other than blue may also be produced. Sometimes the error is manifested in ellipses, rather than in rings, of various colors. Toward the center of the raster, where the error is small, rings of green will be produced. The aggregation of rings or ellipses gives rise to the "bull's-eye" appellation.

As has been stated above, I have found that bull's-eye error is caused because the beams are skewed with respect to one another. They may be skewed if the electron gun is not perfectly symmetrical or is misaligned. Under certain circumstances they may also be skewed because of the influence of part of the magnetic field produced by the focuser. If there is no electric field gradient in the focuser region and the beams are launched behind the rear fringe field of the focuser, the rear fringe field would rotate the beams somewhat, but the forward fringe field would cause the beams to be rotated in the opposite direction tending to equalize the rotation produced by the rear fringe field. However, in either of two other cases the fringe fields of the focuser can cause the beams to be skewed. The first case is one in which the beams are launched in the middle of the axial magnetic field, there being no electric field gradient in the region of the axial magnetic field. Since the electrons then encounter only the forward fringe field of the focuser, and do not encounter the rear fringe field of the focuser field, an angular component of force is exerted on the electron beams only when they emerge from the axial magnetic field. The second case is one in which the electron beams are produced and launched from the electron gun behind the rear fringe field, there being an electric field gradient in this region. In the second case, the beams leave the axial magnetic field having a net angular momentum about the axis of symmetry and become skewed. Regardless of how skew is introduced into the relation of two beams, I have found that it is possible to correct for it by producing an appropriate magnetic field in the grid-anode acceleration gap.

In Figures *4a* and *4b* two forms of my invention for eliminating skew are shown. In Figure *4a* an annular permanent magnet **40** is placed in proximity to the grid-anode acceleration gap indicated at the number **41**. It is polarized such that its rear surface (i.e., the one closer to the cathode **11**) is a south pole whereas its front surface is a north pole, thereby producing a short axial magnetic field. It may be constructed so as to cancel any fringe field from the focuser **13** which may extend into the gap **41**, or it may be made to introduce a skew counter to that which is imparted to the beams by the focuser fringe field. The annular magnet **40** may be moved longitudinally to vary the position of the corrective auxiliary axial field introduced thereby within the tube.

In Fig. *4b*, instead of a permanent magnet, an electromagnet **40'** is placed round the neck of tube **10** in the region of the grid-anode gap **41**. Two degrees of freedom are afforded by the embodiment since the electromagnet **40'** may be moved longitudinally of the neck of tube **10** to adjust the position of its auxiliary axial field, and the strength of the auxiliary axial field produced thereby may be adjusted by means of potentiometer **42** which controls the amount of current passing through the electromagnet **40'**.

Thus it is seen that, by using the above described apparatus, the skewed relation of the two beams may be eliminated by the production of an axial magnetic field in the gap **41** resulting in the elimination of bull's-eye error and approximately perfect tracking of the two beams in the absence of other distortions produced by other elements of the cathode ray tube assembly. As a matter of fact, skew may also be corrected by using apparatus which produces a transverse magnetic field in the grid-anode acceleration gap **41** (as well as elsewhere). This apparatus is pictured in Figure 6, but since the apparatus of Figure 6 also is effective in overcoming the

effects of another type of distortion (i.e., corner-twist error) which occures in plural-beam cathode ray tubes, its use in eliminating skew in the beams will be taken up later together with its use in overcoming the effects of the other type of distortion.

Once the beams have been aligned so that their central rays lie in the same plane as they enter the deflection field, either by using the apparatus shown in Figs. 4*a* and 4*b* or by using the apparatus shown in Fig. 6 as hereinafter explained, it is still possible that the beams may not track perfectly at all points on the scanned raster. Even if the beams are not skewed they may nevertheless be so affected by the magnetic field of the electromagnetic deflection yoke **13** that the corner-twist error scanning pattern results.

In Figure 5 corner-twist error is shown schematically. The elements of the beam-intercepting structure **15** shown in Fig. 5 are essentially the same as those shown in Fig. 3, except that different portions of the structure **15** are considered because they illustrate corner-twist error better. Here again the indexing and video beams do not track at all points in the raster as the respective areas of impingement **30** and **31** indicate. Instead, the area of impingement **30** of the video beam **9** varies in position with respect to the area **31** of the indexing beam **8** at a number of places on the structure **15**. For example, at the upper left-hand corner the video beam impinges on the indexing element **24** (and hence on the green-emissive phosphor strip **22** coincident therewith) whereas the indexing beam impinges on the blue emissive phosphor strip **20**. In the upper central portion of the screen the video beam impinges upon a blue strip **20** while the indexing beam impinges upon an indexing element **24** (and hence upon the green emissive strip coincident therewith).

