Jan. 12, 1960 S. L. REICHES 2,921,213

MAGNETIC DEFLECTION YOKE FOR A MULTIPLE RAY BEAM CATHODE RAY TUBE AND SYSTEM USING THE SAME

Filed March 1, 1957 4 Sheets-Sheet 1

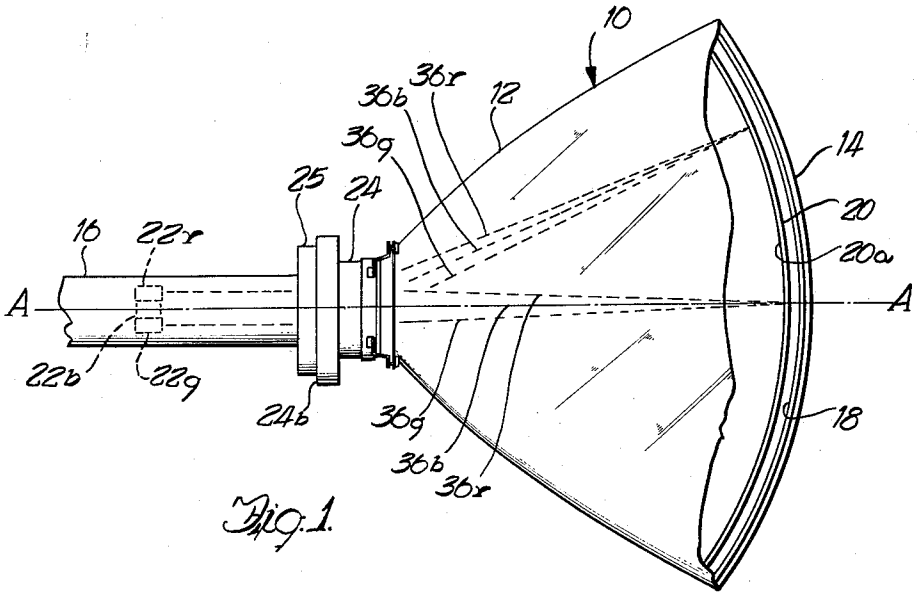


Fig. 1.

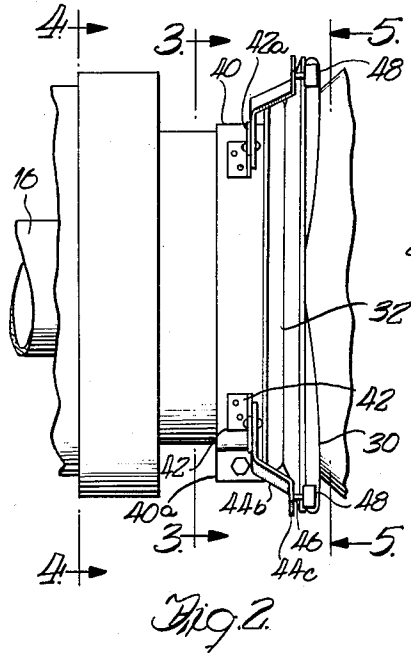


Fig. 2.

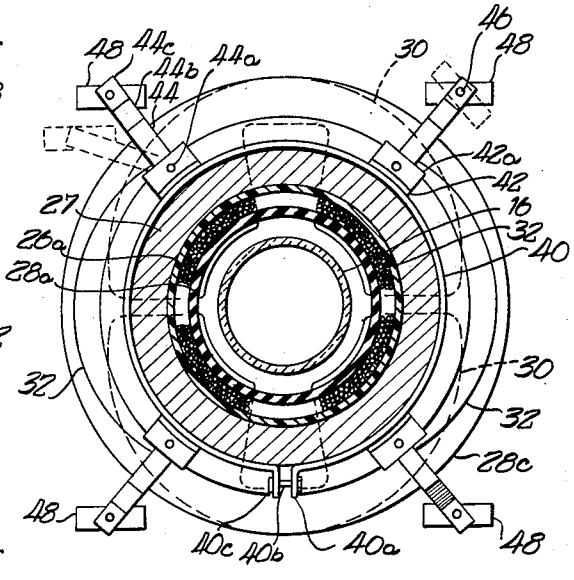


Fig. 3.

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MAGNETIC DEFLECTION YOKE FOR A MULTIPLE RAY BEAM
CATHODE RAY TUBE AND SYSTEM USING THE SAME
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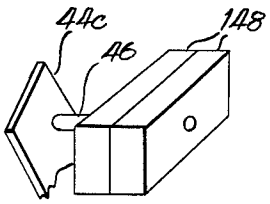


Fig. 7.

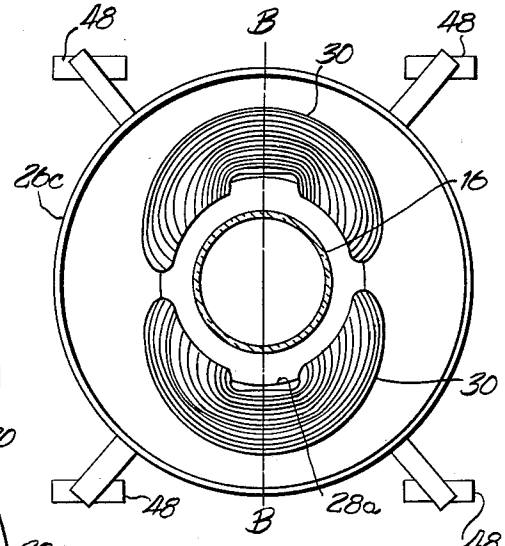


Fig. 4.

