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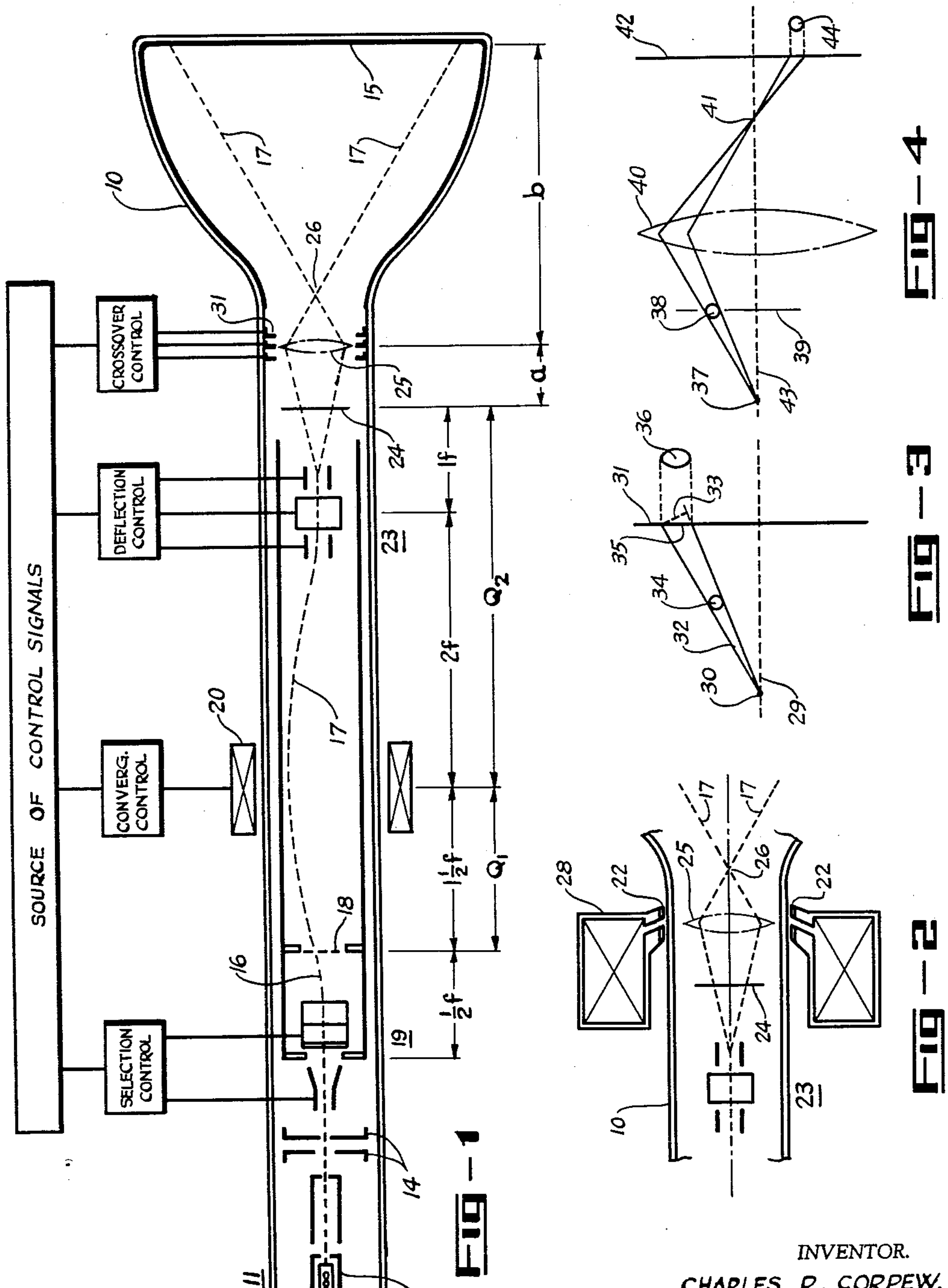

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LENS DEFLECTION IN THE ELECTRO OPTICAL SYSTEM OF A CATHODE RAY TUBE

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This invention relates to lens deflection in the electro optical system of a cathode ray tube and more particularly, to the use of an electronic lens in the deflection part of the electro optical system.