In the lower half of the screen the opposite condition prevails, that is, at the lower left hand corner the indexing beam impinges upon the indexing element **24** at a time when the video beam impinges upon the blue emissive phosphor strip **20**. However, at the lower right hand corner the indexing beam impinges upon the blue emissive strip **20** and the video beam impinges upon the indexing element **24** and its associated green phosphor strip **22**. The displacement between the two beams increases the farther the beam is scanned from the center of the screen.

In the absence of the proper relation between the positions of the beams at all points on a beam-intercepting screen having parallel rectilinear elements as shown in Fig. 2, or in the absence of any special compensating beam-intercepting structure whose elements are disposed to take corner-twist error into account, the effectiveness of the indexing system in coordinating beam position with beam modulation is considerably diminished. This is because an indexing signal, supposedly representing the impingement of the video beam on a green phosphor strip, may be produced when the video beam impinges on a red or a blue phosphor strip, as well as when it impinges on a green strip. Since it is very difficult to eliminate completely corner-twist error, except by maintaining very rigid specifications in the manufacture of deflection yokes, a more desirable and practical solution is to devise a system in which the corner-twist error does not vary with changes in the distribution of the windings of the yoke. As a result, the elements of the screen can be arranged in such a way that, given the unvarying pattern of corner-twist error, the two beams nevertheless track at all points, thus helping to prevent the malfunction of the indexing system. Since the indexing system would then work properly, the fidelity of the reproduced image would be improved.

I have found that if the beams of a plural-beam cathode ray tube cross over one another in the center of the yoke as defined herein, variations in the windings of the yoke will not affect the corner-twist error pattern. By "center of the yoke" I means that point in the space surrounded by the yoke in which there is substantially no change in the magnetic field strength for a minute displacement therefrom in any direction. I have further found that when the beam crossover region coincides with the center of the yoke, the elements of the beam-intercepting structure may be disposed according to a generally pin-cushion pattern as specified by a formula which I have derived. A complete description and explanation of my system for overcoming corner-twist error is contained in my copending application Serial No. 522,648, filed July 18, 1955, and entitled Apparatus and Method for Overcoming Scanning Error Effects in Plural Beam Cathode Ray Tubes.

In order to take advantage of the invention described in the last-named application, and for other purposes as well, it is convenient to provide, for plural-beam cathode ray tube assemblies, a device which can alter the position of the beam crossover region of the cathode ray tube. In Figure 6 apparatus is shown in an exploded view which performs two functions. It may be used to adjust the position of the region within the tube in which the beams cross over one another, or it may be used to correct the skew in the two beams. The entire skew and convergence correcting apparatus **50** is usually slipped around the neck of the cathode ray tube between the electron gun and the focussing magnet as shown in Fig. 1. It consists of a cylindrical mounting member **53** on which the annuli **51**, **56**, **57**, **58** and **52** are mounted between the two sets of flanges **54** and **55**. Adjacent the flanges **54** and **55** are two non-magnetic retaining annuli, **51** and **52** respectively, which help to keep the intermediate annuli close to one another. On the other side of annulus **51** the annular assembly **56** is positioned. It comprises a non-magnetic annular portion **61** to which is affixed a protruding tab portion **60** and to which a permanent magnetic annular member **59** is cemented. As shown in Fig. 6 the magnetic annular member **59** has two sets of like magnetic poles (N_1—N_2, S_1—S_2) which are disposed in quadrature relation to one another. The magnetic annulus **59** may be made of any material having a high coercive force, such as the alloy bearing the trademark "Vicalloy" manufactured by the Indiana Steel Products Corporation. If necessary, several annuli may be cemented together to provide a sufficiently strong magnetic field.

Annular assembly **57** is substantially identical to assembly **56** and consists of a non-magnetic annular ring **62** and a magnetic annulus **63** cemented thereto which is polarized similarly. A tab **64** is provided on annulus **62** to permit rotation of the assembly **57**. The magnetic annuli **59** and **63** should be relatively thin so that the fields produced by them will be substantially in the same plane transverse to the longitudinal axis of the cathode ray tube. However, they should not be so thin that they are not sufficiently magnetized to influence the beams to the extent desired. An annular spring **58** which may be of Phosphor bronze is positioned on the side of the annulus **62** opposite that on which the magnetic annulus **63** is located. Next to the spring **58** is the retaining annulus **52** which sets up against the set of flanges **55** of the cylindrical mounting member **53**. The spring **58**, in conjunction with the retaining annulus **52**, exerts a pressure on the elements of the assembly in a direction parallel to the axis of the entire apparatus **50**. This pressure helps in maintaining the annular assemblies **56** and **57** at desired degrees of rotation. The direction of the transverse magnetic field established by the polarized annuli **59** and **63** can be adjusted by rotating the annuli **61** and **62** by means of the tabs **60** and **64** respectively.