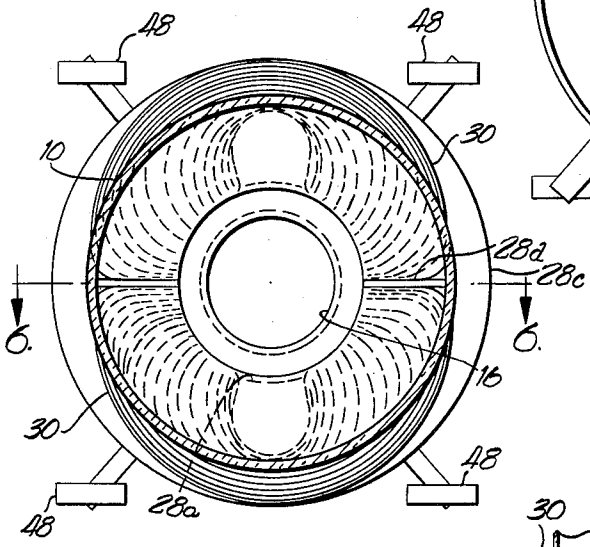


Fig. 5.

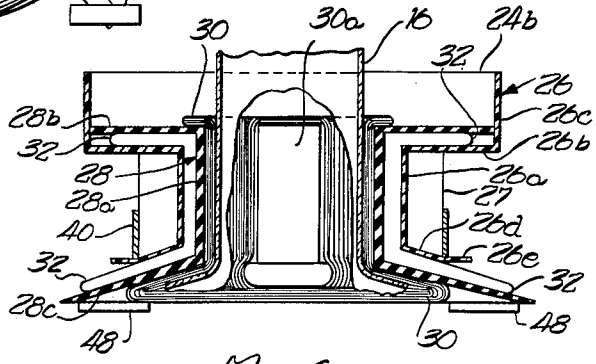
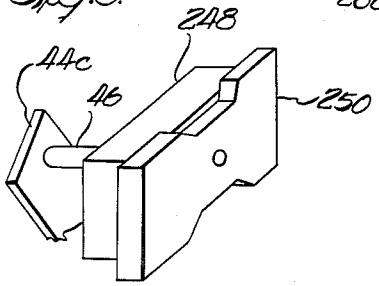


Fig. 6.

Fig. 8.



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MAGNETIC DEFLECTION YOKE FOR A MULTIPLE RAY BEAM CATHODE RAY TUBE AND SYSTEM USING THE SAME

Filed March 1, 1957 4 Sheets-Sheet 3

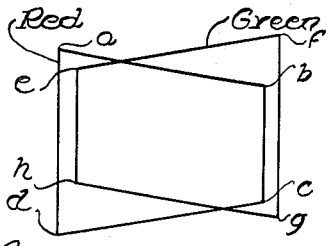


Fig. 10a

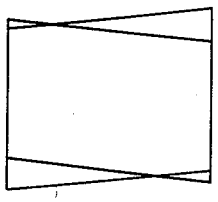


Fig. 10b

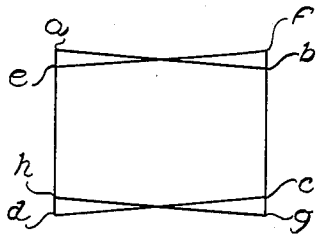


Fig. 10c

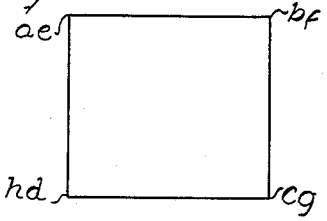


Fig. 10d

Fig. 11.

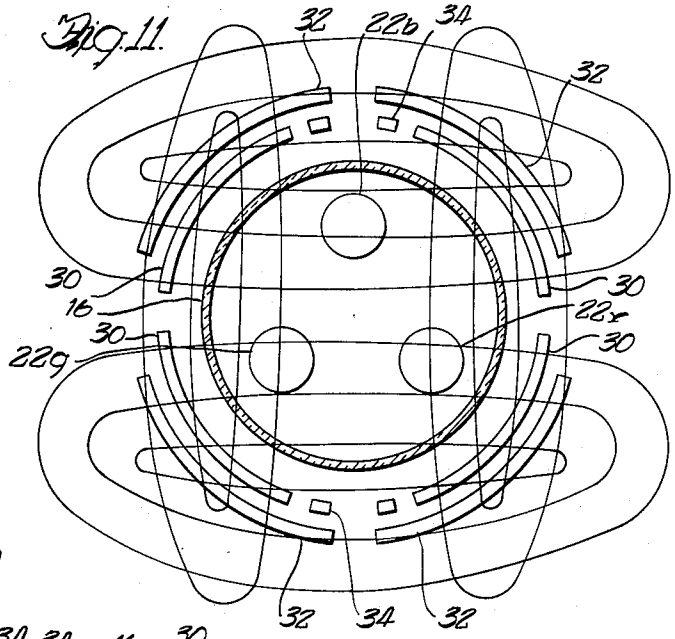
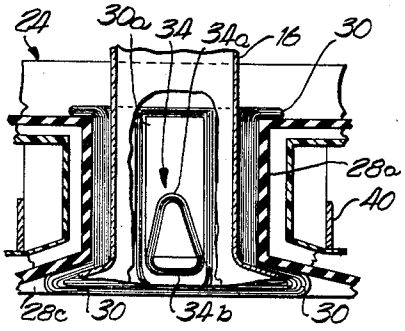


Fig. 9.



