Jan. 19, 1960 F. K. COLLINS ET AL 2,922,072

IMAGE REPRODUCTION DEVICE

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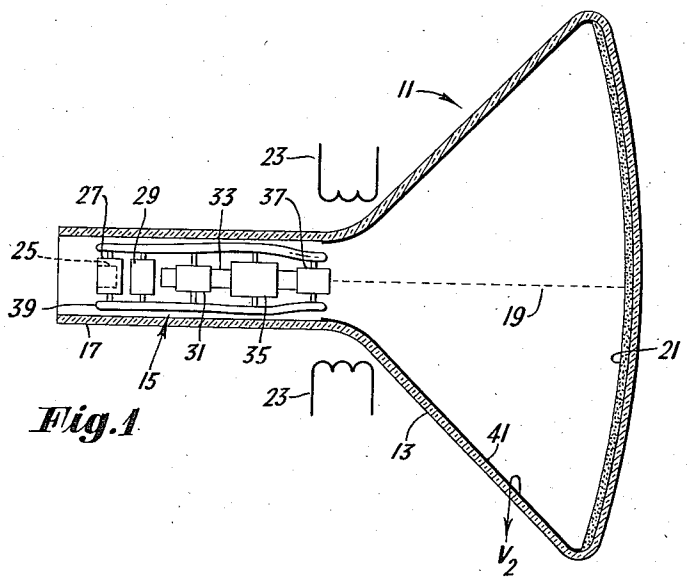


Fig. 1

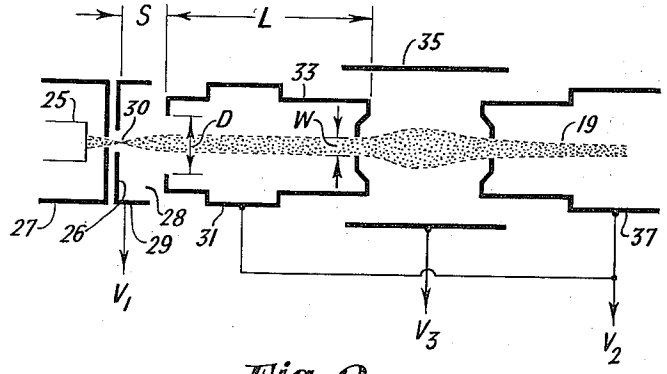


Fig. 2

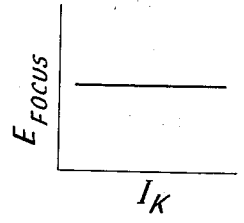


Fig. 3

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IMAGE REPRODUCTION DEVICE

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1 Claim. (Cl. 315—16)

This invention relates to image reproduction devices and more particularly to electrostatic focus type cathode ray tubes.

Generally, cathode ray tubes of the type adapted to be employed in television apparatus presently utilize electrostatic focusing electrodes. The electrical potential applied to these electrodes is of a constant value since dynamic focusing using a varying potential is complicated and expensive to achieve. The voltage needed to focus the electron beam or beams in such tubes has heretofore been dependent upon the beam current. Since this current is being continuously modulated or varied during tube operation, the beam is not correctly focused over the major portions of the reproduced picture or display regardless of the arbitrary focusing voltage selected.

Other aspects of the beam forming problems which are interrelated with focusing concerns the actual shape of the beam spots and the haze which surrounds it when viewed at the impinging position on the screen. Very often, electrode voltages capable of producing the best focusing characteristic with a given tube structure also produces an undesirably distorted and hazy beam spot.

Accordingly, an object of the invention is the provision of substantially constant focusing for cathode ray tubes.

A further object is the provision of substantially constant focusing with the maintenance of a substantially undistorted electron beam spot having a minimum amount of haze.

A further object is to improve the fabrication of cathode ray tubes and the electrode gun mounts employed therein.

The foregoing objects are achieved in one aspect of the invention by the provision of an electrostatic focus type cathode ray tube employing a screen grid spaced from an anode having an aperture formed therein. Substantially constant beam focus with optimum beam spot quality is achieved by providing a specific ratio of the anode aperture to the spacing between the grid and anode when these electrodes have given prescribed voltages imposed thereon relative to one another.

For a better understanding of the invention, reference is made to the following description taken in conjunction with the accompanying drawings in which:

Fig. 1 is a partially sectioned plan view of a cathode ray tube;

Fig. 2 diagrammatically illustrates the electrode mount configurations and the beam shape for an electrode mount of the type adapted to be employed with the cathode ray tube shown in Fig. 1; and

Fig. 3 is a graphical representation of the manner in which the focusing voltage behaves as the cathode or beam current is varied.

Referring to the drawings, a cathode ray tube **11** is shown comprising an envelope **13** having an electron gun **15** disposed in the neck portion **17** thereof. The electron gun provides the source, control, acceleration and focusing of the electron beam **19**, which scans screen **21** under the influence of the magnetic fields provided by deflection coils **23**.

