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TELEVISION TUBE

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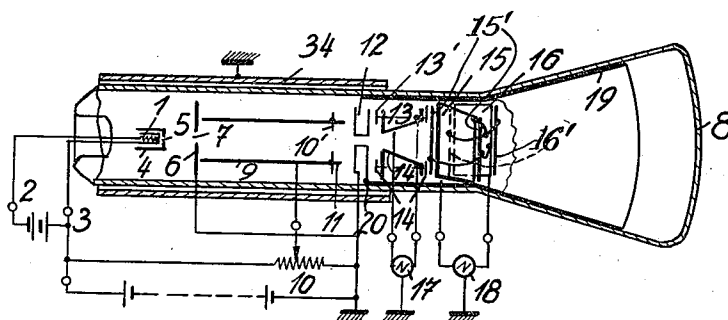


Fig. 1.

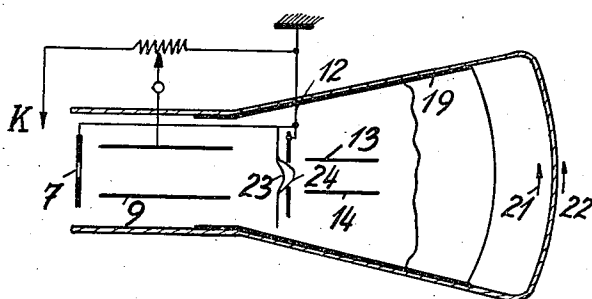


Fig. 2.

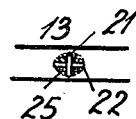


Fig. 2a.

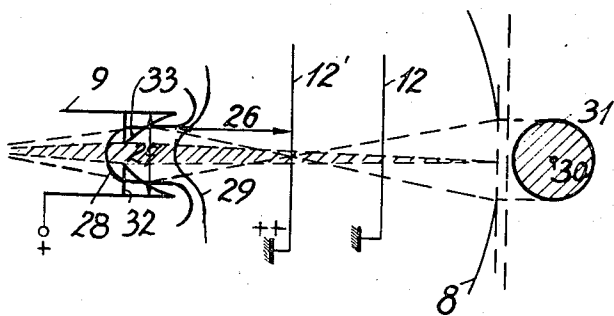


Fig. 3.

Fig. 3a.

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TELEVISION TUBE

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9 Claims. (Cl. 250—162)

The subject matter of the present invention is a high-vacuum television tube with electrostatic concentration and electrostatic deflection in both co-ordinates. Particular features of the invention are:

1. A particular embodiment of the electrostatic reproducing lens in such fashion that the same does not suffer interference from the deflecting plates and that the same on the other hand is also spherically corrected in respect of marginal rays remote from the axis,

2. A particular embodiment of the condenser lens which lights the diaphragm aperture to be reproduced, in such fashion that the rays travel along sufficiently parallel paths, i. e., in the vicinity of the axis, and that they emerge from the diaphragm with a comparatively high tension, in which manner there is obtained the advantage that a disturbing lateral deflection of the bundle of rays by the magnetic earth field is smaller than in the case of the known constructions in which the electrons have small speeds along a long path.

Fig. 1 shows the construction of the tube as a whole,

Fig. 2 explains the problem of assembling a reproducing lens with the deflecting plates,

Fig. 3 explains details of the lighting apparatus of the tube, i. e., the lens required between the cathode and the diaphragm.

In Fig. 1, 1 is the head of an indirectly heated hot cathode having the heating current leads 2 and 3, 4 is a control cylinder having a diaphragm 5 fitted therein, to which there is applied the light-control potential. 6 is a diaphragm having an aperture 7, which is to be reproduced on the luminous screen 8 by means of the electrical lens described later. A tubular member 9 is provided with a special bias, which may be tapped from a potentiometer 10. The front part of the tubular member 9 is narrowed by an additional diaphragm 10', and has an extension in the form of a tubular abutment 11. An anode 12 of peculiar form is raised electrically up to the same potential as the diaphragm 6, for example up to approximately 2000 volts+. There then follow two pairs of deflecting plates, viz., 13, 14 on the one hand and 15, 16 on the other hand, in relatively close proximity. According to the invention, each of these two pairs of deflecting plates is operated in reverse phase, viz. one by a relaxation oscillation generator 17 for the line frequency and one by a relaxation oscillation generator 18 for the frame frequency. The reverse phase operation is indicated in the drawing by earthing the middle of the two generator symbols. A metallic coating on the wall 19 of the bulb is preferably connected inside the tube with earth, i. e. with the anode 12 with the assistance of a contact spring 20. According to the invention, this coating 19 is not made to extend up to the screen 18.