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MAGNETIC DEFLECTION YOKE FOR A MULTIPLE RAY BEAM CATHODE RAY TUBE AND SYSTEM USING THE SAME

Filed March 1, 1957 4 Sheets-Sheet 4

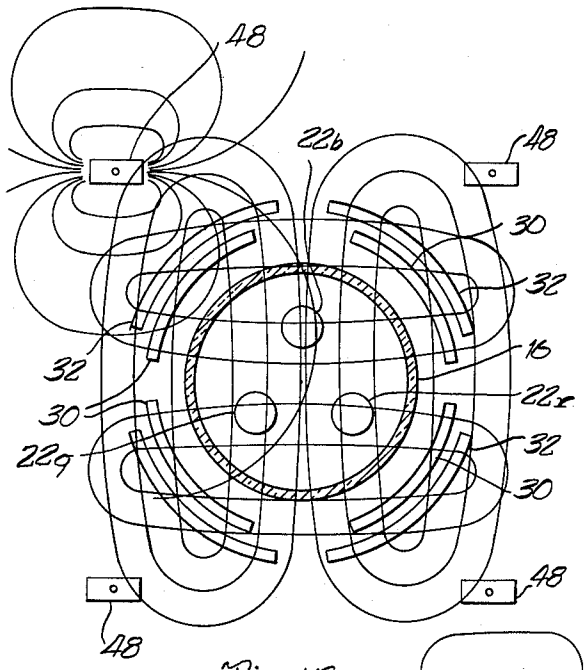


Fig. 12.

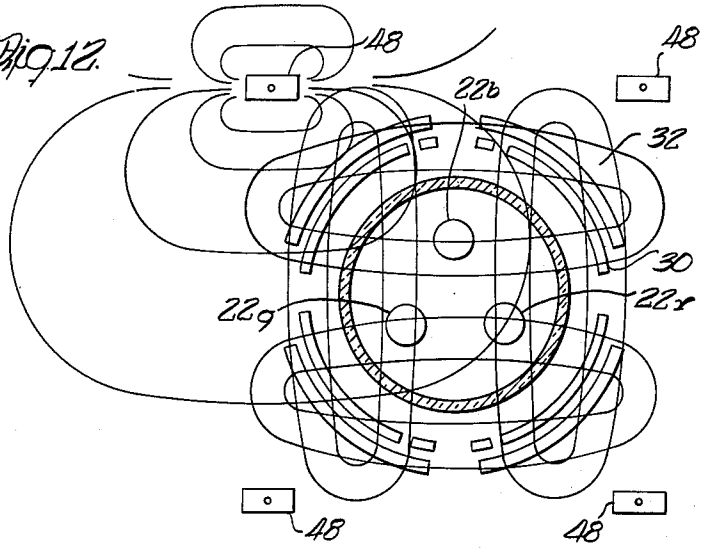


Fig. 13.

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United States Patent Office 2,921,213 Patented Jan. 12, 1960

2,921,213

MAGNETIC DEFLECTION YOKE FOR A MULTIPLE RAY BEAM CATHODE RAY TUBE AND SYSTEM USING THE SAME

Sol L. Reiches, Shaker Heights, Ohio

Application March 1, 1957, Serial No. 643,466

2 Claims. (Cl. 313—77)

My invention relates to a magnetic sweep deflection yoke for a multiple ray beam cathode ray tube having permanent corrector magnets to affect the deflection of the spaced ray beams in different degrees and thus improve convergence during sweep.

In one form of color TV receivers a cathode ray tube having a plurality of electron guns is utilized. The electron guns, one for each basic color used, are located in the neck of the tube and oriented to direct a beam consisting of a stream of electrons towards the viewing screen. Each gun is spaced from the longitudinal axis of the neck of the tube.

The viewing screen of the tube has a phosphor coating which is made up of a plurality of sets of individual dots which emit light when struck by a stream of electrons. Each dot of the set is struck by the beam from one of the guns to emit light of one of the basic colors. The electron beams from the guns are confined to a single set of dots at any one time by a shadow mask positioned close to the viewing screen between the screen and the guns. The shadow mask has a plurality of small openings, one for each set of dots, through which the electron beams must pass. For proper color purity the beam from each gun must strike one dot of the set, and no other. To achieve this condition the beams from the guns, which are spaced from each other as they leave the gun, must converge at the shadow mask and cross as they pass through the opening in the shadow mask. Each dot of the set is positioned in relation to the shadow mask opening to be struck by the beam from the corresponding gun.

The electron guns in the neck of the tube are oriented so that the electrons emitted therefrom initially flow toward the viewing screen in paths parallel to and spaced from the longitudinal axis of the neck of the tube. Adjacent the neck of the tube, downstream in relation to beam travel from the guns, permanent magnet means provide a time-constant magnetic field which bend the beams toward each other, causing them to converge at the center of the shadow mask. A yoke having horizontal and vertical coils encircles the neck of the tube downstream from the guns. When time-varying currents are applied to the coils of the yoke time-varying magnetic fields are produced in the neck of the tube which sweep the beams in unison across the shadow mask and screen in a series of horizontal lines, each vertically spaced from the preceding line. For proper color purity the beams from the guns should converge at the shadow mask during the entire sweeping operation.

