Dec. 3, 1940. C. S. BULL 2,223,908

CATHODE RAY TUBE

Filed Aug. 19, 1938

Fig. 1

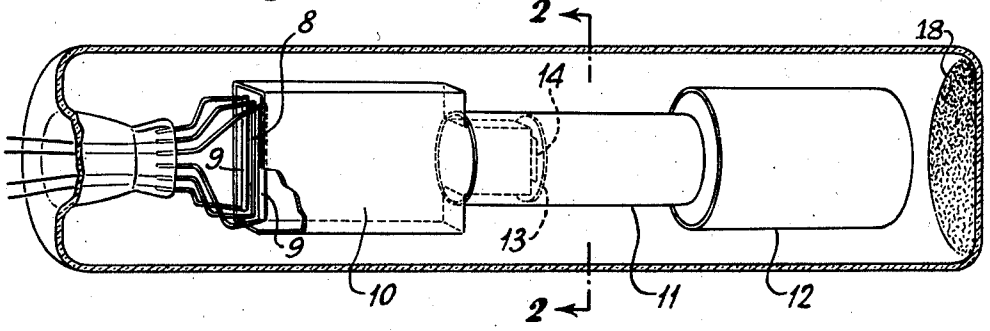


Fig. 2

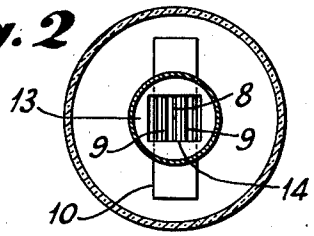


Fig. 3

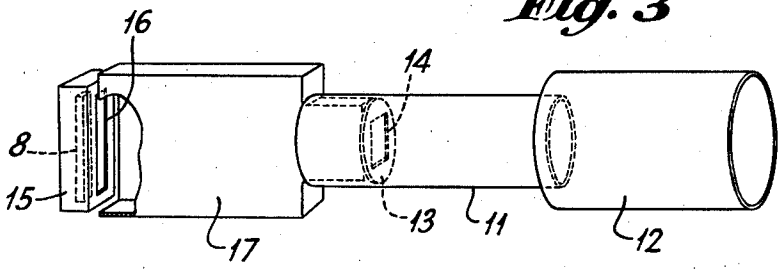
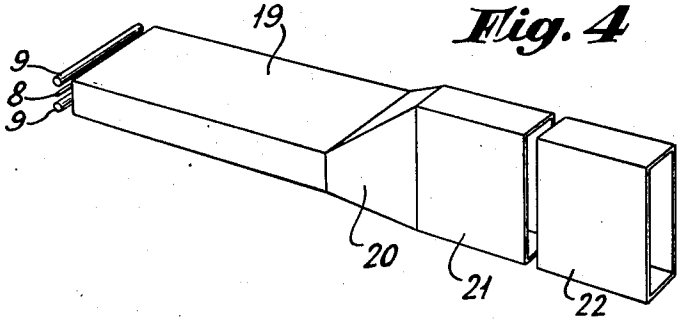


Fig. 4



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CATHODE RAY TUBE

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6 Claims. (Cl. 250—162)

This invention relates to cathode ray tubes such as are employed either for reconstitution of images in television reception or tubes that are employed in television transmission systems.

In cathode ray tubes used for the reconstitution of images in television reception it is usual to employ a circular cathode, sometimes of relatively large area which generates a beam of electrons of cylindrical or conical cross-section, the beam being focussed to a point or circular spot, which is usually an image of a point called a "cross over" in front of the cathode, by the provision of spherical electron lenses.

It is the object of the present invention to provide an improved construction of cathode ray tubes possessing advantages over known types of cathode ray tubes particularly as regards sensitivity.

According to one feature of the invention a method of focussing an electron beam into a small spot is provided wherein electrons emanating from a cathode are constrained by a cylindrical electron lens into a sheet-like form, the sheet-like beam of electrons being subsequently acted upon by a further electron lens which focusses the sheet-like beam into a small spot.