In the development of a tube in which the properties referred to were to be obtained, the following main difficulties were encountered:

1. Central-symmetrical function of the electrical lens, i. e., the production of a circular image point from a circular diaphragm aperture,

2. Preserving the sharpness of the image point at the edge of the image,

3. Satisfactory reproduction also of the marginal rays by the electrical lens 10, 11, 12, particularly in the case of maximum intensity of the light,

4. Good yield, i. e., the passing as far as possible of all electrons leaving the cathode up to the luminous screen 8.

Arrangements are known, of which reference may be made more particularly to the so-called "pinescope" of Dr. Zworykin, in which the image point is produced by an electrical lens. For this purpose, in the case of these prior arrangements, there has been used the field between the edge of a tubular member (9 in Fig. 2) and a conductive coating 19, 9 being linked up with a lower potential than 19. In all of these arrangements, however, the deflection has been performed by means of magnetic fields produced externally. Apparently the designers also found that in the attempt to connect deflecting plates behind the tubular member 9 considerable difficulties occur—for it is in the first place necessary for this purpose to provide a screening anode plate 12 at a relatively short distance from the edge of 9 in order to reduce the influence of the deflecting plates on the distribution of the field between 9 and 12. The applicant has found that a simple plate of this nature is not sufficient. Whereas in the absence of deflecting plates the arrangement 9, 12 results in a circular image point, the provision of two plates 13, 14 behind the anode 12 immediately results in a rod-shaped point, it being found in practice that the focal distance recorded in the plane of the electrical deflection field is smaller than in a plane parallel to the deflecting plates.

This is indicated diagrammatically in Fig. 2 by the two arrows 21 and 22. The phenomenon is explained by the disposal of the potential levels between anode and deflecting plates and the ray. In the plane transverse to the plates the potential lines pass only to a small extent through the anode aperture. This is indicated by the effective potential level 23. If on the other hand the drawing is assumed to have been rotated to the extent of 90°, so that the deflecting plates are situated in front of and behind the plane of the drawing, the potential levels are disposed according to the curve 24, i. e., they engage to a much greater extent through the anode in the direction of the luminous screen. Since, however, the stated curvature of the levels

produces a dispersing lens effect, the refraction of the concentration system constituted by the electrodes 9, 12 will, by a level according to 24, be more greatly weakened than by a level according to 23. In consequence, if the bias of the tubular member 9 is gradually shifted from positive to negative values, there is obtained a change in the form of the image-point on the luminous screen as indicated in Fig. 2a when employing a diaphragm aperture 7 which is circular in itself and with the two stated positions of the deflecting plates 13, 14 in relation to the plane of the drawing. The first sharp reproduction has the form of a rod 21 transversely to the plates 13, 14. The second sharp adjustment discloses a similar rod 22 situated parallel to the plates, while at the same time the first observed reproduction, which has lost its sharpness, has formed a halo 25 about the second reproduction.

It is clear that a sharp image cannot be obtained with a reproduction of this kind. According to the invention, therefore, the eccentric effect of the plates 13, 14 is decreased in the construction of the anode 12 shown in Fig. 1 by furnishing the anode 12 with the form of a small tube of such length that the electrons, upon leaving the same, are raised uniformly to anode potential, and that the penetration of the field of the system 13, 14 into the space of the lens field between 10, 11 and 12 may be ignored in practice. The governing factor in this connection is the ratio between the shortest distance between the plates 13 and 14 on the one hand and the length of the small tube. It has been found that, if this ratio is equal to 10:15, and with a spacing of 5 mm. between the edge of the plates and the disc terminating the anode at its side facing the screen a satisfactory result is obtained in practice. Generally speaking, the distance of the disc terminating the anode on the lens side from the cathode side edge of the plates should be at least equal to and preferably greater than the distance between the deflecting plates.

According to the invention, the influence of the plate edges may also be eliminated in other fashion, viz., by applying on the side of the anode 12 directed towards the plates two auxiliary plates raised to equal potential, which auxiliary plates are disposed at right angles to the deflecting plates 13, 14 are situated near the edge of the anode aperture in 12. It will be quite obvious that by imparting to these two auxiliary plates a bias, which is adjustable for example from the exterior, the refractive power of the lens may be adjusted in itself in the plane vertical to the plates, or that with correct dimensioning of the size and length of the plates the same effect may be obtained even without this bias with a direct connection of the plates with earth and anode.