When multi-gun cathode ray tubes are used with conventional yokes it has been found that if proper convergence is achieved at the center of the shadow mask by the permanent magnets in the absence of the sweep magnetic fields, convergence will be lost when the beams are directed to the margins of the shadow mask under the influence of the sweep magnetic fields. Several factors contribute to this loss of convergence.

One important reason for the loss of convergence when

the beams are deflected by the time-varying magnetic fields is due to the fact that the ray beams are spaced from each other and follow different paths through the magnetic fields to the shadow mask. As the beams are deflected toward the margin of the shadow mask the beams travel unequal distances through the time-varying sweep magnetic fields, because of their spacing, and are accordingly influenced differently by the magnetic fields. The different effect of the time-varying magnetic field on the spaced beams results in a failure of the beams to converge at the shadow mask.

Another cause of loss of convergence of the spaced beams at the shadow mask is imperfection in the manufacture of the yoke. It is necessary that the time-varying magnetic fields produced by the coils of the yoke be symmetrical about the axis of the neck of the tube. To the extent the yoke, as fabricated, produces time-varying magnetic fields which are not symmetrical, the spaced beams will be affected differently resulting in loss of convergence. In the mass production of conventional yokes many must be rejected for this reason.

For proper convergence at all parts of the shadow mask each gun should sweep a rectangular pattern, or raster, on the shadow mask which coincides perfectly with an identical rectangular raster swept out by the other guns. With a conventional yoke this does not occur. Instead the patterns swept out by the guns are not rectangular and do not perfectly coincide. Considering, for example, the red and green guns, spaced horizontally from each other, it has been found that each sweeps out a trapezoid raster. The raster from the ray beam sweep of one gun is reversed, and generally spaced horizontally and vertically from the raster of the ray beam sweep of the other gun. Convergence is poorest at the apices of the raster swept. The primary cause of this lack of convergence results from the spacing of the electron guns. The beam from the gun spaced farthest from any particular corner must travel a greater distance through the time-varying magnetic fields than the beam from a closer gun and hence its deflection is greater, causing it to reach the viewing screen at a more remote point than the other beam.

The improved yoke of the present invention incorporates means to make the rasters swept out by the ray beam guns more coincident to reduce the loss of convergence at the margins of the mask. In brief, the yoke encircles the neck of the tube adjacent the flared portion of the tube. The yoke has a pair of horizontal windings which straddle the tube to establish a vertically aligned field of flux through the neck of the tube for horizontal sweep. The yoke also has a pair of vertical windings straddling the tube which establish a horizontal flux field through the neck for vertical sweep. The yoke has a plurality of permanent corrector magnets spaced circumferentially about the tube, preferably at the apices of the rasters and aligned longitudinally with the downstream end of the coils of the yoke. The magnets may be rotatable about their respective axes and each may also be swingable in an arc about the neck of the tube. Also shunt bars may be installed adjacent each magnet for adjustability of the intensity of the magnetic field established by the magnet. Alternatively, a pair of magnets may be used in place of each magnet, the pair being rotatable in relation to each other for adjustment of the intensity of the field.

The permanent corrector magnets disposed around the tube in the area of the yoke establish a time-constant magnetic field passing through the region traversed by the electron beams. The intensity of the field from each magnet diminishes as the distance from the magnet increases. Consequently the time-constant magnetic field from each magnet, and the resultant time-constant mag-

netic field throughout the region traversed by the electron beams is space-varying, or non-uniform. Since no two electron beams travel the same path they must necessarily pass through the space-varying time-constant field in areas of different intensity and therefore will be affected differently, their paths to the shadow mask being altered in different degrees. This space-varying time-constant magnetic field, which affects the spaced electrons beams differently, can be utilized to change the position of the raster on the shadow mark of each beam in relation to rasters of other beams. This change will render the rasters more coincident and thereby improve the convergence at the margins of the shadow mask. Moreover, the adjustability of the time-constant magnetic field makes it possible to vary the intensity and direction of the field to offset imperfections in the fabrication of the yoke.

In another form of the invention the yoke, in addition to the corrector magnets, also has auxiliary coils within the confines of the horizontal sweep windings. These coils alter the intensity of the time-varying vertically aligned field only in the centered portion of the region traversed by the electron beams. This variation in intensity in the centered portion of the area traversed by the beams will affect the spaced beams in different manners. Considering, again, the beams from the red and green guns, at positions of extreme sweep one beam will pass through the area affected by the auxiliary coils while the other will not, since the guns are spaced on either side of the axis of the tube. This different effect on the two spaced beams, which alters their paths in relation to each other, can be utilized to improve the convergence on the shadow mask at the margins. The corrective effect of the auxiliary coils can be coordinated with the corrective effect of the corrector magnets to improve convergence at all margins of the shadow mask.

It is a general object of the present invention to provide an improved yoke for a multi-gun cathode ray tube which will improve convergence of the ray beams for improved color purity.

It is another object of the present invention to provide permanent magnet correctors which will affect the beams of a multi-gun cathode ray tube differently to improve convergence at the shadow mask of the tube.

It is another object of the present invention to produce space-varying, time-constant, magnetic fields in the region traversed by the spaced electron beams of a multi-gun cathode ray tube to affect their travel to the shadow mask in different degrees and improve convergence.

