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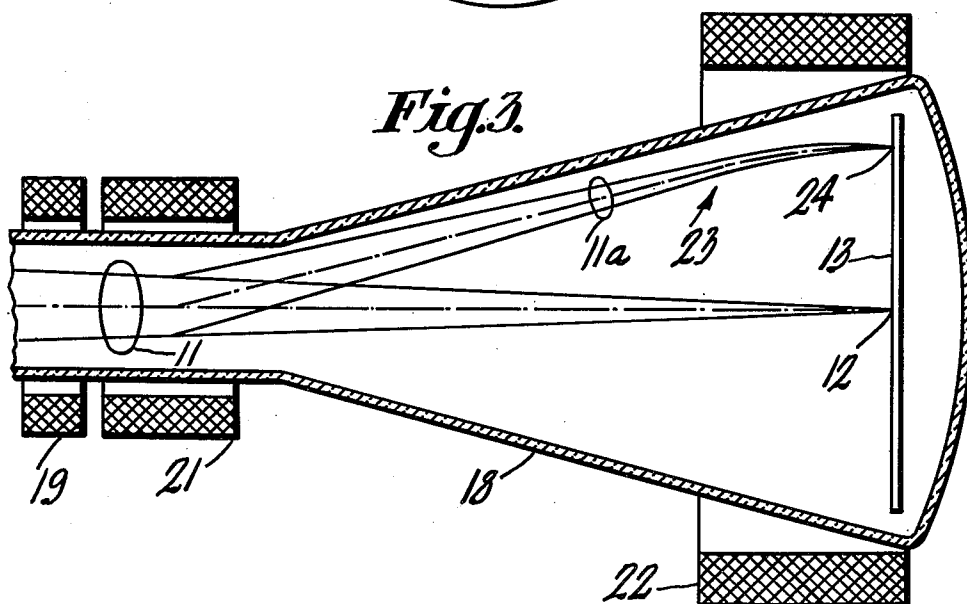
ELECTRON BEAM FOCUSING SYSTEM

Filed Oct. 31, 1950

2 Sheets-Sheet 1

Fig. 1.

Fig. 3.



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April 13, 1954

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2,675,501

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Fig. 4.

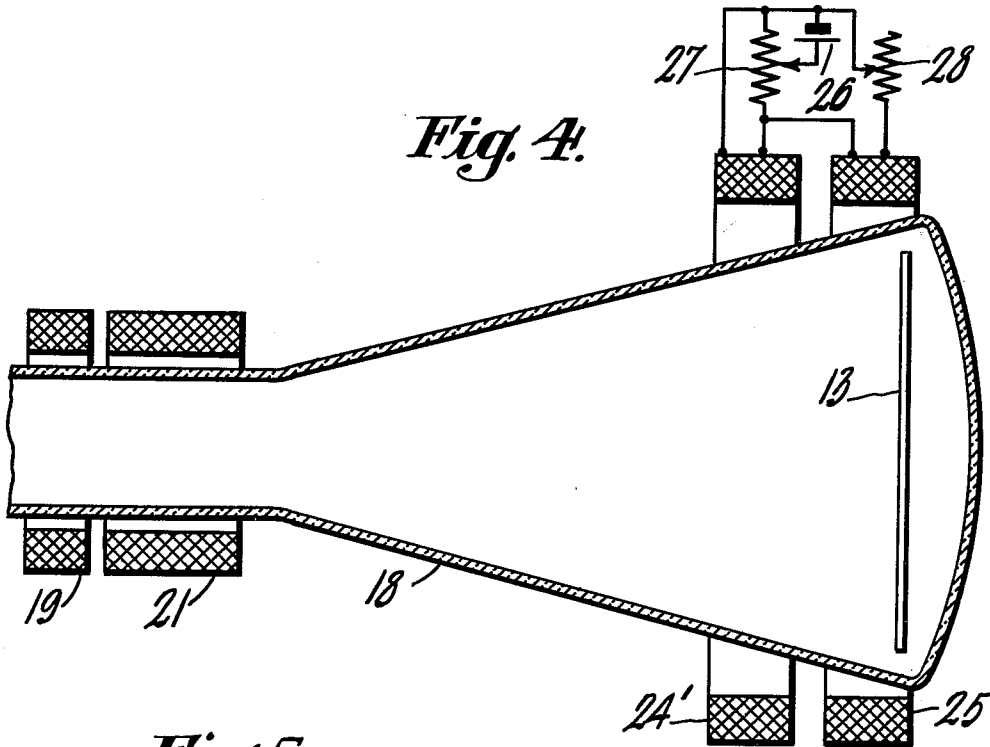


Fig. 5.