The mounting member **53** is split at the gap **65**. A resilient collar **66** slips over the end **67** of the mounting member **53** on the side of the set of flanges **55** opposite the side on which the retaining annulus **52** is located. The inner surface of the collar **66** may be lined with a spongy or other resilient material **68**. A bolt **69** passes through

apertures 70 and 71 and threadedly engages the nut 72. By rotation of the bolt 69 the gap 65 is narrowed and the collar 66 is made tighter about the end 67 of the mounting member 53 thereby causing the member 53 to be more constricted about the neck of the cathode ray tube with which it is employed.

It should be appreciated that the active parts of the apparatus 50 consists of the two annuli 59 and 63 with their particular polarization. The rest of the apparatus 50 serves to align the annuli 59 and 63 and to provide a practical mounting for the magnets on the neck of the tube. Many variations in the construction of the retaining and mounting elements are possible which in no way bear on the essential structure or operation of the apparatus 50.

The operation of the active portions of the apparatus 50, i.e., the magnetic annuli 59 and 63, will now be explained in connection with Figs. 7*a* and 7*b*. To simplify the explanation, the annuli 61 and 62 and portions of the apparatus 50 other than the active annuli 59 and 63 will be ignored both in the drawings and in the text. It is assumed that current is flowing out of the page. The letter "M" signifies the direction of the motion imparted to the beam in response to the magnetic field, and the letter "F" signifies the direction of the lines of force acting on the beam. The filled-in circle represents the video beam position just before entering the field of annulus 59, whereas the unfilled circle represents the indexing beam position at the same time. It may thus be seen that the central ray of the video beam is skewed slightly to the right with respect to the central ray of the indexing beam as shown in Fig. 7*a*. If annulus 59 shown in Fig. 7*a*, is rotated in a counter-clockwise direction 90° until the pole N_1 is positioned where the pole S_1 originally was, the lines of force acting upon the video beam are inverted and extend upwards. Applying the left hand rule, the video beam will therefore be urged toward the left. Conversely, the lines of force acting on the indexing beam will extend downward in the adjusted position of the annulus 59 so that the indexing beam is urged toward the right. The extent to which the video and indexing beams are urged to the left and to the right respectively will be determined by the extent of the skew error to be corrected. Once the two beam centers lie in the same plane, i.e., they are not skewed, the annular member 63 may be rotated to adjust the position of the region in which the beams cross over.

In Fig. 7*b* the centers of the video and indexing beams are shown as lying in the same plane just before they enter the field of annulus 63. When they enter the field they are urged even closer to one another than is shown in Fig. 7*b* so that they will cross over one another at a point near to the electron gun. If it is desired to adjust the position of their cross over region to a point farther from the electron gun, the member 63 may be rotated clockwise 90° from the original starting position as shown in Fig. 7*b* until pole N_2 is where pole S_1 originally was. As adjusted, the lines of force acting on the video beam will then extend from left to right so that the motion of the beam is upward, whereas the lines of force acting on the indexing beam will extend from right to left causing the indexing beam to be urged downward. Thus the two beams will now be separated in a vertical direction more than they were originally, and as a result the beams will cross over one another at a point further from the electron gun.

The skew and convergence corrector 50 acts as an entity, i.e., to correct skew or change the position of the region in which the beams cross over it is generally necessary to adjust both members 59 and 63 since they are interdependent, a change in one member affecting the beams in such a way that a change in the other member is also required. It is to be noted that as annulus 59 is rotated clockwise from 0° to 90°, the respective beams are caused to move in semicircular clockwise paths such that, at 45° rotation, the video beam is higher and to the left of its original position, that is, its position after having been influenced by the field of the annulus. The indexing beam is lower and to the right of its original position at 45° rotation. From 45° to 90° the video beam moves higher and moves toward the right until, at 90°, it is above its original position. Conversely, the indexing beam moves further down, beginning at 45°, and toward the left until, at 90° it is directly below its original position. Thus it is seen that the annulus 63 can impart a horizontal as well as vertical movement to the respective beams. This is also true of the member 59 which, in correcting for skew by introducing a horizontal component, may also introduce a vertical displacement component into the respective beams. In employing this apparatus it is therefore generally necessary to move both members in order to arrive at the desired mutual beam position.