It is yet another object of the present invention to provide an improved yoke for a color TV multi-gun cathode ray tube having adjustable permanent magnet correctors which alter the paths of the beams in relation to each other to improve convergence and which will offset defects in the yoke.

It is still another object of the present invention to provide an improved yoke for a multi-gun cathode ray tube having auxiliary coils and permanent magnet correctors which affect the spaced beams from the gun in different degrees to improve convergence.

It is a further object of the present invention to provide an improved yoke for a multi-gun cathode ray tube which produces a field having a centered portion of different intensity and a time-constant non-uniform, or space-varying, field to improve the convergence of the spaced electron beams.

It is an additional object to provide an improved yoke for a multi-gun cathode ray tube of simple construction, and effective and positive operation, which can be quickly adjusted to improve convergence in a multi-beam cathode ray tube.

The novel features which I believe to be characteristic of my invention are set forth with particularity in the appended claims. My invention itself, however, both as to its organization and method of operation, together with further objects and advantages thereof, will be best understood by reference to the following description taken in conjunction with the accompanying drawings in which:

Figure 1 is a top plan view of a color TV multi-gun cathode ray tube, with parts broken away, showing the improved yoke of the present invention installed on the neck and showing the paths of the spaced electron beams as they converge on the center of the shadow mask in the absence of sweep and as they converge on one side of the shadow mask during sweep.

Figure 2 is an enlarged elevational view of the yoke of the present invention on the neck of the tube;

Figure 3 is a view through section **3—3** of Figure 2;

Figure 4 is a view through section **4—4** of Figure 2;

Figure 5 is a view through section **5—5** of Figure 2;

Figure 6 is a view through section **6—6** of Figure 5;

Figure 7 is a perspective view of one of the corrector magnets showing a modified form thereof;

Figure 8 is a perspective view of one of the corrector magnets showing another modified form thereof;

Figure 9 is a view similar to Figure 6 showing a modified yoke having auxiliary coils;

Figure 10*a* is a schematic representation of the trapezoidal rasters in exaggerated form, swept out by the beams from the red and green guns on the shadow mask when a conventional yoke is used;

Figure 10*b* is a schematic representation similar to Figure 10*a* except that a yoke with supplementary coils is used;

Figure 10*c* is a schematic representation similar to Figure 10*a* except that a yoke with corrector magnets is used;

Figure 10*d* is a schematic representation similar to Figure 10*a* except that a yoke having supplementary coils and corrector magnets is used;

Figure 11 is a schematic view through the neck of the tube looking toward the guns showing the horizontal and vertical windings, and supplementary coils, without supporting structure, and the time-varying magnetic fields established by said windings and coils;

Figure 12 is a view similar to the view of Figure 11 showing the horizontal and vertical windings, and the time-varying magnetic fields established thereby, and showing the corrector magnets and the time constant space-varying magnetic field established by one of said magnets, which is typical of the fields established by the other corrector magnets, and

Figure 13 is a view similar to Figure 11 showing the horizontal windings, the vertical windings, and the supplementary coils and the time-varying magnetic fields established thereby; and the corrector magnets and the time-constant, space-varying field established by one of the corrector magnets which is typical of the fields established by the others.

A TV color television tube with the yoke of the present invention installed thereon is shown in Figure 1. The tube, shown generally at **10**, is a glass bulb having a flared portion **12**, a viewing screen **14** and a neck portion **16**. The neck portion has a longitudinal axis A—A. Within the neck are three electron guns **22***r*, **22***b* and **22***g* which are circumferentially spaced around the longitudinal axis of the neck and at equal radial and angular spacing as shown in Figures 11, 12, and 13. Each of the guns, when energized, emits a beam, **36***r*, **36***b*, and **36***g* respectively, constituting a stream of electrons directed toward the viewing screen **14** of the tube along an axis parallel to axis A—A. The viewing screen **14** has a phosphor coating **18** on its inner surface. The phosphor coating is made up of a plurality of sets of dots. Each set of dots has one dot corresponding to each electron gun. When each such dot is struck by electrons it produces light of a particular color, such as red, blue, or green. A shadow mask **20** having an arcuate surface **20***a* is interposed between the phosphor coated screen **14** and the electron guns and has an array of openings (not shown), one for

each set of dots. The dots of each set are so located behind these openings as to receive the corresponding electron beam and not the other electron beams, thus providing color sensitivity.

As shown in Figure 1, the yoke **24** encircles the neck **16** of the tube with the downstream end of the yoke, in relation to beam travel, adjacent the flared portion **12** of the tube. Permanent magnet means **25**, which produces a time-constant magnetic field which may be adjusted to bend the ray beams to converge on the center of the shadow mask **20** in the absence of sweep, encircles the neck of the tube adjacent the upstream end **24***b*, in relation to beam travel, of the yoke **24**. Alternately, the electron guns may be oriented to emit electron beams which travel at a slight angle to the axis of the neck of the tube and converge, without the necessity of permanent magnet means, at the center of the shadow mask in the absence of sweep.

The yoke **24** is shown in Figures 2, 3, 4, 5 and 6. The yoke has an outer casing shown generally at **26**. The casing has a cylindrical center portion **26***a* and an annular flange **26***b* extending radially outward at the rear, or upstream, edge of the cylindrical portion. The flange **26***b* has a rearwardly extending rim **26***c* at its outer edge. At the forward, or downstream edge of the center portion of the casing there is a flared portion **26***d* extending outwardly and forwardly. An annular flange **26***e* is connected to and extends radially outward from the outer edge of the flared portion **26***d*. A non-metallic collar **27** snugly encircles the center portion **26***a*.