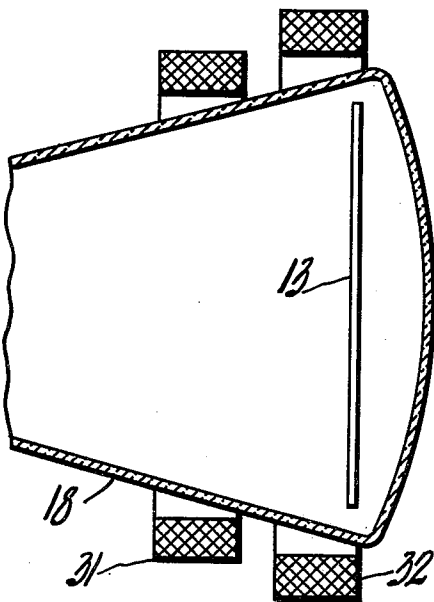
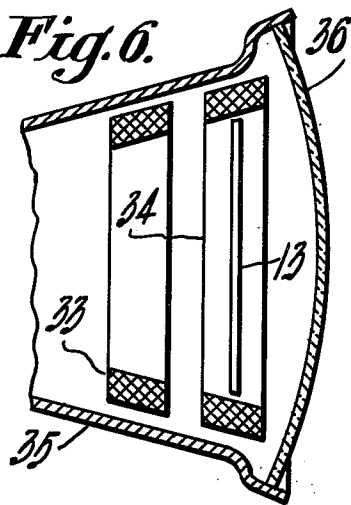


Fig. 6.



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ELECTRON BEAM FOCUSING SYSTEM

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Application October 31, 1950, Serial No. 193,205

5 Claims. (Cl. 315-27)

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This invention relates to the control of the electron beams of cathode ray tubes. More particularly, it has reference to apparatus for effecting a control of the focus of an electron beam so that the size of the scanning spot may be maintained substantially constant throughout the scanned raster and distortions of a rectangular raster may be substantially eliminated.

The use of cathode ray tubes for television and other purposes such as oscilloscopes requires that an electron beam, which may be formed by accelerating and suitably focusing electrons, be deflected to scan a predetermined raster in the plane of a target electrode. The initial focusing of the beam is effective to produce a cross-sectional area thereof of predetermined dimensions in the general region of the target electrode to be impinged by the beam. Ordinarily, where the target electrode has a somewhat concave spherical form, the cross-sectional size of the electron beam is substantially uniform throughout the entire scanned raster, particularly in cases where relatively wide deflection angles are not employed.

Where it is necessary to deflect an electron beam in a conventional manner over a substantially flat target electrode and through a relatively wide angle, the conventional focusing of the beam is not effective to maintain a uniform size of the beam cross-section throughout the entire raster scanned at the target electrode. If the pre-deflection focusing of the beam is effective to produce a cross-sectional size of the desired dimensions approximately at the center of the scanned raster, the size of this beam area in portions of the raster remote from the center is considerably greater. Particularly for television purposes, an objectionable blurring or loss of detail is produced in the corners and along the edges of the picture.

Furthermore, the adjustment of the pre-deflection focusing system so that the desired size of the beam cross-section is achieved at the center of the scanned raster may cause an objectionable distortion of the raster from the desired rectangular shape. This distortion is particularly noticeable when the beam is employed to scan a substantially flat target electrode and is generally known as "pin-cushion" distortion. The horizontal and vertical edges of the scanned raster are not straight, but instead are somewhat concave inwardly.

It is an object of the present invention, therefore, to provide an electron beam control system, whereby to maintain substantially the same focus of the electron beam in all portions of a raster

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scanned thereby in the plane of a target electrode.

Another object of the invention is to provide an auxiliary electron beam focusing system, whereby to maintain a substantially uniform size of the beam cross-section in all parts of the raster scanned thereby in the plane of a substantially flat target electrode and whereby the raster may be maintained substantially free from distortion.

Still another object of the present invention is to provide a post-deflection focusing system for an electron beam, whereby to maintain the beam in good focus in all areas of a substantially flat target electrode and whereby "pin-cushion" distortion of the scanned raster is eliminated.

In accordance with this invention the cathode ray tube is provided with a focusing system located in a region along the path of the beam after it is deflected. In a preferred form of the invention, the post-deflection focusing system is electromagnetic including a plurality of coils and surrounds the deflected path of the beam and encompasses the target electrode.