In many applications of cathode ray tube use, the size of the tube and its neck extension is determined by the final angle of deflection of the electron beam necessary to illuminate the greatest possible area upon the screen of the tube. That is, if the neck of the tube is relatively short, the deflection angles are required to be large. If the neck is rather long, these deflection angles can become somewhat smaller. As the electron beam increases in speed on its path toward the screen, it becomes more difficult to deflect accurately toward or away from the tube's axis. Therefore, considerable power requirements are normally needed to terminally deflect the beam at wide angles of deflection. The use of large amounts of power to obtain wide angles of deflection in the final deflection means presents problems of considerable magnitude and especially so where rapid deflections in the beam are desired.

These problems arise whether electromagnetic or electrostatic deflection is used. However, the situation that generally manifests the problem is when large electromagnetic coils having large control currents are used in finally deflecting the electron beam. The rapid fluctuations in the control current necessary for quick deflection of the beam creates a condition capable of permanently damaging the coils. Further, the time constant of large magnetic coils is normally too long to permit the desired rapid changes in wide angle deflections of the beam. When electrostatic means is used for final deflection of the beam, the large voltage differentials required to give wide angle deflection causes distortion of the beam to be excessive.

Another problem encountered in deflecting the beam from the axis of the electro optical system, is that it is necessary that the electron beam not have its cross section distorted. Therefore, when using electrostatic or electromagnetic deflection means, great care is required in placing the beam at the electrical center of the final deflection means. However, even at that, the cross section of electron beams deflected to maximum angles of a general bulb configuration will cause cross sectional distortion.

The present invention improves considerably the aforesaid difficulties by utilizing an additional electron lens placed generally in the area of intersection of the neck of the tube and the bulb portion. This effects a cross over the electron beams immediately in front of the lens and permits wide angle focusing of the beam on the screen. Thus, the final deflection means is required to provide only small deflections of the beam to the lens, and accordingly, permits smaller control currents or potentials to be used. The electronic lens is capable of seeing a shaped image, in accordance with its deflection by the final deflection means, and to focus the image on the screen with a deflection dependent upon the deflection of the image and the focal length of the electron lens. Thus, very wide deflections of the beam are obtainable commensurate with the use of a short focal length electronic lens. Inasmuch as the control potential to the electronic lens is steady state, it is readily apparent that large deflection angles can be obtained without requiring the use of large fluctuating potentials or currents. Hence, the invention obviates the problem of the required use of large potentials or currents to obtain wide deflection angles, and further permits the beams to be deflected to any angle including the maximum angle of deflection without distortion of the beams cross section. The invention may also be utilized to provide added flexibility in the control of the beam as the properties of an electron lens can be variably controlled through variations in its control potential or current, as is well known in the art.

This invention is of particular value in the optical system of shaped beam tubes. Shaped beam tubes are those series of tubes in which an electron beam is shaped into a particular configuration by a stencil like cutout portion of a matrix. The cross section of the electron beam, being in that configuration, must then be deflected at various points in the tube toward or away from the optical axis of the tube. In its travel, the beam is subject, in many of these deflections, to slight distortions. Therefore, when a shaped beam, such as disclosed herein, is normally deflected to maximum angles by known final deflection means, distortions do occur at the greater deflection angles. The introduction of an additional lens system as exemplified by the present invention at or about the juncture of the neck of the bulb of the tube, will permit maximum deflection through the lens system by effecting short focal length cross over immediately in front of the lens. This permits presentation of a cross sectional beam image upon the screen, having a reduced distortion while still having wide angle deflection. Also, it is possible through use of this invention to effectively shorten the overall length of the cathode ray tube, as will be more readily apparent from the following description:

In addition to any objects and advantages aforestated, it is an object of the present invention to facilitate the use of a shortened cathode ray tube by utilizing an improved system of providing wide angle deflection of the electron beam.

Another object of this invention is to provide a cathode ray tube capable of deflecting an electron beam through maximum final deflection angles in a substantially distortionless manner.

A further object of this invention is to provide a cathode ray tube capable of providing wide angle deflection of an electron beam through the use of an electronic lens.