The yoke 24 has a rubber sheath, shown generally at **28**, which is received inside the casing **26**. As shown in Figure 6, the sheath has a central cylindrical portion **28***a*. The inner diameter of the cylindrical portion is sufficiently large to receive the neck **16** of the tube. The outer surface of the cylindrical portion is spaced from the inner surface of the cylindrical portion **26***a* of the casing. The sheath **28** has a rear annular flange **28***b* which snugly fits inside the rim **26***c* of the casing. The flange **28***b* of the sheath is spaced from the flange **26***b* of the casing. At the forward end of the cylindrical center portion a flared portion **28***c* extends outwardly and forwardly and is spaced from the flared portion **26***d* of the casing. The inner surface of the central portion **28***a* of the sheath has a pair of ribs **28***d* protruding therefrom positioned opposite each other and centrally on the sides. The ribs extend over a portion of the forward flared portion **28***c* of the sheath.

The yoke has a pair of opposed horizontal sweep windings **30** having an axis B—B at right angles to the axis A—A of the neck and disposed to produce a vertically oriented magnetic field. The windings **30** straddle the neck **16** of the tube with one of the windings carried on the upper half of sheath **28** above the ribs **28***d* and the other winding carried on the lower half of the sheath below the ribs **28***d*. Each winding is carried on the forward face of the flared portion **28***c*, the inner surface of the central portion **28***a*, and the rear face of flange **28***b*. The portions of the two windings carried on the inner surface of the central portion **28***a* of the sheath define a generally cylindrical face. Each winding has a window **30***a* within its confines which, as shown in Figure 6, extends substantially in all directions about the axis of the windings.

The yoke also has a pair of opposed vertical sweep windings 32 which are spaced circumferentially 90° from the horizontal windings **30** to produce a horizontal magnetic field. The vertical sweep windings **32** are sandwiched between the sheath **28** and the casing **26**. A portion of the windings **32** is interposed between the rear flange **28***b* of the sheath and the rear flange **26***b* of the casing, a portion is interposed between the central portion **28***a* of the sheath and the central portion **26***a* of the casing, and a portion is interposed between the forward flared portion **28***c* of the sheath and the forward flared portion **26***d* of the casing.

In one form of the present invention, the yoke **24** also has a pair of opposed auxiliary coils **34**, as shown in Figure 9. The coils **34** are glued flat to the inner surface of the sheath **28** to lie opposite each other in the windows **30***a* within the confines of the horizontal sweep windings **30** so that at least a portion of the coil is in the same general cylindrical surface as the windings. The auxiliary coils are preferably located in the downstream portion of the windows **30***a*, in relation to beam travel. The coils are preferably of triangular configuration having an apex **34***a* at the upstream end of the coil and a base **34***b* at the downstream end of the coil. The apex **34***a* lies on the inner surface of the central cylindrical portion **28***a* of the sheath and the base **34***b* lies on the forward surface of the forward flared portion **28***c* of the sheath.

The yoke **24** has a band **40** encircling the collar **27**. The band has a pair of ears **40***a*, each having a hole. A bolt **40***b* is received in the holes in the ears and threadedly receives wing nut **40***c* to hold the strap snugly around the collar. The strap has a plurality of brackets **42** connected thereto, each having a leg **42***a* extending radially outward. An arm **44** is swingably connected to the leg **42** of the bracket by means of a rivet **44***a*. The arm has a center portion **44***b* which is inclined at an angle towards the forward end of the yoke to bring the radially outward extending end **44***c* of the arm in alignment with the forward portion of the windings **30**. A forwardly extending pin **46** is received in the outer end **44***c* of the arm. The corrector magnet **48** is rotatably received on the pin **46**.

Figure 7 shows another form of the corrector magnet. In this modification two like magnets **148** are rotatably received on the pin **46**. The ends of each magnet define opposite magnet poles. Since the two magnets **148** are rotatable in relation to each other they may be aligned so that like poles are at each end. With this alignment a strong time-constant magnetic field is established by the pair. However, the intensity of the field can be greatly reduced by rotating one of the magnets 180 degrees so that opposite poles are adjacent each other.

Another modification of the corrector magnet is shown in Figure 8. In this embodiment the corrector magnet **248** and a shunt bar **250** are rotatably received on the pin **46**. The shunt bar provides a path for the magnetic flux and reduces the flux through the neck of the tube. The shunt bar **250** can be rotated in relation to the magnet **248** to diminish the effect of the shunt bar on the magnetic field in the neck and thereby increase the intensity of the latter.

In operation a beam of electrons is emitted from each gun **22***r*, **22***g*, and **22***b*, directed toward the viewing screen, as shown in Figure 1. Initially, the paths of these beams of electrons are parallel to the axis of the neck of the tube. When no current is flowing in the windings of the yoke **24**, no time-varying magnetic field is produced in the neck of the tube and the streams of electrons strike the center of the shadow mask **20** as shown in Figure 1. A device **25** having permanent magnets is provided to bend the beams together to converge on the shadow mask. If the device **25** is set properly, convergence will occur at the center of the shadow mask and the beam **36***r* from the gun **22***r* will strike the dot in the set which gives off red light. Similarly the beam **36***b* from the gun **22***b* will strike the dot in the same set which gives off blue light and the beam **36***g* from the gun **22***g* will strike the dot of that set which gives off green light.

