

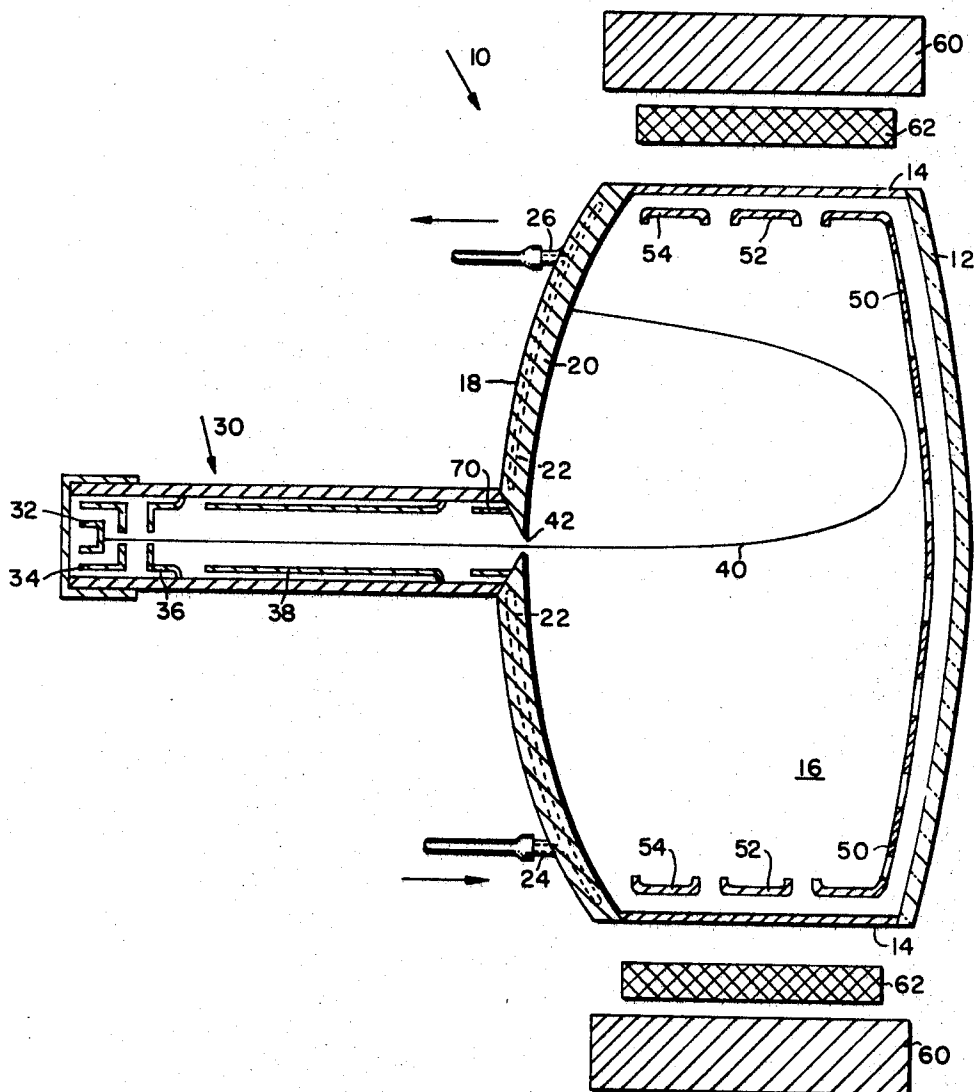
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HIGH INTENSITY PROJECTION CATHODE RAY TUBE

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HIGH INTENSITY PROJECTION CATHODE RAY TUBE

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6 Claims

ABSTRACT OF THE DISCLOSURE

A high intensity projection cathode ray tube comprises an electron gun disposed behind a concave phosphor screen which is mounted on the rear wall of the tube at a distance from the tube face plate. The electron beam is injected through a small central aperture in the screen and then reflected back to the screen by a negative electrode in the forward portion of the tube. A permanent magnet is employed for focusing and magnetic yokes are used for vertical and horizontal deflection. The rear wall of the tube is formed of a heavy metal plate which may be water-cooled for effective heat sinking.