Still another object of the present invention is to permit substantial reduction in the deflection angle normally necessitated by the final deflection system through the use of a lens capable of providing short cross over of the electron beam to permit a wide range of substantially distortionless deflection of the beam to maximum deflection angles permitted by screen size and bulb configuration.

Still a further object of the present invention is to provide a cathode ray tube capable of focusing an image of the cross section of the electron beam through a maximum desired final deflection angle, which cross sectional image is presented upon the screen substantially free of any distortions resulting from such final deflection.

Objects and advantages other than those set forth above will be apparent when read in connection with the accompanying specification and drawings, in which:

FIGURE 1 is the schematic view of a cathode ray tube embodying the instant invention;

FIGURE 2 is a view in detail of another embodiment of the invention in which electromagnetic lensing means are utilized;

FIGURE 3 is a schematic representation of a disadvantage encountered in prior art wide angle deflection systems;

FIGURE 4 is a schematic representation of how the invention provides wide angle deflection with substantially no distortion.

Shown in FIGURE 1 is a shaped beam tube having an evacuated envelope **10**. Positioned at one end of the envelope **10** is a beam generating and projecting means **11** capable of projecting an electron beam **16** substantially along the longitudinal axis of the tube **10**. A conventional electron generating cathode **13**, along with desired accelerating and focusing anodes **14**, may be included in the beam generating means **11**. A target **15**, such as a phosphor screen, may be positioned at the other end of the tube **10** for electron to light conversion of the information to be displayed by a shaped electron beam **17**.

In brief, the operation of the tube is as follows. An electron beam is projected by the projecting means **11** to electrostatic selection plates **19**, which select which character in matrix **18** the beam will contact causing a distinctively shaped beam **17**. The path of travel of beam **17** is redirected by convergence coil **20** so that its path is substantially along the longitudinal axis of the tube. Also, coil **20** focuses the shaped character of the beam to an image in a two dimensional image zone **24**. Positioning means, including final deflection means **23** and lens **25**, positions the beam on the screen. Final deflection means **23** deflects the shaped beam to a desired point in lens **25** thus, placing the imaged character at a predetermined point along the image line **24**. Lens **25** sees the shaped character of the beam at its point along the image line **24**, and images the character in focus on screen **15**. Since lens **25** has a short focal length and is of the convergence type, it crosses over the beam at a point **26** close to the lens and provides wide deflection of the beam to the screen.

In a more detailed description of the invention with reference to FIGURE 1, the electron beam **16** may be shaped into a predetermined character cross section or configuration by a beam shaping member **18** positioned along the axis intermediate target **15** and beam generating means **11**, resulting in the shaped electron beam **17**. Shaped electron beam **17** acquires the cross sectional shape imparted to the beam **16** by a stencil like opening or object in beam shaping member **18**. A selection deflection means **19**, which may be of the electromagnetic or electrostatic construction, is shown in the exemplification as two pairs of electrostatic deflection plates placed in quadrature with each other. The selection deflection means **19** is capable of deflecting beam **16** to the desired character of shaping member **18**. This illuminates the character object opening or portion of the beam shaping member **18**, thus, giving the desired shaped beam **17**.

Convergence means **20**, which may be of an electrostatic or electromagnetic construction, is shown in the instant exemplification as electromagnetic and is utilized to effect a converging of the divergent electron beam **17** to the longitudinal axis of the tube. Along with its convergence effect, converging means **20** effects substantially simultaneously a focusing action of the shaped beam **17**, whereby the character illuminated in the beam shaping member **18** is imaged at a desired imaging point **24**. Convergence means **20**, therefore, effects a redirection of the divergent shaped electron beam **17** and presents the beam **17** on a path converging with the longitudinal axis to the final deflection means **23**. The final deflection means serves to deflect the beam to the electron convergence lens **25** and comprises electrostatic plates which may have horizontal plates split into two portions permitting deflection of the beam in a manner as illustrated and described in United States Patent No. 2,811,668, issued October 29, 1957, to Joseph T. McNaney and assigned to the same assignee as the present application. This electrostatic plate arrangement permits deflection of the electron beam **17** to lens **25** in substantially a distortion free manner, even though beam **17** in its path from convergence means **20** may not be moving in a direction exactly parallel with the longitudinal axis of the tube, at the time of entering deflection control unit **23**. The amount of deflection applied to the beam by deflection means **23** is dependent upon the predetermined signals received from the deflection control unit, which generally establishes a deflection commensurate with that required to deflect the beam to a point in the electron lens **25** giving the desired cross over of the beam to the screen.