When time-varying current is passing through the windings of the yoke **24** a time-varying magnetic field will be established in the neck of the tube in the area traversed by the beams and the beams will be deflected in unison from the center point of the shadow mask as shown in Figure 1. For proper color purity the beams should

converge at the shadow mask regardless of the amount of deflection of the beams.

When a conventional yoke is used there is a tendency, on deflection, for the beams to converge before they reach the shadow mask, at a point upstream from the mask. This tendency is increased as the beam sweeps towards the margin of the shadow mask and hence color purity at the margins is not good. Two factors contribute to the poor convergence at the margin of the shadow mask. Considering, for example, the beams **36***r* and **36***g* emitting from the guns **22***r* and **22***g*, respectively, it will be noted that these beams are spaced from each other as they traverse the region of the time-varying magnetic flux established in the neck of the tube by the windings in the yoke **24**. When the magnetic field established by the currents in the yoke is such to deflect the beams toward one margin of the screen the beam which is spaced farthest from that edge of the shadow mask must traverse a greater area of the magnetic field and hence is affected more than the beam spaced closest to the margin of the shadow mask. This causes a greater deflection of the one beam than is required for proper convergence at the shadow mask. Another factor affecting convergence at the margins of the screen is lack of symmetry in the yoke **24** due to manufacturing errors. These errors result in a magnetic field which affects convergence at the edge of the screen.

The results produced by these factors affecting convergence is shown schematically in Figure 10*a*. As the beam of one gun, for example, **22***r*, is swept across the shadow mask in sweeping operation, the raster swept out by the beam will be in the form of a trapezoid, with apices *abcd*. The beam from the green gun **22***g*, which is spaced from the red gun **22***r*, will also sweep out a trapezoidal raster having apices *efgh* which, however, will be opposite and displaced from trapezoid *abcd*.

Figure 12 shows schematically the windings of the yoke **30** and **32** encircling the neck **16** of the tube and the corrector magnets **48** of the present invention positioned around the tube outboard of the coils. The position of the guns **22***r*, **22***g*, and **22***b*, is also shown. Although, in Figure 12, only the field from one corrector magnet **48** is shown, each magnetic corrector **48** establishes a time-constant space-varying magnetic field, the intensity of which diminishes as the distance from the magnet is increased. Thus each magnetic corrector, and the combination of all the magnetic correctors, establishes a non-uniform, or space-varying, time-constant magnetic field in the area traversed by the spaced beams. The intensity and orientation of this resultant field are adjustable.

It will be noted that the windings **30** and **32** in the yoke **24** establish a horizontal time-varying magnetic field, and a vertical time-varying magnetic field, respectively, both of which permeate the area traversed by the spaced beams. The addition of a non-uniform, or space-varying, time-constant magnetic field in this region serves to aid the time-varying magnetic field as each beam is deflected in one direction and to oppose the time-varying magnetic field as the beam is deflected in the opposite direction.

Since the intensity of the time-constant magnetic field varies from point to point it is evident that it will influence the spaced beams in different degrees. The beam traversing the path through the more intense portion of the time-constant magnetic field will be aided more as the beams are deflected to one side of the shadow mask and opposed more as the beams are deflected to the opposite side of the mask, in relation to the beam passing through a less intense portion of the time-constant magnetic field. This difference in influence on the spaced beams can be utilized to improve the vertical and horizontal alignment of the two trapezoidal rasters swept out by the respective beams. It should be noted that since the intensity and orientation of the time-constant magnetic field is adjustable, the difference in intensity of the field at the two regions traversed by the spaced beams can be made greater or less, depending on the amount of shift of the trapezoidal rasters required to achieve improved alignment.

The influence of the space-varying time-constant magnetic field is illustrated in Figure 10*c*. As a result of improving the horizontal and vertical alignment of the trapezoidal rasters swept out by the two guns, the spacing between apices *a* and *e*, *f*, and *b*, *h* and *d*, and *c* and *g* have been made equal to each other, which improves the convergence.

In another form of the present invention the corrector magnets are used in conjunction with supplementary short-circuited coils **34** located within the confines of at least one of the pairs of windings, for example, windings **30**. The time-varying magnetic field is produced when a time-varying current flows in the horizontal sweep windings **30**. This field is substantially uniform in the area through which the beams from the electron gun pass. The magnetic field produced by the sweep current induces in the auxiliary short circuited coils **34** a current which tends to oppose the flux produced by the sweep windings **30**. However, since the auxiliary coils **34** are relatively small in comparison with the sweep windings **30**, and are positioned within the confines of those windings and to straddle the axis of the tube, the influence of the current in the coils **34** will not be over the entire magnetic field produced by the windings **30**. Instead, the effect of the current in the coils **34** will be limited to a portion of the magnetic field passing through the center of the neck of the tube. For this reason the change in the magnetic field of the sweep windings affected by the auxiliary coils **34** will not influence the path of travel of all of the beams of electrons in the same manner. For example, when the beam from the gun **22***r* is deflected to the right, as viewed in Figure 11, the path of the beam will not be substantially affected by the auxiliary coils **34**. On the other hand, when a beam from the gun **22***g* is directed to the right the coils will substantially affect the travel of the beam since the beam must pass through the area influenced by the coils. The reduction in the intensity of the magnetic field in the area traversed by the farthest beam, but not the closest beam, tends to overcome the tendency of the beams to converge before they reach the shadow mask.