FIELD OF THE INVENTION

The present invention relates to cathode ray tube devices characterized by high intensity output, and more effective cooling to permit such high intensity operation. More specifically, such devices find application as improved cathode ray tube visual displays.

THE PRIOR ART

In the field of cathode ray tube visual display devices, it is recognized that a concave phosphor screen has advantages both from the standpoint of optics and from the standpoint of electron refraction. Such concave viewing screens are more effectively coupled optically to the variety of viewing systems that are used with cathode ray tube displays, as for example in radar systems. In addition, the use of a concave screen simplifies the problem of designing the electron refraction system within the cathode ray tube itself.

Unfortunately, all prior art techniques for developing a cathode ray raster upon a concave phosphor screen have made it difficult to achieve the level of phosphor cooling which is required by high intensity operation. Conversely, those cathode ray tube designs which are best from the standpoint of phosphor cooling have poor optical and electron refraction characteristics.

The solution to the problem of providing an optimal screen configuration with adequate cooling for high intensity operation, it is felt, lies in the direction of projecting the electron screen from a point behind the phosphor screen through an aperture in the screen and into the region directly in front of the screen. Reflector electrodes in the forward portion of the cathode ray tube are employed to accelerate the emerging electrons back toward the phosphor screen, with appropriate provisions for focusing and deflection.

This general cathode ray tube configuration has been suggested previously, as for example in U.S. Pat. No. 3,064,154 of H. B. Law. That patent, however, does not suggest a concave viewing screen; on the contrary the viewing screen is convex. Nor does the Law patent suggest any way in which such a tube configuration can lend itself to the problem of phosphor cooling at high intensity operations. Finally, the Law cathode ray tube suffers from a serious defect in that deflection of the electron beam begins at a point before the electrons have emerged from the aperture in the screen. As a result, the screen aper-

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ture must be large enough to accommodate all possible electron paths to the extremes of the viewing screen, and this results in an undesireably large portion of the viewing screen area being devoted to electron permeability at the expense of its utility for picture display purposes.

SUMMARY AND OBJECTS OF THE INVENTION

Accordingly, a primary object of this invention is to provide a cathode ray display tube which has a concave viewing screen, for optimum electron refraction characteristics and optical coupling, but which at the same time provides maximum phosphor cooling so that it can be operated at high emission intensities.

An additional object of the invention is to provide a cathode ray tube of the type in which the electron beam is projected from behind the phosphor screen, through an aperture in the screen, but in which the beam is not deflected until after it has cleared the screen aperture so that a minimal portion of the screen area need be devoted to the aperture at the expense of the viewing area.

According to this invention, these objectives are achieved by providing a metal plate, for more effective heat-sinking and cooling, upon which phosphorescent material is coated to provide a cathode ray tube screen. An electron gun is located behind, and arranged to transmit an electron beam toward, the metal plate. The plate is formed with a single aperture in the path of the electron beam, through which the electrons pass, emerging into the region in front of the metal plate. The aperture has a diameter comparable to that of the electron beam so that the useful area of the viewing screen is maximized. A negative electrode in the front section of the cathode ray tube accelerates the emerging electrons back toward the screen. Conventional focusing and deflecting means are provided, but in order to make sure that the electron beam is not deflected until after it passes through the aperture, the metal plate is connected to a positive potential so as to shield the beam initially from the effects of the accelerating, focusing, and deflection fields in the forward section of the cathode ray tube. In this way, the small plate aperture can accommodate the electron beam under all conditions of horizontal and vertical reflection, without unduly detracting from the phosphor-coated area.

In one embodiment of the invention, the phosphor-coated surface is concave so as to provide a superior screen for display tube purposes.