According to another feature of the invention, a cathode ray tube is provided comprising a cathode for generating a beam of electrons, means adjacent to said cathode and serving, when energised, to form a substantially cylindrical electron lens for constraining said beam of electrons into a sheet-like form and a further electron lens disposed between said electrode system and a screen upon which said sheet-like beam is focussed into a small spot. The said cylindrical lens will, in most cases, be of the electrostatic type but may in some cases be of the magnetic type. The further lens may be a cylindrical lens arranged substantially at right angles to the first-mentioned cylindrical lens or, alternatively, it may be a spherical lens produced either magnetically or electrostatically.

Preferably, the cathode comprises a straight rod-like element either in the form of a straight directly heated filament or of the indirectly heated type and the emission from the cathode may be controlled by the provision of a control electrode in the form of a pair of rods mounted one on each side of the cathode to which suitable bias potentials or signals for controlling the electron emission for modulating the electron beam can be applied. The first cylindrical lens may be formed by the use of an open-ended electrode enclosing said cathode and control electrodes, said enclosing electrode being of elongated form. In another form of the invention the control electrode may comprise an electrode surrounding the cathode and having an elongated opening through which the electrons from the straight cathode pass, the cylindrical lens being formed between the control electrode and an adjacent electrode.

In order that the said invention may be clearly understood and readily carried into effect it will now be more fully described with reference to the accompanying diagrammatic drawing in which:

Figure 1 is a perspective view of a cathode ray tube and electrode structure embodying the invention,

Figure 2 is a cross-sectional view taken along the line 2—2 of Figure 1,

Figure 3 is a perspective view of the electrode system of a cathode ray tube embodying a modified form of the invention,

Figure 4 is a perspective view of the electrode system of a cathode ray tube embodying a further form of the invention.

In the form of the invention shown in Figures 1 and 2, the cathode ray tube comprises a cathode 8 which is in the form of a rod-like member either of the directly heated or indirectly heated type and arranged on each side of the cathode and in the same plane thereto is a pair of rods 9 which serves as the control electrode. The cathode and control electrodes are arranged at one end of an enclosing electrode 10 of box-like form and of a rectangular form in cross-section, the end of the electrode 10 remote from the end in which the cathode and control electrodes are arranged being open to permit of the passage of electrons. The electrode 10 is in effect a first anode and consists of two portions, a principal portion of rectangular cross section and a minor portion likewise of rectangular cross section, with their major axes of cross section parallel and parallel with the longitudinal axis of the cathode 8. The electrode 10, and the control electrode 9, function as a cylindrical lens for producing a sheet-like beam of electrons of a parallel or convergent form the cathode 8 being parallel with the axis of the lens. The electron emission from the cathode 8 due to the disposition of the control electrode 9 emerges in a divergent sheet-like form, the electrode 10 then serving to converge the beam in a direction normal to the length of the cathode 8. Preferably the diameter of the cathode is small compared with its distance from either rod 9, and the length of the rods 9, long