The novel features that are considered characteristic of this invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and method of operation, as well as additional objects and advantages thereof, will best be understood from the following description when read in connection with the accompanying drawings.

In the drawings:

Figure 1 is a graphical representation of the behavior of a conventionally focused electron beam as it is deflected over a substantially flat target electrode;

Figure 2 is an indication of the "pin-cushion" type of distortion effected by deflecting a conventionally focused electron beam over a substantially flat target electrode; and,

Figure 3 is a cross-sectional view of a part of a cathode ray tube showing a general embodiment of the invention.

Figure 4 is a cross-sectional view of a cathode ray tube showing another embodiment of the invention by which to prevent the possible introduction of other distortions of the raster.

Figure 5 shows still another embodiment of the invention similar in general to the form shown in Figure 4; and,

Figure 6 is a still further embodiment of the invention of the type shown in Figures 4 and 5.

Reference first will be made to Figure 1. An electron beam 11 is shown at a magnified scale. This beam conventionally is focused so that all

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electrons forming the beam converge substantially at a point 12 which is centrally located in the plane of the target 13. When the beam is deflected, by suitable means operative generally in the region 14, through relatively large angles such as the angle A, the focusing of the beam produced by the conventional systems occurs at some such point as 15. It is seen that the focus or electron convergence point 15 is considerably removed from the target 13. The electrons forming the beam, however, continue to travel toward the electrode 13 in the usual way. In so doing, the electrons cross from one side of the beam axis to the other and diverge from the axis in traveling away from the convergence point 15. Accordingly, by the time the electron beam reaches the plane of the target 13, the area 16 of the target which is impinged by the beam is considerably greater than the area at the point 12. Such a behavior of the beam, of course, prevents the reproduction of an image in as great detail at the edges as at the center.

Furthermore, the deflection through substantially wide angles over a flat electrode causes a pin-cushion distortion of the scanned raster. Figure 2 represents, for example, one side of a target electrode such as 13. The raster scanned in the manner described has a pin-cushion shape as indicated at 17. Even though in this figure the pin-cushion distortion of the raster may be somewhat exaggerated for illustrative purposes, it will be appreciated that in many practical cases, nevertheless, it may be sufficient to be objectionable in the image reproduced.

Reference now will be made to Figure 3, showing one illustrative embodiment of the present invention. Only that portion of a cathode ray tube 18 which is essential to a complete disclosure of the present invention is shown in cross-section. The electron gun by which the beam 11 is produced is assumed to be located somewhere at the left of the drawing. The electron beam is produced conventionally and directed toward the flat target electrode 13 located in the large end of the tube. In this case, electromagnetic pre-deflection focusing of the beam is effected by means of a coil 19. This coil is conventionally mounted around the outside of the neck portion of the tube along the beam path and produces a field within the tube of a character to sharply focus the beam at a point 12 centrally located on the target 13 and on the axis of the tube. Also, there is provided a conventional deflection yoke 21 surrounding the neck of the tube. This coil is assumed to be energized by the usual saw-tooth currents at horizontal and vertical scanning frequencies. Under the influence of this coil the electron beam is deflected over the target 13 in a conventional manner.

In accordance with this invention, there also is provided a post-deflection focusing system which, in this case, includes a coil 22. The post-deflection coil 22 is mounted on the outside of the tube so that it encloses a region along the path of the electron beam which is in proximity to the target 13. The coil 22 is energized by unidirectional energy (by means not shown) so as to produce a field of a character to effect the desired post-deflection focus of the electron beam. In general, this field is parallel to the axis of the tube and, therefore, is substantially perpendicular to the target electrode 13.

As the electron beam 11 enters the region in which the post-deflection focusing field is produced by the coil 22, it is influenced by this field

to follow along the magnetic field. For example, the deflected beam 11a, under the influence of the axial magnetic field produced by the coil 22, is bent in a manner such as indicated at the region 23 and follows this magnetic field until it strikes the target 13 at the point 24. The influence of this field upon the beam insures that good beam focus is maintained at all points in the scanned raster. It is seen that the incidence of the beam with the target 13 is substantially normal. This normal beam incidence at the screen produces a substantially undistorted raster. There is no pin-cushion distortion of the desired rectangular raster when employing this invention.