Lens action **25** is illustrated in phantom in FIGURE 1. This lens action is created by electrostatic lens **31**, which is illustrated as a three-element Einzel lens. FIGURE 2 illustrates a sectional view of FIGURE 1, wherein an electromagnetic focusing coil **28** is used. The coil is characterized by having its gap made very small and brought as close to the axis of the tube as possible by pole pieces **22**. The particular types of electrostatic and electromagnetic focusing means illustrated in FIGURES 1 and 2 are disclosed only for purposes of this specific embodiment. It is to be understood that any type of electronic lens, capable of providing a thin lens action, may be used. Both of the electrostatic and electromagnetic lens illustrated are well known in the art. Generally, the electrostatic type lens is preferred over electromagnetic as their power requirements are smaller and the field they generate is capable of being adequately controlled free of interference with the adjoining fields. While lens **25** is normally controlled by steady state current or voltage, application of independently variable control voltages or currents to the lens **25** will permit independent variation of the imaging distance and the cross sectional size of beam **17**, as will be explained in greater detail later.

Lens **25** serves to focus image **24** in an inverted display on screen **15** having an increased magnification. Thus, lens **25** must be positioned in correct distance relationship with respect to image **24** and screen **15**, thereby permitting image **24** to be focused onto screen **15**. As lens **25** serves merely to re-image, image **24** on screen **15**, it is apparent that the shorter the focal length of lens **25**, the closer cross over point **26** will be to lens **25** and accordingly, the wider the angle of deflection of shaped beam **17** to the screen and the shorter the overall length of the tube.

In the operation of shaped beam tubes, the shaped beam image is normally focused on screen **15** by the convergence lens **20**. However, in the present invention, it is required that an image be focused at point **24** rather than on screen **15**, therefore, new distance relationships must be established between the various components of the tube to permit an image to be focused at image point **24**. As shown in FIGURE 1, the established distance, for the specific embodiment illustrated, between selection means **19** and deflection means **23** is four focal lengths. The center of convergence lens **20** being positioned equidistant (two focal lengths) between deflection control unit **23** and deflection control unit **19**. The matrix is set ½ focal length from selection control **19** and 1½ focal lengths from convergence lens **20**. The latter 1½ focal lengths being the object distance Q_1. By the application of well known image optical formulas, it may be established that with this relationship, the image distance Q_2 will be three focal lengths from the center of convergence lens **20**. These parameters, for the specific embodiment, provide that the image **24** will be twice the size of the characters in matrix **18**. This image size at image point **24** may be varied as desired by changing the ratio of Q_1 to Q_2 or the object distance to the imaged distance. It is generally desired that the image size of image **24** be small in view of the high magnification of the thin lens element **25**.

The magnification of shaped beam **17** by thin lens **25** depends upon the ratio of the object to lens distance a to the lens to image distance b. Thus, if distance a is 1 and distance b is 5, the magnification provided by lens **25** will then be 5, and the shaped beam character **17** illustrated on the screen **15** will be 5 times the size of the character imaged at point **24**. Thus, if the image **24** is twice the size of the matrix characters at matrix **18**, then the final image on the screen **15** will be ten times the size of the matrix character of the matrix **18**. The magnification of lens **25** may be varied by varying the control current or potential to coil **28** or electrostatic lens **31** in FIGURE 2. However, if the magnification of lens **25** is varied, then it will generally be desirable that the electromagnetic coil **28** or electrostatic lens **31** be moved axially within the tube thereby realigning the ratio of the image to object distance *a* and *b* and permitting focusing of the beam under the new conditions. This provides flexibility in varying the size of the image on the screen as well as its degree of wide angle deflection.