compared with their diameters, whilst the length of the electrode 10 should be long compared with the distance between the sides thereof. In Figs. 1 and 2 the second lens is of the spherical type and comprises a cylindrical elongated electrode 11 and a further cylindrical electrode 12 which may constitute the second anode of the usual form of cathode ray tube. Both the cylindrical lens and the spherical lens formed by the electrodes 11 and 12 are of the electrostatic type. It will be seen from Fig. 1 that the electrode 10 extends along the whole length of the cathode 9 and the open end of the electrode 10 is recessed so as to fit into the interior of the cylindrical electrode 11. Adjacent to the end of the electrode 10 which projects into the electrode 11 there is provided a diaphragm 13 having a rectangular aperture 14 the width of which is slightly larger than the distance between the sides of the electrode 10, the purpose of this diaphragm 13 being to intercept the upper and lower portions of the sheet-like beam, these portions containing electrons which are not travelling at right angles to the cathode on account of the change in the cylindrical field at the ends of the electrodes 8 and 9 and would otherwise constitute aberrations. The diaphragm 13 is provided in a position which is substantially free from focussing fields. The electron beam, after passing through the aperture 14 is acted upon by the spherical lens generated between the electrodes 11 and 12 which serves to focus the sheet-like beam of electrons travelling in the direction at right angles to the cathode into a small spot upon a screen or target 18. The screen or target 18 may be of any suitable form, such as a screen adapted to be rendered luminous under the impact of electrons, or it may comprise a screen of the mosaic type or any other screen, such as may be used for the generation of picture signals for television transmission purposes or any other form of screen as may be found desirable. The electrode structure is disposed in an evacuated envelope, as shown in Figure 1. Where a cathode ray tube in accordance with the invention is designed for use in the reconstitution of television signals, the signals being employed to modulate the beam of electrons, such signals may be applied to the control electrode 9 and may serve to vary the potential of the electrode 9 from a low positive value to a negative potential. The electrodes 10 and 11 which are in contact with one another may have a positive potential of about 300–400 volts, whilst the electrode 12 may have a positive potential of about 1000 volts or more. The quantity of electrons emanating from the cathode 8 is varied by the signals applied to the rods 9. They are then accelerated by the increasing potentials applied to the electrodes 10, 11 and 12 and focussed into a small spot on the screen of the tube. The spot is then deflected over the surface of the screen to reconstitute the image, such deflection being accomplished in known manner by the provision of suitable deflecting plates or deflecting coils. It will, of course, be understood that the two lenses i. e., the cylindrical and spherical lenses should effectively be spaced sufficiently far apart so as to avoid interaction between the fields produced by each lens.

In the embodiment of the invention shown in Fig. 3 the first cylindrical lens is formed between the control electrode and an adjacent electrode, but instead of the control electrode being in the form of rods, as shown in Figures 1 and 2 it is in the form of a box-like structure 15 enclosing the cathode 8 which, in this example, is of the indirectly heated type and of rectangular form in cross-section, the control electrode 15 having an elongated opening 16 extending along the length of the cathode 8 and opposite the emissive area thereof. Adjacent to the control electrode 15 is an open-ended box-like electrode 17, the first cylindrical lens being formed between the electrodes 15 and 17. The ends of the electrode 17 remote from the cathode are reduced in size so as to fit into the interior of a cylindrical electrode 11 which together with a further cylindrical electrode 12 constitutes a spherical lens as in the arrangement shown in Figs. 1 and 2. A diaphragm 13 is also provided similar to the arrangement shown in Figures 1 and 2. The operation of the embodiment shown in Fig. 3 is similar to that described in connection with Figures 1 and 2, the main differences between the two arrangements being the construction of the control electrode.

Figure 4 of the drawing illustrates a construction in which two cylindrical lenses are provided, the first cylindrical lens functioning in the manner described in connection with the preceding figures whilst the second cylindrical lens is arranged with its axis at right angles to the first lens and replaces the spherical lens formed by the electrodes 11 and 12. The cathode and control electrodes are of the form shown in Figures 1 and 2 comprising a cathode 8 disposed between a pair of rods 9. Adjacent to the cathode and control electrodes is an open-ended box-like electrode 19. As in the case of the arrangement shown in Figs. 1 and 2, the field between the electrodes 8, 9 and 19, serve to focus the beam into a parallel beam of electrons travelling at right angles to the cathode. Joined to the electrode 19 by an intermediate section 20 is a further box-like electrode 21 and spaced from the electrode 21 is a further box-like electrode 22. The electrodes 21 and 22 constitute a further cylindrical lens the axis of which is arranged at right angles to the cylindrical lens formed by the electrodes 8, 9 and 19. The sheet-like beam of electrons thus produced by the electrodes 8, 9, or 19 is then acted upon by the cylindrical lens formed by the electrodes 21 and 22 which accelerate the electrons and focus them into a small spot upon the screen.

In operation, the electrodes 19 and 21 may be maintained at a positive potential of about 300 volts, and the electrode 22 at a positive potential of 1000 volts.