BRIEF DESCRIPTION OF THE DRAWING

The single appended figure is a schematic sectional view of an embodiment of the cathode ray tube of this invention, adapted for use as a visual display device.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

In this embodiment a cathode ray tube 10 according to the invention comprises an evacuated envelope including a conventional transparent glass face plate 12 which is sealed to an annular metal band 14. The glass plate 12 forms the front viewing window of the display tube 10, while the metal band 14 forms a peripheral annular wall. Together, these elements define a large evacuated electron ballistics chamber 16 which is bounded at the rear by a curved solid copper or other suitable metal plate 18, sealed at its edges to the metal band 14. The front surface 20 of copper plate 18 is coated with phosphor material which forms a video picture screen.

In accordance with the objectives discussed above, the surface of copper plate 18 upon which the video screen 20 is coated, is concavely curved so as to provide the most desirable type of video picture screen; both from the point of view of superior optical coupling to a display system, and also from the point of view of ease of

electron ballistics design. In this cathode ray tube configuration, the picture is seen by looking through the transparent glass window 12 into the interior of the tube to view the image generated on the screen 20 internally of the tube.

In order to combine the advantage of a concave viewing screen 20 with the cooling necessary for high intensity operation, the copper plate 18 is provided with channels 22 for cooling water to flow. The coolant circuit includes an inlet pipe 24 and an outlet pipe 26 at the rear of the copper plate 18. It will be readily appreciated that it is the particular configuration of the cathode ray tube 10, with the copper plate 18 and video screen 20 located at the rear of the tube, that enables the copper plate 18 to provide a high thermal conductivity heat sink for the phosphors 20, and also enables the cooling water to be brought into heat exchange contact with the plate 18 at the rear surface thereof without in any way interfering with the electrical or optical characteristics of the tube.

In order not to interfere with the electron ballistics and optical paths in the forward section of the tube, the cathode ray gun 30 is mounted at the rear of the copper plate 18. It comprises a conventional heated cathode 32, a control grid 34 which is connected to a signal source, and the usual focusing anode 36 and second anode 38. In the usual manner, the electron gun 30 fires an electron beam 40 which proceeds axially along the center of the electron gun and passes through a small central aperture 42 formed in the copper plate 18.

Once the electron beam 40 emerges from the aperture 42, it is subjected to a strong rearward acceleration by means of electrodes 50, 52 and 54 which are all connected to a source of strongly negative potential. The electron velocity at the time of emergence from aperture 42 and the potential of the reflecting electrodes 50, 52 and 54 are calculated so that each electron in the beam 40 is slowed to zero velocity just prior to reaching the electrode 50 and then is propelled backward toward the phosphor screen 20 by the electrostatic field.

Since the main reflecting electrode 50 extends entirely across the glass front faceplate 12 of the video tube, it is necessary that this electrode be optically transparent. In a preferred embodiment of the invention, this electrode 50 would comprise a metallic mesh of high optical transmissivity, but it may also consist of a thin transparent metal coating on the inside surface of the glass faceplate 12.

The electron gun 30 is conventionally designed to provide an electron beam 40 of the desired current density, terminal velocity, and objective diameter at the point where it emerges from the plate aperture 42. From that point on, focusing is the function of a permanent magnet 60 which annularly surrounds the electron ballistic chamber 16 of the cathode ray tube. However, the focusing is considerably simplified by calculating the curvature of the phosphor screen 20 so that the total curved path length of the electron beam 40 from the aperture 42 to its impingement upon the video screen 20 is the same regardless of which portion of the video screen 20 the beam strikes, i.e. the same for all deflection conditions, so that each point in the video raster is equally in focus.

The field of the permanent magnet 60 causes each electron of the beam to describe a helical trajectory, in which the curved beam path 40 forms one geometric element of the helix. Thus the individual electrons gyrate helically in the vicinity of the curved path 40, returning exactly to the path 40 at the end of each complete helical revolution. In order to make sure that each electron in the beam returns to the curved path 40 exactly at the moment when that path terminates upon the picture screen 20, the objective of focusing design is to make each electron perform an integral number of helical revolutions over the entire length of the curved path 40 from the aperture 42 to the point of impingement upon the video screen 20. This ob-

jective can be achieved over the entire video raster, in view of the fact that all points on the video screen are equidistant from the aperture 42 over any curved electron path 40.

