Dec. 31, 1940. K. SCHLESINGER 2,227,016

TELEVISION CATHODE RAY TUBE

Filed Feb. 5, 1937

Fig. 1

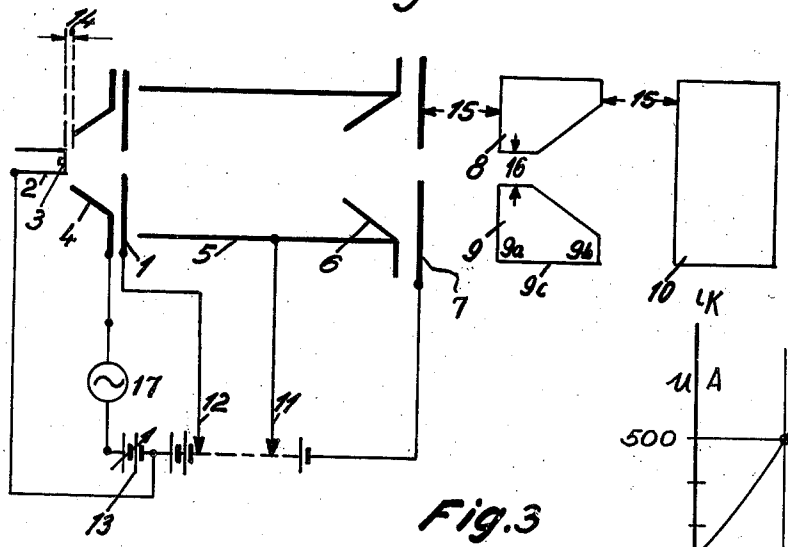



Fig. 3

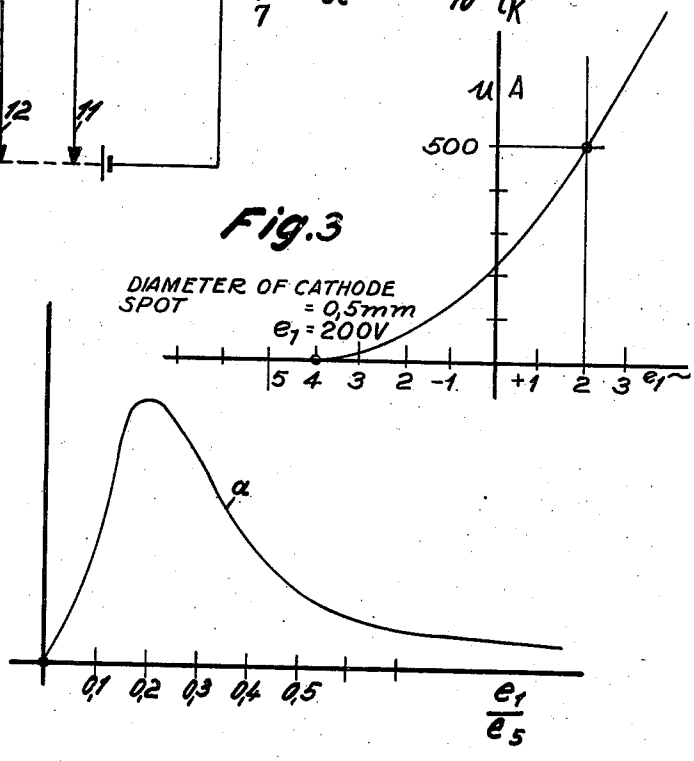



Fig. 2

Inventor:

Kurt Schlesinger.

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## TELEVISION CATHODE RAY TUBE

Kurt Schlesinger, Berlin, Germany, assignor, by mesne assignments, to Loewe Radio, Inc., a corporation of New York

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In Germany February 11, 1936

8 Claims. (Cl. 250—27)

The object of this invention is to provide a television tube with an electron-optical system, preferably one to be operated in a highly evacuated condition, which has the following peculiarities: A sensitive light control, a constant size of the image spot with all light intensities, exclusion of all ray current losses by suppression at diaphragms, adjustable pre-concentrator and image producing lens, insensitivity of the main lens against inclined incidence or rays.

The invention will be described with reference to the accompanying drawing, of which

Fig. 1 is a diagrammatic sectional elevation of the electrode system of a television tube designed in accordance with the invention, including a diagrammatic showing of certain essential circuits associated with the tube, whereas

Figs. 2 and 3 show certain curves which are characteristic for the operation of the tube.

Referring now to Fig. 1, the so-called "lid" is a member, by means of which the tube is divided into two discharge spaces. To the left of the lid there are situated the cathode 2 with the oxide surface 3 and a conical sheet metal member 4, which acts simultaneously as a control grid and as a pre-concentrator to the right of 1 there is situated the main lens, which is well spaced from 1 by means of a tubular member 5 and is composed of a conical sheet metal member 6 in conjunction with the anode 7. 8, 9, and 10 are deflecting plates.