The electron gun **15** comprises a cathode **25**, control grid **27**, screen grid **29** and a first anode **31** arranged substantially along the axis of the tube to provide the source, control, pre-focusing and acceleration of beam **19**. An electrostatic focusing assembly comprising a first lens cup **33**, lens ring **35** and second lens cup **37** is shown mounted upon common insulating support rods **39** with the other electrodes. If desired, the focusing electrodes may be mounted separately, and the first anode **31** and first lens cup **33** may be fabricated as one part, as shown, or as separate parts.

During operation of tube **11**, the video signal is generally coupled to cathode **25** to provide a bias relative to grid **27**. A voltage V_1 of approximately 300 volts may be imposed upon screen grid **29** while first anode **31**, first lens cup **33** and second lens cup **37** may be coupled to voltage V_2 of 16 kv. or over. Generally, lens ring **35** is operated at a voltage V_3 up to 300 volts. The lower voltages may be applied to their respective electrodes through lead-in base connections (not shown) to the tube while the high potentials are applied through internal connections (not shown) with the second anode conductive coating **41**.

Electron beam **19** is focused in the manner shown in Fig. 2. The electrons emitted from cathode **25** proceed through the apertures in grids **27** and **29** to a crossover point **30**. The electrostatic field between anode **31** and grid **29** forms the electrons into a beam which extends through the apertures in lens cups **33** and **37**. The primary focusing is achieved by the electrostatic fields or lens existing in the vicinity of lens ring **35**. Beam **19** is thereby focused to provide a small beam spot on screen **21**.

It has been found that spacing S between the internal surface of the base **26** of cup-shaped grid **29** and the edge of tubular anode **31** disposed adjacent the open mouth portion **28** of grid **29** along with the diameter D of the aperture in anode **31** are instrumental in achieving constant focus of beam **19** for a wide range of beam current values with minimum distortion and haze. A ratio D/S greater than 1.3 has been found to produce the desired results. Referring to Fig. 3, it can be seen that a structure of the type described herein provides constant focus voltage E_s for a wide range of beam currents I_k.

It has been found that as the spacing S becomes too small, e.g., below .050 inch, the curve loses its linearity, the spot quality of beam **19** deteriorates, haze develops at high beam currents, and the curve will, in some cases, assume a positive slope. When the spacing S becomes too large, e.g., over .200 inch, the curve will assume a negative slope, thereby indicating that the focus voltage should be decreased with increasing beam current I_k to provide constant focus. By keeping the anode aperture D over .200 inch, the electrostatic lens provided by grid **29** and anode **31** is less sensitive to alignment and less haze is generated at all values of beam currents.

The ratio of D/S which has been found satisfactory is between 1.3 and 6.0 when the voltage V_2 on anode **31** is at least 10 times greater than the voltage V_1 imposed on grid **29**. Results have indicated that for anode voltages even below 6 k.v., the ratio still provides good focusing characteristics.

Excellent results have been attained by using a spacing S of .145 inch with an anode aperture diameter D of .235 inch when V_1 and V_2 are 300 volts and 16 k.v. respectively. Varying within reasonable limits the length and width of anode **31** and the length and width of grid **29** has

been found not to materially affect the focusing characteristics of the tube.

Spot hazing may be improved somewhat by varying the aperture diameter W in lens cup **33** in accordance with the length L of the integral structure comprising anode **31** and lens cup **33**. Generally, it has been found that the aperture diameter should vary with the length L of the anode cup cylinder to provide minimum spot hazing. For instance, with a length L of .650 inch, aperture size W is found to be approximately .060 inch, i.e. $L/W=10.8$, whereas for a value L of .775 inch, a satisfactory aperture diameter W is .090 inch, i.e. $L/W=8.6$.

Although the electrodes described herein generally have cylindrical forms, it is to be understood that the invention is not restricted to such an electrode. For instance, grid **29** may be formed as an apertured disc, if desired. Also, anode **31** may be formed as a straight cylinder and may be fabricated separately from the first lens cup.

Although several embodiments of the invention have been shown and described, it will be apparent to those skilled in the art that various changes and modifications may be made therein without departing from the scope of the invention as defined by the appended claim:

What is claimed is:

An image reproduction device electrode structure employing a plurality of axially aligned electrodes comprising, in order, a cathode providing an electron beam, a control grid, a screen grid having a base portion and an open mouth portion, a tubular anode spaced from said base portion a distance S ranging from .050 to .200 inch formed with an aperture of diameter D which is smaller than said open mouth portion, and an electrostatic beam focusing lens comprising a first lens cup integral with said anode having a re-entrant wall portion formed to provide an aperture of diameter W, the integral anode and first lens cup having an overall length L, a lens ring, and a second lens cup, the electrode structure providing substantially constant focusing of said beam when the ratio D/S ranges from 1.3 to 6.0, the ratio of L/W ranges from 8.6 to 10.8, and the voltage imposed upon said anode is greater than ten times the voltage imposed upon said screen grid.

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