

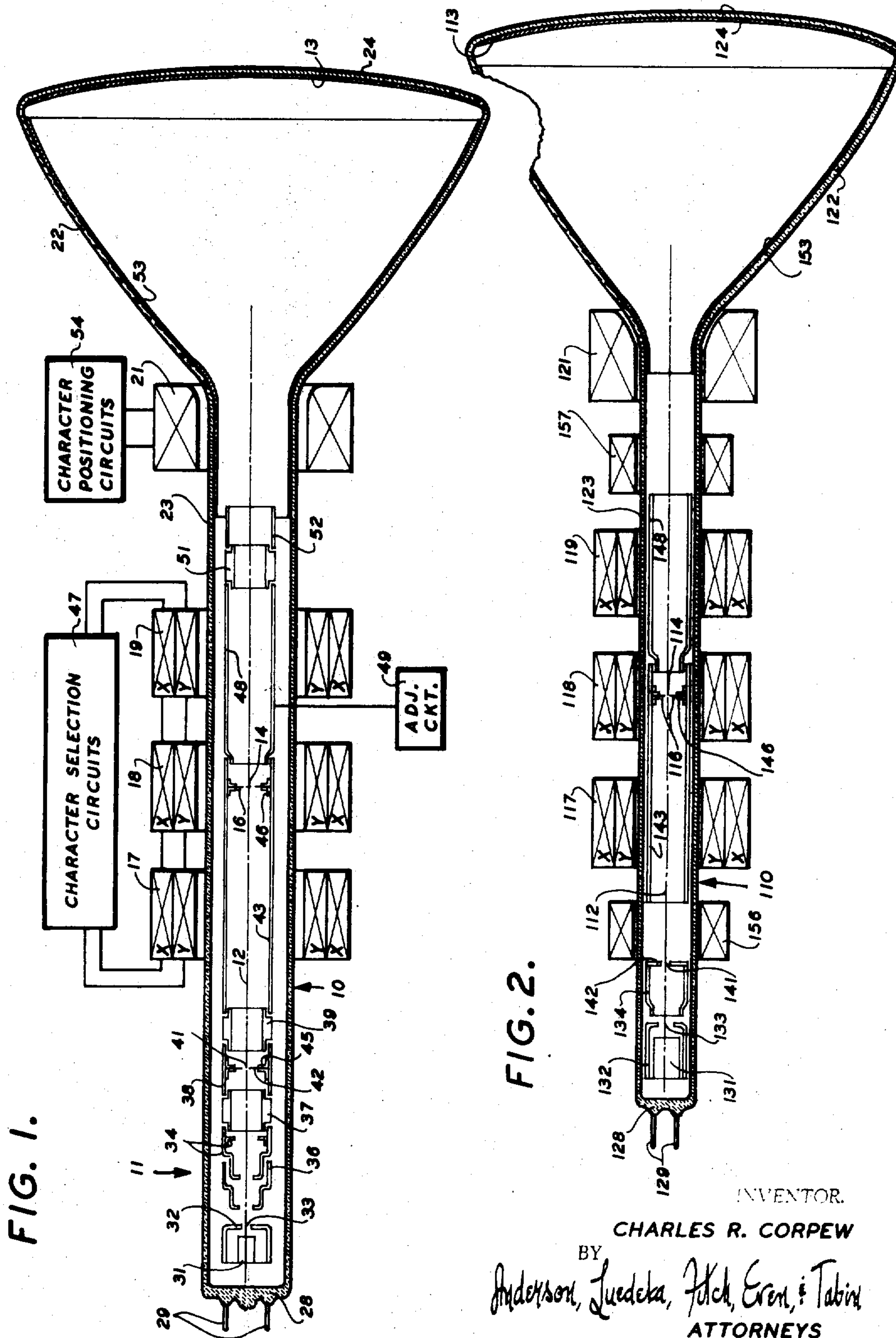
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C. R. CORPEW

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SHAPED BEAM CATHODE RAY TUBE

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1

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Charles Robert Corpew, La Mesa, Calif., assignor to
Stromberg-Carlson Corporation, Rochester, N.Y.,
a corporation of Delaware

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ABSTRACT OF THE DISCLOSURE

A cathode ray tube of the shaped beam type is described. The tube includes an electron beam gun, a target screen and an apertured stencil. Aperture selection, beam convergence and beam realignment are accomplished by three electromagnetic deflection yokes positioned along the tube in a substantially unipotential region thereof.