After obtaining in this manner in the absence of an electrical field between the deflecting plates a centric reproduction, i. e. a circular image point from a circular diaphragm, one observes renewed disturbances in the electro-optical reproduction when switching on the deflecting potential. These errors naturally increase all the more the greater the deflecting fields, i. e., the more the image point approaches the edge of the image.

The applicant has already explained in an earlier application that these considerable errors in reproduction and also the trapezoidal deformation of the rectangular form of image occurring simultaneously may only be avoided by operating the plates in reverse phase in relation to the anode.

It has been found that by this measure faults in definition and form of the raster may be satisfactorily eliminated as far as a first approximation is concerned. If, however, an approximation of the second order, i. e. an exactitude within 5% is required, the errors in reproduction remaining at the edges are still sensible. These errors are due to the fact that by reason of the simple reverse phase operation actually only the potential in the axis of symmetry is maintained permanently at zero relatively to the anode, whilst the dipole potential of each pair of plates naturally still greatly varies with the approach towards the field-generating plates themselves.

According to the invention, remedy may be obtained by the provision of auxiliary plates, for example 13' and 14'. If these auxiliary plates are electrically connected each with the deflecting plate situated opposite, and arranged on the bounding planes of the deflecting condenser in the manner indicated in Fig. 1, there is, when viewing the plates 13, 14 from the anode, at each moment a quadruple with polarities alternating as follows: $+-+-$. It will be obvious that the resulting potential of a four-pole of this nature, i. e., a field generator having four different alternating poles, must necessarily have not only one, but three stationary zero equipotential planes. By correct spacing of the four different field-generating poles it may be accomplished that the two additional points of undisturbed earth potential coincide exactly with the edges of the anode or exactly with those situations assumed by the ray in the case of strong deflection. The same measure may also be applied to the two marginal planes of the front condensers 15, 16 (see auxiliary plates 15' and 16'), in which manner it may be accomplished that the mutual effect of the two pairs of deflecting plates on each other and the distant effect of the condenser last referred to towards the screen may be reduced to a much better extent than is possible by means of a simple reverse phase dipole operation.

The difficulties referred to under 3 and 4 generally relate to the electrical reproduction utilizing the marginal rays and to the current economy. Both of these difficulties are closely related insofar as in the cathode ray optic as well as in the light optic it is difficult to concentrate a large amount of energy in a bundle of parallel rays, and in both cases a certain angle of opening of the cone of light must be accepted behind the lighted diaphragm aperture 7. From an electron-optical point of view the problem accordingly arises of passing a bundle of rays of large cross-section in such fashion through a lens that the extreme marginal rays are also focused into the image point. The electrical lens requires to have a large optical aperture and at the same time to be corrected spherically. The applicant has now discovered the following law (Fig. 3):

If a high-tension anode 12, which for the purpose of these considerations may be assumed to be an uninterrupted disc, is more and more approached towards a low-tension tubular member 9, i. e., if the ratio between the electrode spacing 26 and the diameter 27 of the opening of the tubular member 9 is decreased, and the bias of the tube 9 is always adjusted in relation to the earthed sheet 12 in such fashion that a sharp reproduction obtains in the plane of the screen, there will be reproduced a gradually decreasing fraction of the cross-section of the ray on the

screen and an increasing marginal ray cross-section in front of the screen, i. e., in blurred fashion on the screen. These conditions will be explained by the two sections 28 and 29 through certain potential levels. The section 28 corresponds with an anode approached very closely (12') and the section 29 with an anode 12 spaced at a greater distance, with conditions otherwise unchanged. In the case of approached anode the potential lines engage to a much greater extent into the tubular member 9, and since the tubular member 9 itself is a potential level the positive potential levels adapt themselves snugly to the tubular member 9 in pot-like fashion, and the resulting refractive area, represented by the line 28, accordingly assumes more and more the form of a pot, whilst the same in the case of the anode being more remote possesses the form of a spherical bowl practically over the entire cross-section of the tubular member 27. In the case of a bundle of rays which entirely fills out the aperture 27 a potential level is required to have the shape indicated by 29 if it is to result in a reproduction with sharp contour whilst a pot-like potential level will result in a sharp reproduction on the screen of the control portion only of the bundle of rays indicated in broken lines, the marginal rays of the bundle being united into a sharp reproduction in front of the screen, their reproduction on the screen itself thus considerably lacking in sharpness. The applicant has proved this effect by experiment, and the effect, as was to be expected, occurred upon the adjustment of maximum intensity of the ray current, i. e., when the bundle of rays possessed its greatest cross-section. The applicant operated with a cross-section of the bundle of rays amounting to 12 mm., a diameter of the tubular member 9 amounting to 30 mm. and a spacing 26 of 10 mm. They observed in point of fact, as shown in Fig. 3a, an image point 30 of approximately 1 mm. diameter which remained permanently sharp, and a halo 31 of approximately 15 mm. in diameter occurring in the case of white.