In known types of cathode ray tubes the cathode is of the indirectly heated type and is in the form of a circular electron emissive cap enclosing a heater. In the present invention the cathode may take the form of a straight filament or a rod-like member and thus conform substantially to the type of cathode employed in thermionic valves. These cathodes are more easily manufactured than the cap-like indirectly heated cathodes. With the construction according to the invention the mutual conductance may be at least of the same order or even considerably higher than that of existing cathode ray tubes. The width of the beam in the initial cylindrical lens may be made relatively small without loss in mutual conductance or a decrease in thermionic emission. It is found also that the width of the beam increases as the control electrode 9 in Figs. 1, 2, and 4 is made more and more positive, but decreases as the potential of the accelerating electrode 10, in Figs. 1 and 2, or 19 in Fig. 4, is

made more and more positive. The second lens serves to focus relatively high velocity electrons and any correction for aberration which may be required due to the width of the electron beam when passing through such a lens may be accomplished by known methods. With the construction in accordance with the invention the power consumed by the cathode may be considerably reduced and if a directly heated filament is employed it may be heated by the high tension current employed for operating, for example, the receiving apparatus without the need for a separate source of cathode current. Alternatively, the cathode may be supplied with current intermittently during the "black out" periods of the cathode ray tube.

The particular construction of cathode and control electrodes described enables the input capacity to be made very small and reduced to such an extent that high frequency signals may be applied directly to the control electrodes without intermediate rectification by a diode. The bias is then chosen so that the grid voltage just swings to cut off when the carrier wave of, for example, television signals has the amplitude corresponding to black.

The present invention is of course not limited in its application to cathode ray tubes for use in television receiving or transmitting systems, but also cathode ray tubes employed for other purposes.

I claim:

1. A cathode ray tube comprising an evacuated envelope enclosing an electrode structure including an elongated cathode to develop an electron stream of rectangular cross section, a target oppositely disposed and substantially parallel to the longitudinal axis of said cathode to receive electrons from said cathode, control means adjacent the cathode, a boxlike anode between said cathode and said target having a portion of rectangular cross section and of extended length to generate with said control means a cylindrical focusing field to focus and converge the electron stream from said cathode in a direction normal to the length of said cathode and transverse to the minimum cross-sectional dimension of said target, an integral extension of rectangular cross section mechanically supported by and electrically connected to said anode, and means between said anode and said target for focusing the electron stream from said cathode in a direction normal to the first direction of focus and transverse to the maximum cross-sectional dimension of said stream to focus said stream on said target.

2. A cathode ray tube comprising an envelope enclosing an electrode structure comprising an elongated electron emissive cathode to generate an electron stream, a target oppositely disposed from said cathode, a control electrode adjacent said cathode, an elongated boxlike anode having a rectangular cross section normal to the axis between said cathode and said target, an extension on said anode of rectangular cross section, said anode and said extension being adapted to be maintained at a positive potential with respect to said cathode for converging the stream of electrons from said cathode, an electron limiting disk adjacent said extension having an elongated aperture, the longer dimension of said aperture being normal to the length of said cathode, and means between said anode and said target including two cylindrical members one of which overlaps the extension on said anode for focusing the electrons from said cathode which pass through said limiting disk on said target.

3. A cathode ray tube as claimed in claim 2 wherein the one of said cylindrical members which overlaps the extension on said anode is electrically connected to and mechanically supported by said anode.

4. A cathode ray tube comprising an evacuated envelope, an elongated cathode near one end of said envelope to generate a sheetlike beam of electrons, a target oppositely disposed from said cathode to receive electrons therefrom, a control electrode adjacent said cathode to control the number of electrons flowing to said target, an elongated boxlike anode having a principal section of rectangular cross section and having an extension of rectangular cross section, the major axis of which is perpendicular to the major axis of the principal section of said anode, and a second anode between said first-mentioned anode and said target to focus the electrons from said cathode passing through said anode on said target.

5. A cathode ray tube having an evacuated envelope and an electron gun comprising an electron emitting cathode, electrode means to control the electron emission from said cathode, an elongated anode having a principal portion of rectangular cross section and a minor portion of rectangular cross section, the major axis of said minor portion being substantially at right angles to the major axis of said principal portion, and a second anode more remote from said cathode than said first-mentioned anode, and a target oppositely disposed from said cathode and in the path of electrons issuing from said cathode.

6. A cathode ray tube as claimed in claim 5 wherein the said second anode is of rectangular cross section having its major axis parallel with the major axis of the minor portion of said first-mentioned anode.

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