This invention relates to cathode ray tubes and, more particularly, to an improved cathode ray tube of the shaped beam type.

Cathode ray tubes of the shaped beam type are used for generating alphanumeric characters, line segments of graphs and charts, and similar configurations. In cathode ray tubes of the shaped beam type, one or more electron beams are shaped as they pass from an electron gun to a target such that the resulting cross section of each shaped beam is of predetermined configuration. At the target which, for example, may be a phosphor coated screen, an area is energized or illuminated corresponding in shape to the shape of the beam. The target may be constructed, for example, to provide a visible display for direct observation or for photographing onto film, such as microfilm. The display may also be utilized in connection with printing apparatus, such as an electrostatic printer.

The desired beam cross sectional configuration is attained by passing the beam through one of a plurality of shaping apertures in an electron opaque plate or stencil disposed perpendicularly with respect to the initial axial path of the beam. The apertures usually are distributed on the stencil in the form of a matrix, the electron beam being deflected from its initial axial path to pass through the selected aperture. After passing through the aperture, the beam is then redirected to the axis at a crossover point. In addition, the beam is generally focused, at some convenient point after passing through the aperture, to provide for sharp imaging on the target. The beam is then deflected to a predetermined position on the target by an electromagnetic deflection yoke or similar means. The various elements which accomplish the directing and focusing of the electron beam may be disposed inside or outside of the cathode ray tube envelope. As used in this specification and claims, the term "cathode ray tube" is intended to include associated elements disposed either inside or outside of the tube envelope.

Should the beam be off axis or of large cross sectional area at the point of final deflection to a position on the target, the deflection usually causes undue distortion of the character on the target, thereby rendering such character partially or totally unintelligible.

It is therefore desirable that the beam be redirected from its initial deviating path from the tube axis back toward the axis to cross the axis near the point of final deflection. To do this, previously known systems have generally utilized a convergence lens. The convergence lens, which may either electrostatic or electromagnetic, not only redirects the electron beam to the convergence or crossover point on the axis but, in addition, effects lens action upon the beam to focus the beam to a minimal cross sectional area at the crossover point. The beam is

2

then redirected along the axis by a suitable reference deflection system. A cathode ray tube of the foregoing described type is shown and described in U.S. Patent No. 2,824,250, assigned to the assignee of the present invention.

In order to minimize distortion, convergence lenses in shaped beam tubes of the type described have heretofore been made relatively large. This is because, under most conditions, only a small portion near the center or electro-optical axis of an electrostatic or electromagnetic focusing field is of sufficient uniformity to avoid distortion. Although relatively large diameter convergence lenses are perfectly satisfactory in many cases, and have been successfully applied in many shaped beam tubes where wide beam deviations are desired, relatively large diameter convergence lenses may be undesirable under some conditions. Reduction of convergence lens size, however, many introduce undesired focusing aberrations unless the beam deviation is reduced. This limitation on the amount of deviation of the beam from the axis may result in a corresponding limitation in matrix size, thus limiting the number of apertures which may be used.

Accordingly, it is an object of this invention to provide an improved cathode ray tube of the shaped beam type.

Another object of the invention is to provide a shaped beam tube wherein a relatively wide beam deviation may be achieved without introducing focusing aberrations.

A further object of the invention is to provide a shaped beam tube wherein all focusing of the electron beam is accomplished on the electro-optical axis of the focusing fields.

Other objects of the invention will become apparent to those skilled in the art from the following description, taken in connection with the accompanying drawings wherein:

FIGURE 1 is a schematic sectional view of a cathode ray tube constructed in accordance with the invention; and

FIGURE 2 is a schematic sectional view of an alternative embodiment of the invention.