As a remedy the applicant has found on the basis of the considerations set forth that the ratio between the spacing 26 and aperture diameter 27 must be selected not less than approximately 1:1, and preferably 2:1, or more. If removal of the anode 12 from the tubular member 9 is no longer possible with consideration to the spacial conditions, it will be found to be sufficient if by means of a diaphragm 32 the free aperture of the tubular member is decreased to such extent that the stated conditions with regard to the spacing again apply. Thus, for example, with a diaphragm 32 having an aperture of 12 mm. located at a distance of 20 mm. from the anode 12' there may be adjusted a faultless reproduction with sharp edges with the same optical system which possessed the described marginal error without the diaphragm 32. By means of the diaphragm 32 the penetration of the potential levels into the interior of the tubular member 9, and the pot-like formation thereof, is prevented. The effect is additionally supported by the provision of spherical segments composed of sheet metal on the lines of 33. It is desirable to make the extent of penetration of the diaphragm 32 into the tubular member 9 so great that a spherical segment 33 having the same curvature that a plano-convex glass lens corresponding in its optical properties to the electron lens just touches the middle point of the diaphragm 32. The depth of penetration should be made ap-

proximately equal to or smaller than the radius of the tubular member 9.

The law discovered with regard to the spacing has been taken into consideration in accordance with the invention in the construction according to Fig. 1 also as regards the condensing arrangement 1, 4, 5, 6. The spacing of the diaphragm 6, which in this case plays the part of the anode, from the edge of the control cylinder 4 amounts to 7 mm., and is, therefore, twice as great as the extent of penetration of the grid diaphragm 5 into the interior of the cylinder (3.5 mm.). The latter is approximately equal to the radius of the cylinder, which amounts to 5 mm. As compared with the known constructions the diaphragm 6 with the aperture 7 is in the case of this tube electrically insulated from the tubular member 9, and is preferably raised to the highest positive potential occurring in the tube. The same, for example, is linked up with the anode 12. In this manner it is accomplished that it is very difficult to deflect the rays emerging from the aperture 7 so that these rays traverse the reproducing optical system of the tube exactly centrally. It is true that this is not the case to the requisite degree in the operation of the unprotected tube free in space. According to the invention, an iron cylinder 34 composed of sheet iron is placed on the outside over the neck of the tube and passed to earth. A cylinder of this nature, if the same is composed of a material offering good magnetic conduction, need merely be 1/2 mm. in thickness.

The emissive surface consists, for example, of a spot of oxide in the cathode 1 of .3 mm. diameter. The same supplies a maximum emissive current amounting to approximately 4 m. a., of which in operation 500 micro-amperes at an anode potential of 2000 volts are made use of (maximum energy accordingly 1 watt). The diaphragm aperture amounts for example to .7 mm., and with the stated dimensions allows practically all electrons to pass. With a length of the tubular member 9 amounting to 200 mm. and a spacing between anode 12 and screen 8 amounting to 280 mm. an image point is obtained approximately 1.2 mm. in diameter, the intensity of which with the stated maximum energy of 1 watt is more than sufficient for direct observation of the picture on the screen. The construction according to the invention operates readily with potentials up to 10,000 volts with correspondingly increased electrical output, and in these cases also enables the plane of the image screen to be advanced much more closely to the anode, whereby correspondingly smaller images result with the same power of disintegration or relative definition. It is also readily possible to reproduce true to form diaphragm apertures of other than circular form, for example square diaphragm apertures, as the optical system operates symmetrically with respect to the tube axis, and it is also possible to increase or decrease the diaphragm and cathode radii in the same proportion, whereby larger or smaller image points are obtained with the same yield and same intensity of light.

The arrangement according to the invention is also suitable for tubes with magnetic deflection if considerable sharpness at the picture edges is required.

An additional advantage of the measure according to the invention is the minimizing of the transverse currents of the ray flowing to the plates, and accordingly a closer approximation towards an entirely powerless deflection.

The arrangement for reverse phase operation of the deflecting plates has been quoted merely as an example. Naturally all other known arrangements may be employed for this purpose.

5 The method according to the invention may be employed fundamentally in connection with all Braun tubes having an electron-optical system, preferably, however, with high-vacuum tubes and more particularly those according to the drawing.