The coil 22 may be wound in any one of several forms, all of which will be evident to one skilled in the art. For example, it may be wound as a simple cylindrical helix. Furthermore, it is contemplated that a suitable winding distribution may be made in the coil to compensate for minor distortions of a scanning pattern without departing from the spirit of the present invention.

Another form in which the post-deflection focusing system of this invention may be embodied is shown in Figure 4. In this case, the system includes a plurality of coils such as 24' and 25. In this form of the invention, these coils are substantially cylindrical in form and have approximately the same dimensions. They are mounted in spaced relationship along the axis of the tube 18, substantially as shown. In this way the entire post-deflection focusing system encompasses the region which includes the target electrode 13 and the space in proximity thereto and located at the rear thereof.

The two coils 24' and 25 are wound and/or energized in such a manner as to produce electromagnetic fields of opposite polarity. If it be assumed that the coils 24' and 25 are similarly wound, the oppositely poled fields may be produced by suitably connecting the coils to a source of energy such as represented by the battery 26. One terminal of the energy source 26 is connected to non-corresponding terminals of the coils 24' and 25 through a current-controlling device such as a rheostat 27. The other terminals of the coils are connected to the other terminal of the energy source 26 through another current-controlling device such as a rheostat 28. The rheostat 27 is used to control the current through both of the coils. Accordingly, an adjustment of this rheostat will enable the correction of any pin-cushion distortion of the raster. The rheostat 28 is used to control the current through coil 25 only. An adjustment of this rheostat enables the adjustment of the relative strengths of the fields produced by the coils 24' and 25 for an additional purpose to be described subsequently.

By means of such an arrangement the coils 24' and 25 are effective to produce electromagnetic fields of opposite polarity. A stronger electron-optical lens may thus be produced to control the focusing of the electron beam. By reason of the fact that a stronger electron-optical lens is produced in the manner described, it is seen that the embodiment of the invention shown in Figure 4 may be more economically operated and/or may include a coil structure which is less expensive to fabricate.

The arrangement shown in Figure 4 also has the advantage that it prevents the possible introduction of another type of raster distortion incidental to the elimination of the pin-cushion type

of distortion. This other distortion is of a character to produce a twisting or skewing of the corners of the raster. In an exaggerated case, this type of distortion tends to change a straight line into one having substantially an S shape. Such a distortion of the raster tends to be produced by reason of the use of an electromagnetic field for electron beam focusing. Electrons entering such a field at an angle with the axis of the tube have, in addition to a velocity component in the direction of the field, a velocity component at right angles to the direction of the field. As is well-known in the art, an electron beam which is influenced by a field of this character tends to produce an S-distortion of a raster scanned at a target electrode. By providing at least two electromagnetic fields of opposite polarity, the tendency for the production of the described S-distortion is practically eliminated. This is particularly true where both electromagnetic fields produce substantially equal and opposite effects upon the electron beam.

The manner in which the two coils 24' and 25 operate to prevent the S-distortion of the scanned raster is substantially as follows. The fields produced by the respective coils tend to distort the corners of the raster. However, since the fields are of opposite polarity, the distortion tendencies are of opposite senses. Since the two coils 24' and 25 produce their respective fields in different regions along the path of the electron beam, it is necessary that the relative strengths of the fields be somewhat different, in order that the distortion effects produced thereby may be made to nullify one another. In general, the field produced by the coil 24' is required to be somewhat stronger than the field produced by the coil 25. In this case, where the two coils are substantially similar and have the same number of turns, the field produced by the coil 25 may be made somewhat weaker than the field produced by the coil 24' by means of the rheostat 28. A suitable adjustment of this rheostat enables the production of a proper balance between the energizing currents for the two coils so that the electromagnetic fields produced by the respective coils have substantially equal and opposite effects upon the electron beam.

It is to be especially noted that the coils 24' and 25, operating together, perform the functions of (1) maintaining the electron beam in focus at all points in the plane of the target electrode 13, (2) correcting any pin-cushion distortion of the scanned raster and (3) preventing the introduction of any S-distortion of the raster. The fields produced by the coils 24' and 25 produce additive corrections of the pin-cushion distortion and, at the same time, produce subtractive rotations of the outer portions of the raster with respect to its center.

In Figure 5 there is represented still another embodiment of the invention. As in the form of the invention shown in Figure 4, the present post-deflection focusing system comprises a pair of coils 31 and 32. These coils are spaced apart along the axis of the tube and are cylindrical in form but of somewhat different sizes. The internal diameters of the coils 31 and 32 may be made to conform substantially to the diameters of the largest cross-section of the tube 18 which is to be encompassed by the respective coils. Since the tube has a generally conical shape, the coil 31 has a somewhat smaller diameter than the coil 32. These coils also may be energized in a manner similar to that shown in Fig-

ure 4, whereby to produce electromagnetic fields of opposite polarity and of different intensity.