Very generally, the cathode ray tube of the invention comprises an elongated envelope 10 having at one end therein an electron gun 11 for producing an electron beam aligned on an electro-optical axis 12. A target or screen 13 is provided at the other end of the envelope 10 and a stencil 14 is disposed between the electron beam gun and the screen. The stencil has a plurality of apertures 16 therein for shaping the electron beam cross section, each aperture producing a predetermined shape. A first deflection yoke 17 is positioned between the electron gun and the stencil for deflecting the electron beam from the electro-optical axis to select one of the apertures. A second deflection yoke 18 is positioned at the stencil for deflecting the electron beam in a path convergent with the electro-optical axis. A third deflection yoke 19 is positioned between the stencil and the screen for deflecting the electron beam from the convergent path to a path coincident with the electro-optical axis. A fourth deflection yoke 21 is positioned between the third deflection yoke and the screen for deflecting the electron beam to impinge on a predetermined area of the screen.

Referring now more particularly to FIGURE 1, the cathode ray tube of the invention includes the envelope 10, which may be made of glass, having an enlarged bell-shaped or generally frustoconical section 22 and a long slender neck section 23 appended thereto. For purposes of description, the end of the tube toward the right in the drawings is referred to as the front end and the other or left end in the drawings is referred to as the rear end. The generally frustoconical section 22 of the glass envelope is provided with a face plate 24, and the target or screen 13, of a suitable phosphor or electro-

luminescent material, is deposited on the inside of the face plate 24. Energization of areas on the screen 13 by the electron beam, as will be explained, may be utilized for visual readout, photography, electrostatic printing, or other analogous processes.

The rear end of the neck section 23 is provided with a glass end cap 28 through which suitable electrical connectors 29 extend in a sealed relationship thereto. Electrical leads, not illustrated, extend from the connectors to the various internal elements of the tube for maintaining potentials thereon, as will be described. Some of the connectors 29 are also utilized to supply a heating current for the filament, not illustrated, inside the cathode described below.

The electron beam gun 11 is disposed at the rear end of the neck section 23 and includes a cup-shaped cathode 31 coated with electron emissive material, such as barium oxide, on the exterior surface of its closed end. The cathode is supported by suitable means, not shown, on the electro-optical axis 12 of the tube. A heater wire or filament, not illustrated, positioned inside the cathode cup 31, raises the temperature of the cathode and causes emission of electrons from the coated closed end surface. A cup shaped control electrode 32 is positioned coaxially about the cathode and is supported by means, not shown, so that an aperture 33 therein is positioned along the axis 12. By applying suitable potentials to the control electrode 32, the electron beam may be turned on or shut off as desired. With the control electrode slightly negative with respect to the cathode 31, for example -10 volts, an electron beam passes through the aperture 33. This beam is accelerated by a suitable positive potential on a generally cylindrical accelerating electrode or first anode 34 disposed in the neck section in front of the control electrode.

A generally cylindrical focusing electrode 36 is provided inside the neck section 23 before the first anode, and two cylindrical electrodes 37 and 38 are provided after the first anode. The electrodes 36, 37 and 38, together with the first anode 34, are suitably supported in axial alignment and are maintained at appropriate potentials to form a series of convergent electrostatic lenses. These lenses focus the electron beam so that its cross sectional area is slightly larger than the cross sectional area of a trim aperture 41 provided in an electron opaque trim aperture plate 42. The plate 42 is supported within the electrode 38 in a generally cylindrical plate support member 45. The electron beam, as it leaves the aperture 41, has a cross section conforming to the shape of the aperture cross section, and is desirably square or rectangular.