I claim:

1. In a television cathode ray tube including an electrostatic electron optical image reproducing lens and at least one pair of cathode ray deflecting plates located near said lens: two auxiliary plates both mounted in the same cross-section of said cathode ray tube between said lens and said deflecting plates, and adapted to be supplied with a common adjustable bias to adjust the refractive power of said lens in a plane forming right angles with the direction of the cathode ray deflection effected by said deflecting plates.

2. In a television cathode ray tube including an electrode system comprising at least one electrode adapted to be supplied with a direct current potential, said electrode system comprising an electrostatic electron optical image reproducing lens and at least one pair of cathode ray deflecting plates located near said lens, two auxiliary plates both mounted in the same cross-section of said cathode ray tube between said lens and said deflecting plates, and a direct connection from said auxiliary plates to one of said electrodes for adapting said auxiliary plates to be supplied with the same potential which said electrode is adapted to be supplied with to correct the refractive power of said lens in a plane forming right angles with the direction of the cathode ray deflection effected by said deflecting plates.

3. In a television cathode ray tube including a cathode, an electrostatic electron optical image reproducing lens including an anode adapted to be supplied with a high positive potential with respect to said cathode and at least one pair of cathode ray deflecting plates located near said lens, two auxiliary plates both mounted in the same cross-section of said cathode ray tube between said lens and said deflecting plates and at right angles to said deflecting plates, and a direct connection from said auxiliary plates to said anode for adapting said auxiliary plates to be supplied with the same potential which said anode is adapted to be supplied with to correct the refractive power of said lens in a plane forming right angles with the direction of the cathode ray deflection effected by said deflecting plates.

4. In a television cathode ray tube including an electrostatic electron optical image reproducing lens: the combination with at least one pair of deflecting plates mounted inside said tube in axial consecution to said lens, two edges of each plate of said pair lying in a plane which forms right angles with the axis of said tube, said pair being adapted to be operated in counter-cadence, of two pairs of narrow auxiliary electrodes in which each auxiliary electrode is mounted along and adjacent to one of said edges which lies in a plane forming right angles with the axis of said tube and is directly connected to that one of said pair

of deflecting plates which it is located more remote from.

5. In a television cathode ray tube an electron optical reproducing lens formed by a tubular member co-axial with said cathode ray tube and an anode disc located in front of said tubular member, said tubular member being adapted to be supplied with a negative potential with respect to said anode disc, the spacing of said anode disc from the adjacent opening of said tubular member being at least equal to the diameter of said tubular member.

6. In a television cathode ray tube an electron optical image reproducing lens formed by a tubular member co-axial with said cathode ray tube and an anode disc located in front of said tubular member, said tubular member being adapted to be supplied with a negative potential with respect to said anode disc and furnished with a diaphragm mounted inside said tubular member in a cross-section thereof and having an aperture of at least the same diameter the cathode ray has in the cross-section of said tubular member wherein said diaphragm is mounted, the spacing of said anode disc from said diaphragm being at least equal to the diameter of said aperture.

7. In a television cathode ray tube an electron optical image reproducing lens formed by a tubular member co-axial with said cathode ray tube and an anode disc located in front of said tubular member, said tubular member being adapted to be supplied with a negative potential with respect to said anode disc and furnished with a diaphragm mounted in a cross-section of said tubular member at a distance at most equal to the radius of said tubular member from the edge of said tubular member facing said anode disc, said diaphragm having an aperture of at least the same diameter the cathode ray has in the cross-section of said tubular member wherein said diaphragm is mounted.

8. In a television cathode ray tube including electro-static cathode ray deflecting means: an electrode system consisting of axially aligned electrodes for causing the formation of an electrostatic electron optical image reproducing lens, said electrode system being located near said deflecting means in axial alignment therewith and at one side thereof, and including an anode located at the side of said system facing said deflecting means and consisting of two apertured discs and a small tube connecting the edges of the apertures in said discs to be axially traversed by the cathode ray.

9. In a television cathode ray tube including electro-static cathode ray deflecting means: an electrode system consisting of axially aligned electrodes for causing the formation of an electrostatic electro-optical image reproducing lens, said electrode system being located near said deflecting means in axial alignment therewith and at one side thereof and including in axial consecution a wide tube shaped member and an anode consisting of two apertured discs and a small tube connecting the edges of the apertures in said discs to be axially traversed by the cathode ray, said tube shaped member being adapted to be maintained negative relatively to said anode, said anode being located at the side of said system facing said deflecting means.

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