It will be understood that still other embodiments and applications of apparatus according to my invention will occur to those skilled in the art. Consequently, I desire the scope of this invention to be limited only by the appended claims.

I claim:

1. Beam positioning apparatus for a cathode ray tube in which a plurality of electron beams are produced, said apparatus comprising first and second magnetic means in close juxtaposition, each of said means having a pair of north poles opposite one another and a pair of south poles opposite one another, said pairs of north poles being situated in space quadrature with said respective pairs of south poles.

2. The apparatus according to claim 1 wherein said first and second magnetic means are constructed and arranged so that their mutual orientation is rotatably adjustable.

3. In combination a cathode ray tube having means for producing a plurality of electron beams, and first and second magnetic means situated close to one another for producing respective magnetic fields which lie substantially in the same plane transverse to said beams, said first and second means each having a pair of north poles opposite one another and a pair of south poles opposite one another, said pairs of north poles being situated in space quadrature with said respective pairs of south poles, said magnetic means being constructed and arranged so that their mutual orientation is rotatably adjustable.

4. Beam positioning apparatus for a cathode ray tube in which a plurality of electron beams are produced, said apparatus comprising first and second magnetic annuli in close juxtaposition, each of said annuli having a pair of north poles opposite one another and a pair of south poles opposite one another, said pairs of north poles being situated in space quadrature with said respective pairs of south poles, and means connected to each of said annuli for rotating each of said annuli.

5. The apparatus according to claim 4 with the addition of a resilient cylindrical mounting member having flanges protruding outwardly therefrom at each edge, said magnetic annuli being mounted on said mounting member intermediate said flanges.

6. In combination: a cathode ray tube having a plurality of electron-sensitive phosphor strips arranged to extend in a first direction, means including a control grid for producing in said tube a first beam which is adapted to be modulated in intensity by signals representative of pictorial intelligence which are applied to said grid, means for producing a second beam, a first anode separated from said control grid by a gap for accelerating the electrons in said beams, a single magnetic means encircling the neck of said tube and being substantially coaxial therewith for producing a magnetic field which has a primary axial component for focussing said beams, said magnetic field also having a rearwardly-extending fringe component of a magnitude sufficient to cause undesired

variations in the mutual relation of the axis of one beam to the axis of the other when said beams are deflected, means for deflecting said beams in unison in a plurality of scanning paths which extend in a second direction which is substantially perpendicular to said first direction, and means for substantially eliminating said variations, said eliminating means comprising means for producing a predetermined magnetic field in the gap between said control grid and said first anode for counteracting the effects of said fringe component therein.

7. The combination according to claim 6 wherein said predetermined magnetic field is substantially parallel to the longitudinal axis of said tube.

8. The combination according to claim 6 wherein said predetermined magnetic field is substantially transverse to the longitudinal axis of said cathode ray tube.

9. In combination: a cathode ray tube having a plurality of electron-sensitive phosphor strips arranged to extend in a first direction, means including a control grid for producing in said tube a first beam which is adapted to be modulated in intensity by signals representative of pictorial intelligence which are applied to said grid, means for producing a second beam, an electron-accelerating electrode disposed between said control grid and said phosphor strips, means for deflecting said beams in unison in a plurality of scanning paths which extend in a second direction which is substantially perpendicular to said first direction, said beams being subject during said deflection to undesired variations in displacement relative to one another as measured in said second direction, and means for substantially eliminating said variations in displacement, said eliminating means comprising means for producing a predetermined transverse magnetic field in the space between said control grid and said accelerating electrode, said field producing means including first and second magnetic means situated close to one another for producing respective magnetic fields which lie substantially in the same plane transverse to said beams, said first and second means each having a pair of north poles opposite one another and a pair of south poles opposite one another, said pairs of north poles being situated in space quadrature with said respective pairs of south poles, said magnetic means being constructed and arranged so that their orientation with respect to one another is rotatably adjustable, said field producing means being adapted to be rotated for adjusting the positions of said beams.

10. Cathode ray tube apparatus comprising: means for producing within said tube a plurality of beams which are to be deflected in unison, said beam-producing means including a control electrode and a first anode separated from said control electrode by a gap for accelerating the electrons in said beam, a single magnetic means encircling the neck of said tube and being substantially coaxial therewith for producing a magnetic field which has a primary axial component for focussing said beams, said magnetic field also having a rearwardly-extending fringe component of a magnitude sufficient to cause undesired variations in the mutual relation of the axis of one beam to the axis of the other when said beams are deflected, and means for producing an auxiliary axial magnetic field in said gap for counteracting the effects of said fringe component therein thereby to minimize said variations.

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