The rectangular or square electron beam is then focused by a pair of electrostatic lenses established between the forwardmost focusing electrode 38 and another cylindrical focusing electrode 39 and between the latter mentioned focusing electrode 39 and still another cylindrical electrode or second anode 43. The electrodes 39 and 43 are supported in axial alignment by suitable means, not shown. The focusing action is such that the beam cross section at the electron opaque plate or stencil 14 is slightly greater than the area occupied by one of a plurality of apertures 16 in the stencil. In this manner, the beam will flood the entire aperture at which it is directed and emerge on the other side of the stencil 14, having a cross section conforming to the shape of the aperture in the stencil through which it passed. The stencil 14, which may be of conventional construction, is supported perpendicularly to the beam axis 12 by an annular stencil support structure 46 positioned within the second anode 43.

In order to cause deviation of the electron beam from the axis 12 to select a predetermined aperture 16, and to return the beam to its former axial path, the three deflection yokes 17, 18 and 19 are provided. The deflection yokes are supported externally of the neck section 23 by means, not shown, so that the yokes 17, 18 and 19

are respectively disposed rearward of, at, and forward of the stencil 14, the rearward and forward yokes 17 and 19 being equally spaced from the center yoke 18. Each deflection yoke 17, 18 and 19 is provided with an X deflection winding and a Y deflection winding, schematically illustrated, as is well known in the art. Suitable currents supplied to the X and Y windings of each deflection yoke determine the amount of deflection of the electron beam as it passes through the magnetic fields established by the yokes. Such currents are provided, in the illustrated embodiment, by suitable character selection circuits, indicated generally at 47. Although the character selection circuits may include separate amplifiers for driving each of the X and Y windings in each yoke, a substantial saving in cost may be achieved by connecting the X windings of the yokes 17, 18 and 19 in series such that they may be driven by a single amplifier. Similarly, the Y windings of the yokes 17, 18 and 19 are also connected in series to be driven by a single amplifier. The X windings in the yokes 17 and 19 are identically wound, whereas the X winding in the yoke 18 is wound oppositely. Similarly, the Y windings in the yokes 17 and 19 are identically wound whereas the Y winding in the yoke 18 is wound oppositely.

The magnetic field established by the currents in the rearward deflection yoke 17 causes the electron beam within the magnetic field of the yoke to deflect from its axial path. Application of the proper currents causes the beam to select any one of the character apertures 16 in the stencil 14.

After passing through the selected aperture in the stencil 14, the beam is turned from its divergent path back toward the electro-optical axis 12 of the tube by the magnetic field established by the center yoke 18. In the illustrated configuration, such turning or deflection occurs both before and after the beam passes through an aperture in the stencil, since the stencil is at about the midpoint of the second yoke's field. If desired, however, the second yoke may be shifted to a position on either side of the stencil to provide all deflection of the beam either before or after it passes through an aperture.

The angle through which the beam is deflected by the center yoke 18 is nominally twice the deflection angle imparted by the rearward yoke 17, and is in the opposite direction. Since in series connected yokes the current is the same in each yoke, the yoke 18 is provided either with twice the number of turns on its coils, or with twice the axial length of yoke 17, to give it twice the deflection sensitivity. The field of the yoke 18 is made opposite in direction either by winding its coils in the opposite sense or by crossing the connecting wires between the yoke 17 and the yoke 18. The correction provided to the beam by the center deflection yoke 18 is sufficient to cause the beam to intersect the axis 12 at about the center of the forward yoke 19.

The forward deflection yoke 19 operates to deflect the electron beam an amount sufficient to cause it to be coaxial, once again, with the electro-optical axis 12 of the tube. Since the windings in the forward deflection yoke 19 are identical with the windings in the rearward deflection yoke 17, the direction of deflection is the same. The amount of current flowing in the forward yoke 19 is also identical to that flowing in the rearward yoke 17 and, consequently, the amount of correction is just sufficient to compensate the beam for its initial deviation.

In producing the previously described deflections for aperture selection, focusing action on the beam is held to minimum levels. This is accomplished by maintaining the second anode 43 and an adjacent cylindrical electrode or third anode 48, which define the region wherein the beam is deflected, at substantially the same potential, thereby creating a drift region or unipotential region wherein virtually no acceleration, deceleration, or focusing occurs. Distortions introduced by lens aberrations are thereby minimized. If high speed operation is required,

the second and third anodes 43 and 48 may be provided with a number of longitudinal gaps (not shown) to prevent the anodes from acting as shorted turns.