As shown in Figure 10*b* the effect of the supplementary coils **34** without the corrector magnet is to improve the horizontal alignment of the two trapezoidal rasters but not to materially affect or improve the vertical alignment of the rasters.

However, when the corrector magnets are used in conjunction with the supplementary coils **34** both the horizontal and vertical convergence can be materially improved as shown in Figure 10*d*. The time-varying and time-constant, space-varying fields produced by the horizontal windings with auxiliary short-circuited coils, the vertical windings, and the corrector magnets are shown in Figure 13. With this construction the two rasters from the red and green gun, respectively, approach coincidence and vertical and horizontal alignment. Probably one of the principal reasons for the improvement in coincidence when both the supplementary coils and the corrector magnets are used is that much of the horizontal alignment required is achieved by the supplementary coils. Thus, the permanent magnets can be adjusted and oriented to improve the vertical alignment and overall coincidence.

It should be noted that the permanent corrector magnets are rotatable about their axis and also swingable in an arc about the neck of the tube. This permits a ready and quick means of changing the intensity and direction of the time-constant magnetic field permeating the neck of the tube. Thus adjustments can be quickly made, not

only to offset the inherent characteristics of the spaced electron beams, but also to permit quick adjustment to offset for lack of symmetry in the windings introduced during the manufacture of the yoke. It has been found, for example, that convergence can be achieved much more quickly with the adjustable permanent magnets of the present invention than heretofore was possible with conventional yokes. More importantly, however, it has been found that with the corrector magnets, yokes which previously had to be rejected because of imperfections introduced in manufacture resulting in lack of symmetry in the magnetic fields produced, can now be used quite satisfactorily because of the correcting features of the permanent magnets.

While I have described the location of the permanent magnets as being aligned with the forward or downstream end of the horizontal windings it should be noted that some variation in this longitudinal location is possible.

While I have shown and described specific embodiments of the present invention it will be understood that numerous modifications and alternative construction may be made without departing from its true spirit and scope. In the above description I have referred to the phosphor coating on the screen as being made up of a plurality of sets of dots. It will, of course, be understood that I have described this particular construction of the screen merely for purposes of illustration and that the present invention can be used in any TV cathode ray tube having guns spaced from a longitudinal axis where convergence of the beams from the guns is desired. I, therefore, intend by the appended claims to cover all such modifications and alternative construction as fall within their true spirit and scope.

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

1. A ray beam convergence corrector for use with a multiple ray beam cathode ray tube having a neck with a longitudinal axis, a plurality of electron guns located in the neck in spaced relation to the axis, an arcuate surface upon which the ray beams should converge to reproduce a television image, the electron beams from the guns converging on the surface at said axis in the absence of sweep, and a yoke having windings straddling the neck of the tube and adapted to produce time-varying magnetic fields encompassing said neck and transverse to said axis to deflect the beams in sweeping action, each beam defining a raster on the arcuate surface during sweep, the corrector comprising: auxiliary sweep coils located within the confines of at least one pair of the windings of said yoke and operable to resist the creation of time-varying fields in the central portion of the neck of the tube, said coils serving to make the rasters of the respective beams more coincident and thereby overcome in part the loss of convergence of the ray beams incident to sweep action, the action of said coils and of inherent errors in the system serving to cause the ray beams to sweep in non-coincident trapezoidal patterns; and a plurality of permanent magnets located circumferentially approximately at the apices of the rasters and longitudinally in a plane generally coextensive with the plane of the yoke, each magnet being rotatable about an axis generally parallel to the axis of the neck of the tube and in relation to the other magnets and the yoke to define a time-constant space-varying magnetic field operable to overcome the tendency of the ray beams to execute trapezoidal rather than rectangular rasters, and further improve the coincidence of the rasters from the respective beams.

2. A ray beam convergence corrector for use with a multiple ray beam cathode ray tube having a neck with a longitudinal axis, a plurality of electron guns located in the neck in spaced relation to the axis, an arcuate surface upon which the ray beams should converge to reproduce a television image, the electron beams from the guns converging on the surface at said axis in the absence of sweep, and a yoke having windings straddling the neck of the tube and adapted to produce time-varying magnetic fields encompassing said neck and transverse to said axis to deflect the beams in sweeping action, each beam defining a raster on the arcuate surface during sweep, the corrector comprising: auxiliary sweep coils located within the confines of at least one pair of windings of said yoke and operable to resist the creation of time-varying fields in the central portion of the neck of the tube, said coils serving to make the rasters of the respective beams more coincident and thereby overcome in part the loss of convergence of the ray beams incident to sweep action, the action of said coils and of inherent errors in the system serving to cause the ray beams to sweep in non-coincident trapezoidal patterns; and a plurality of magnets located circumferentially approximately at the apices of the rasters and longitudinally in a plane generally coextensive with the plane of the yoke, each magnet being rotatable about an axis generally parallel to the axis of the neck of the tube and each magnet being swingable from its circumferential location at the apex of the rasters in the plane of the yoke, each magnet being rotatable and swingable in relation to the tube and the other magnets to define a time-constant space-varying magnetic field operable to overcome the tendency of the ray beams to execute trapezoidal rather than rectangular rasters and further improve the coincidence of the rasters of the respective beams.

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