In order to minimize the magnetic field requirements for focusing, the integral number of helical revolutions performed by the electrons of the beam 40 should be kept to a minimum, for example one full helical revolution between the aperture 40 and the point of impingement upon the video screen 20. In a practical example, it was calculated for a tube in which the electrons perform one full helical revolution under the influence of the focusing field, and having a curved path length of 15 centimeters from aperture 42 to the video screen 20, that a focusing field of 430 gauss is required. This is a substantial field for a solenoid, but is easily generated by the permanent magnet 60 without using power, and without dissipating heat.

In order to "spray" the electron beam across the video screen 20 in a raster pattern, conventional electromagnetic deflection coils are provided. In the view illustrated in the appended figure vertical deflection coil 62 is indicated schematically. It is understood that a similar horizontal deflection coil would also be required.

It is one of the key objectives of this invention that no curvature of the electron beam 40 shall take place until after the beam 40 emerges from the aperture 42 into the electron ballistic chamber 16 in front of the video screen 20. This avoids the disadvantage of the prior art cathode ray tubes which required either a large central aperture 42, or a plate 18 which was permeable to the electron beam over a large central area, in order to accommodate various deflection conditions of the electron beam 40.

According to the present invention, the electron beam 40 is uncurved from its origin to the point where it emerges from the aperture 42. This is insured by connecting the copper plate 18 to the ultor, or highest positive, potential of the tube. In addition, anodes 70 are provided which surround the aperture 42 at the objective end of the electron gun 30 and are mechanically and electrically connected to the copper plate 18 so as to exert an electrostatic influence which keeps the beam traveling straight toward the aperture 42. It is only after the beam emerges from the aperture that it comes under the influence of the reflecting field of electrodes 50, 52 and 54, the focusing field of the permanent magnet 60, and the deflection field of the vertical and horizontal deflection coils (e.g. vertical deflection coil 62).

As a result, the aperture 42 does not have to be large enough to accommodate various deflection conditions of the electron beam 40. On the contrary, its diameter is comparable to that of the electron beam itself, which has the advantage of leaving only a very small central opening (approximately 1/4 inch diameter) in the phosphor viewing screen 20. Even this small flaw in the picture can be eliminated if the deflection coils are provided with a signal which rapidly shifts the picture location at some frequency above the flicker rate of the human eye; for example 25 hertz.

The invention claimed is:

1. A projection cathode ray display tube comprising a concave metal plate having a single centrally disposed aperture therein, a phosphor screen disposed on the concave surface of said plate, an electron gun disposed behind said plate such as to transmit a beam of electrons through said central aperture, field producing means disposed forwardly of said plate for accelerating and focusing said electrons upon said phosphor screen, and means disposed forwardly of said plate for selectively deflecting said electrons to desired portions of said phosphor screen.
2. Apparatus as recited in claim 1 wherein

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the radius of curvature of said concave surface is such that all electron paths are equalized regardless of deflection by said deflecting means.

3. Apparatus as recited in claim 1 wherein said field producing means includes an optically transparent mesh electrode disposed forwardly of said phosphor screen and coupled to a sufficiently negative potential source for rearward acceleration of said electrons.

4. Apparatus as recited in claim 3 wherein said deflecting means are disposed forwardly of said screen, rearwardly of said mesh electrode, and radially outside the electron paths to the extremities of said phosphor screen.

5. Apparatus as recited in claim 1 further including heat exchange means disposed in heat transfer relation with said metal plate.

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6. Apparatus as recited in claim 1 wherein the dimension of said aperture is substantially equal to the diameter of said beam of electrons.

References Cited

UNITED STATES PATENTS

3,064,154	11/1962	Law	313—79
2,264,709	12/1941	Nicoll	313—82 X
2,839,700	6/1958	Navarre	313—82
3,014,148	12/1961	King	313—44 X
3,090,882	5/1963	Benway	313—82

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313—44, 84