The second and third anodes 43 and 48 may be replaced by a single cylindrical electrode if individual amplifiers and gain controls are provided for driving each of the yokes 17, 18 and 19. Such gain controls permit adjustment to compensate for deviation of the fields established by the yokes within manufacturing tolerances. In the illustrated embodiment, however, the corresponding X and Y windings of the yokes 17, 18 and 19 are connected in series to reduce the required number of yoke driving circuits. To allow for variation in the gain of the yokes 17, 18 and 19, an adjusting circuit 49 is connected to the third anode 48. The adjusting circuit 49 is constructed to permit adjustment of the potential of the third anode over a very narrow range near the potential of the second anode 43, to thereby adjust the velocity of electrons in the electron beam. By changing the velocity of the electrons in the electron beam, they may be made more or less subject to the influence of the magnetic field through which they are passing. Accordingly, the deflection of the beam may be adjusted to compensate for variation in field strength due to variation of the fields of the yokes within manufacturing tolerances. The effect of varying the deflection sensitivity of the center and forward yokes 18 and 19 by variation of the potential on the third anode 48 produces little or no significant focusing action where only a slight difference in potential between the third anode 48 and the second anode 43 exists and where the anodes are of equal diameter and are telescoped as shown in FIGURE 1.

After passing the forward deflection yoke 19, the electron beam, which is once again on the axis 12 of the tube, is focused by a pair of suitably supported cylindrical focusing electrodes 51 and 52, acting with the third anode 48 and an aquadag coating 53 provided on the inner surface of the frustoconical section. The electrodes 48, 51, and 52 and the aquadag coating 53 form convergent electrostatic lenses which focus the character-shaped beam on the screen 13. The size of the displayed characters may be selected by varying the voltages on the electrodes 51 and 52 to vary the focusing of the lenses. The final deflection yoke 21 is coupled to character positioning circuits 54 to deflect the shaped electron beam to any desired position on the screen 13.

The cathode ray tube of the invention provides satisfactory operation with low distortion. It may be noted that each time the electron beam passes through a focusing region or electrostatic lens, the beam is on the axis 12 of the tube and hence, in the region of minimal distortion. Accordingly, distortion of displayed characters is minimized. In the region where the electron beam is displaced from the axis of the tube, the potential is uniform, with virtually no acceleration, deceleration or focusing. As a result, little distortion occurs in the region.

Because the region of off-axis deviation of the beam is unipotential, further deviation of the beam from the axis is possible than where convergence lenses are utilized. Thus, the foregoing described design makes possible the use of a stencil with a much larger matrix of apertures therein for a given tube neck diameter. A greater number of character shapes is therefore possible. Moreover, with the series connected arrangement of deflection yokes, as above described, the number of driving circuits required is reduced over that required in many prior art arrangements. In addition, the diameter of the neck section 23 is smaller than in many prior art arrangements, increasing deflection sensitivity, since the yoke diameters may be correspondingly smaller.

Another advantage accruing from the invention is that power supply requirements are reduced over the requirements of many prior art devices. In prior art devices utilizing electrostatic deflection of the electron beam for aperture selection, it has frequently been desirable to

operate the deflection plates near ground potential in order that their driving power supplies need not be "floated" at a high potential. The fixed potentials of the cathode and the aquadag coating therefore are considerably minus or plus, respectively, from the operating potential of the plates. As a result, two high voltage power supplies may be required, one for maintaining the cathode potential at a high negative value and one for maintaining the aquadag coating potential at a high positive value. In the cathode ray tube of the invention, because electromagnetic deflection is utilized, either the aquadag coating or the cathode (usually the cathode) may be maintained at ground potential. Accordingly, only a single power supply is needed—that required for driving the high negative elements (cathode) or the high positive elements (Aquadag coating).