The ability of the electron lens arrangement to provide substantially distortion free focusing of image **24** on screen **15**, even though wide angle deflection of the beam is obtained, may be attributed to several reasons. One of which is that electrostatic or electromagnetic deflection apparatus do not have completely uniform fields and this is especially so when the field intensity is large. Therefore, when wide angle deflection is obtained by electrostatic or electromagnetic deflection means alone, high intensity fields are required which increases the distortion of the beam. With smaller angles of deflection, however, there is less distortion of the beam. This invention requires that the beam be deflected only a small amount to lens **25**, thereby presenting an image **24** to lens **25** that is relatively free of distortion.

FIGURES 3 and 4 illustrate diagrammatically the ability exhibited by electronic lens **25** in focusing image **24** onto the screen at wide angles with substantially no distortion. With respect to FIGURE 3 which discloses the prior art method of providing wide angle deflection, the beam is deflected from the longitudinal axis **29** of a tube to the screen represented by line **31** from a point **30** in the final deflection means. The beam **32** is in the shape of a circle **34** and will strike the screen **31** at point **35** at the angle as shown. This angular striking of the beam against screen **31** gives an oval image **36**. Dotted line **33** represents where the line of contact with the screen would have to be to cause a completely circular beam to be illustrated. FIGURE 4 shows how the shaped beam is illustrated in true representation on the screen through the use of a thin lens as is illustrative of this invention. The beam is deflected from the longitudinal axis **43** at point **37** by a deflection means. The beam has the shape of a circle **38**, and is deflected to the point of convergence of lens **40**. The beam forms an image **39** which is picked up by lens **40** crossed over at point **41** and illustrated on screen **42** as a distortion-free circle **44**. This follows because the lens merely re-images the image **39** onto screen **42**. Therefore, since circle **38** is a part of image **39**, it is focused onto screen **42** without distortion regardless of the fact that screen **42** receives the beam **41** at an angle.

Lens **25** is also capable of providing an added control of the beam supplementary to convergence coil **20**, thus, the length of the tube is not determinative by the distance required by coil **20** to focus an image upon screen **15**.

The particular embodiment of the invention illustrated and described herein is illustrative only and the invention includes such other modifications and equivalents as may readily appear to those skilled in the art, within the scope of the appended claims.

I claim:

1. A shaped beam cathode ray tube capable of producing undistorted large size presentations without using large deflection angles, or powerful deflecting circuitry and power-consuming deflection systems, comprising: an evacuated cathode ray tube envelope having a faceplate; means, positioned in said tube, for producing an electron

stream; a matrix having character-shaped apertures, positioned in the path of said electron stream; means for directing said electron stream toward selected portions of said matrix—whereby electrons traversing said apertures emerge as a shaped electron beam whose cross section corresponds to the shape of said traversed aperture; electron optical means for converging said shaped electron beam at a crossover point and forming an image of said character-shaped apertures in an image plane; means, comprising a low-powered, small-angle deflection system positioned to straddle said crossover point, for causing the image of selected character-shaped apertures to be selectively positioned in said image plane to form a display; and means, comprising a fixed-strength symmetrical electron lens positioned between said deflection system and said faceplate, for converting said display in said image plane into a larger presentation on said faceplate.

2. A shaped beam cathode ray tube capable of producing undistorted large size presentations without using large deflection angles or powerful deflecting circuitry and power consuming deflection systems comprising: an evacuated cathode ray tube envelope having a faceplate; means for producing a shaped electron beam; electron optical means for converging said shaped electron beam at a crossover point and forming an image in an image plane; means, comprising a low-powered, small-angle deflection system positioned to straddle said crossover point, for causing the image produced by said shaped electron beam to be selectively positioned in said image plane—whereby selected said images form a display in said image plane; and electron lens means, positioned between said deflection system and said faceplate, for converting said display on said image plane into a large presentation on said faceplate.

3. A shaped beam cathode ray tube capable of producing undistorted large size presentations without using large deflection angles or powerful deflecting circuitry and power consuming deflection systems comprising: an evacuated cathode ray tube envelope having a faceplate; means for producing an electron beam; electron optical means for converging said electron beam at a crossover point; means, comprising a low-powered, small-angle deflection system, for causing said electron beam to produce a display in an image plane; and electron lens means, positioned between said deflection system and said faceplate, for converting said display in said image plane into a large presentation on said faceplate.

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