Still another form of the invention is shown in Figure 6. The post-deflection focusing system, in this case, comprises a pair of coils 33 and 34 mounted on the inside of the tube envelope which is the type having a metallic conical section 35. Even though many of the cathode ray tubes presently employed have metallic conical envelopes of materials which may not be strongly magnetic, it may be desirable to mount the post-deflection coil system inside of the tube envelope. In this way, the metallic portion of the tube envelope will have no shielding effect upon the fields produced by the coils. In the present case, the coils are generally frusto-conical in shape so as to conform to the shape of the tube envelope. They also are spaced along the axis of the tube. By reason of the particular shapes of the coils 33 and 34, they are necessarily of different dimensions. Preferably they are operated substantially in the same manner as the coils of Figure 4 so as to produce electromagnetic fields of suitable relative strength to effect the desired control of the electron beam.

The disclosed embodiments of the invention are intended primarily for illustrative purposes. It is not intended that they be considered as necessarily limiting or restrictive in any sense. The presently disclosed forms of the invention may be used singly, as disclosed, or parts of one may be used interchangeably with parts of another embodiment. For example, in the case of a cathode ray tube having a metal cone, such as shown in Figure 6, and in which the target electrode or screen is mounted on the inner wall of the tube face 36, one of the coils such as the coil 33 may be mounted inside of the tube envelope behind the target electrode, substantially as shown and described. The other coil corresponding to the coil 34 may be mounted outside of the tube in such a manner such as to encompass the target electrode.

The present invention has the advantage of enabling the scanning of a raster at a substantially flat target electrode by means of an electron beam which is deflected through relatively wide angles without the electron beam losing focus in any part of the raster and without producing any substantial distortion of a rectangular raster. The invention also has the further advantage of permitting a simplification in the fabrication and operation of the deflecting yoke for tubes of the character described. Heretofore, it has been necessary to distribute the windings of an electron beam deflection yoke in a non-uniform manner in order to avoid imparting to the raster scanned by the beam in objectionable pin-cushion distortion. However, in winding yokes so as to correct for pin-cushion raster distortion, the effect upon the electron beam is such that it may be considerably out of focus in the corners of the raster. Accordingly, it may be seen from the foregoing disclosure of the present invention that deflection yokes need no longer be designed to correct for pin-cushion distortion. A simplification of the deflection yoke manufacture may thus be effected.

The nature of this invention is indicated in the foregoing disclosure of several illustrative embodiments thereof. The scope of the invention is set forth in the following claims.

What is claimed is:

1. A system for controlling an electron beam which is directed toward a target electrode com-

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prising, means located along the path of the beam at a point remote from said target electrode for producing a substantially constant field by which to focus said beam at a predetermined point in the plane of said target electrode, means located along the path of said beam at a point less remote from said target electrode for producing a varying field by which to deflect the beam to scan a raster in the plane of said target electrode, and means including a plurality of coils located along the path of the beam in proximity to said target electrode for producing respective component fields jointly constituting a substantially constant field by which to effect focusing of said beam at all points of the raster scanned in the plane of the target electrode, said two constant fields being effectively independent of one another.

2. An electron beam control system as defined in claim 1 wherein, said plurality of coils are effective to produce respective electromagnetic fields of different polarities.

3. An electron beam control system as defined in claim 1 wherein, said last-named means is a pair of coils mounted along the axis of said tube in spaced relationship to one another, said coils having substantially the same dimensions and being energized in a manner to produce electromagnetic fields of opposite polarity.

4. An electron beam control system as defined in claim 1 wherein, said last-named means is a

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pair of coils mounted along the axis of said tube in spaced relationship to one another, each of said coils being of cylindrical form and having different inside dimensions corresponding substantially to the dimensions of the adjacent respective tube cross-sections, and said coils being energized in a manner to produce electromagnetic fields of opposite polarity.

5. An electron beam control system as defined in claim 1 wherein, said last-named means is a pair of coils mounted along the axis of said tube in spaced relationship to one another, each of said coils having a frusto-conical form and having different inside dimensions corresponding substantially to the dimensions of the adjacent respective tube cross-sections, and said pair of coils being energized in a manner to produce electromagnetic fields of opposite polarity.

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