Referring now to FIGURE 2, an alternative embodiment of the invention is illustrated. Components of the device in FIGURE 2 having function substantially the same as corresponding elements in the embodiment of FIGURE 1 have been given the same reference numerals preceded by a 1. Operation of the deflection yokes 117, 118 and 119 is as described in connection with FIGURE 1. The same is true for the cathode and grid, 131 and 132, and the accelerating anode 134 and plate 142. The deflection yoke 121 for character positioning is also operable as described in FIGURE 1.

The difference in the embodiment of FIGURE 2 over that of FIGURE 1 is that, in place of electrostatic focusing elements, all focusing is accomplished electromagnetically. An electromagnetic focusing coil 156 is provided between the cathode 131 and the deflection yoke 117. Similarly, an electromagnetic focusing coil 157 is provided between the deflection yoke 119 and the deflection yoke 121. The focusing action on the electron beam produced by the coil 156 is similar to the focusing action produced on the beam by the arrangement of the electrodes 37, 38 and 39 in FIGURE 1. Similarly, the focusing action provided on the electron beam by the focusing coil 157 is similar to that provided by the focusing electrodes 51 and 52 in FIGURE 1.

By utilizing electromagnetic focusing as well as electromagnetic deflection, as described in connection with FIGURE 2, the initial cost of the total system may be higher than some prior art devices. The system, however, is less complex since the power supply need not contain the high voltage elements required for typical electrostatic focusing arrangements. The latter are often unreliable and expensive. Moreover, the tube itself is easier and less expensive to build, since there are fewer internal elements. Such a tube is consequently less expensive to replace and, over the life of the equipment, this may provide an advantage that more than offsets a higher initial cost.

It may therefore be seen that the invention provides an improved cathode ray tube of the shaped beam type wherein beam distortion is minimized, and wherein greater beam deviation from the electro-optical axis of the tube is possible than in prior art tubes of similar size.

Various modifications of the invention, in addition to those shown and described herein, will become apparent to those skilled in the art from the foregoing description and accompanying drawings. Such modifications are intended to fall within the scope of the appended claims.

What is claimed is:

1. A cathode ray tube of the shaped beam type, comprising an electron beam gun for producing an electron beam directed along an electro-optical axis, a target, a stencil disposed between said electron beam gun and said target and having a plurality of apertures for shaping the cross section of the electron beam, each aperture to produce a predetermined shape, a first deflection yoke positioned between said electron beam gun and said stencil for deflecting the electron beam from the electro-optical axis to select one of said apertures, a second deflection yoke positioned near said stencil for deflecting the electron

7

beam to a path convergent with the electro-optical axis, a third deflection yoke positioned between said stencil and said target for deflecting the electron beam from the convergent path to a path substantially coincident with the electro-optical axis, said second deflection yoke providing a magnetic field which is substantially transverse to the electro-optical axis in the region of off axis deviation of the electron beam, and focusing means positioned between said third deflection yoke and said target.

2. A cathode ray tube according to claim 1 wherein each of said deflection yokes includes an X deflection winding and a Y deflection winding, wherein said X deflection windings are connected in series and wherein said Y deflection windings are connected in series, and wherein the windings of said second deflection yoke are wound and connected to produce magnetic fields opposite in directions to the directions of the corresponding fields of said first and third deflection yokes.

3. A cathode ray tube according to claim 1 including a pair of cylinders coaxially disposed within said first, second and third deflection yokes, and means for varying the relative potentials on said cylinders to vary the deflection sensitivity of one or more of said deflection yokes, said relative potential variation being less than would produce substantial focusing action.

8

4. A cathode ray tube according to claim 1 including a fourth deflection yoke positioned between said third deflection yoke and said target for deflecting the electron beam to impinge on a predetermined position on said target, said focusing means being positioned between said third deflection yoke and said fourth deflection yoke.

5. A cathode ray tube according to claim 4 including further focusing means positioned between said electron beam gun and said first deflection yoke, each of said focusing means and said further focusing means being electromagnetic.

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RODNEY D. BENNETT, JR., Primary Examiner

25 MALCOLM F. HUBLER, Assistant Examiner