The control of the ray intensity may take place by inserting in the lead connecting 4 and 13 the source 17 of a controlling voltage, e. g. the output of a radio receiver.

The tube may contain a diaphragm on the lid 1, of the aperture of which a reproduction is produced on the screen which can be sharply adjusted by means of the sliding tap 11. A diaphragm of this nature at 1, however, may also be omitted and the aperture of 1 may be made larger than the cross-section of the ray (2 mm. in diameter), oxide surface 3 being made small instead, and an image of the surroundings of 3 being produced on the screen to form the actual picture element.

If the potential of the lid 1 is varied with the assistance of the tap 12, the adjusted sharpness of the image point on the luminous screen remains unaltered. If, however, upon variations of 12 the current is maintained constant by simultaneous variation of the grid bias 13, there is to be observed at the luminous screen a variation in the light intensity approximately in accordance with Fig. 2, curve *a*. In this figure the potential quotient $e_1:e_5$ (lid potential against tubular member potential) has been entered as abscissa, and the light intensity of the image spot in the case of a constant ray current as ordinate. The dependency, being of the type of a resonance curve, is due to the fact that the structure 4/1 has an adjustable pre-concentrator action. If 1 has a low potential, the strength of the field between 1 and the conical member 4 is too weak to concentrate the electrons; if the potential of 1 is too high, the path of the electrons is almost independent therefrom, and the electrons entering the main lens 6 have a very wide angle of dispersion and are subject to considerable loss. By the adjustment of an intermediate value which is about ⅕ of the tube member potential $e_5$ the angle of dispersion at the lens aperture 6 is at a minimum. With this ratio results not only a considerable increase of intensity owing to elimination of the losses due to suppression at the diaphragms, but at the same time an increased sharpness of the image point. This is due to the fact that the reproduction performed by an imperfect electron lens is the better, the smaller the aperture angle may be which it is required to deal with. It can be observed that the by-light and stray light at the luminous screen disappear entirely upon that adjustment of 1 which results in the optimum light yield.

The invention makes use of the fact that the bias of a lid member 1 having a small aperture may be varied within wide limits without at the same time affecting the electron-optical conditions behind the lid. This is due to the fact that the walls of tubular member 5 are disposed at a practically infinite distance from the rays (see earlier Application 72,535, filed on January 7, 1935). The equipotential surfaces behind the line accordingly form substantially planes disposed perpendicular to the ray, and there occurs a pure acceleration in the direction of the rays, but no refractive effect.

The main lens 6, 7 likewise comprises a 45° cone having an inlet aperture of 7 mm. and a total length of only 10 mm. with an outlet aperture (aperture of the anode 7) amounting to 5 mm. in diameter. This lens is accordingly very "short" or "thin," and consequently has a very large potential gradient. In the case of a potential difference of, say, about two-thirds of the anode potential it amounts on an average in a normal television receiving tube with an anode potential of 3,000 volts to about 100–200 volts per mm. The applicant has found that thin lenses of this nature having strong gradients

differ very favourably from the known and conventional lenses, which are formed by the potential field in an open cylindrical tube 5 in conjunction with a biassed wall of the bulb. With these lenses the potential gradient is only about one-tenth of that mentioned, the refractive power being, in compensation thereof, distributed over a larger space (thick lenses). The operation of such lenses is very easily affected by any inclination of the rays and even by the smallest deviations from the central axis, such as may be caused by inexact assembly, inclined incidence of the rays, earth magnetism, etc. The thin lens is highly independent of directional faults.

The control of the light intensity takes place at the pre-concentrating conical member 4. This conical member is likewise a 45° cone having a 2 mm. diameter inlet aperture and a 10 mm. diameter outlet aperture. Its distance 14 from the hot cathode is important. It determines the penetration of the field of 1 towards the cathode and accordingly the bias 13 required. With the stated apertures and angles the distance from the mouth of the cone to the lid 1 amounts to about 5 mm. The bias of the lid member is governed by the pre-concentrator condition (of Fig. 2) in conjunction with the anode potential. In the case of a television tube for direct observation with a free length of ray amounting to 300 mm. it amounts to about 200 volts with a 3,000-volt anode potential and a tubular member potential of 1,000 volts. In order, therefore, with the grid bias to be able to remain substantially negative to avoid grid currents the distance 14 should not be made too large. In practice it is preferably .5–1 mm.

The light control of a tube of this nature takes place according to the characteristic curve shown in Fig. 3. As will be seen, it is very sensitive: 500 microamperes are completely modulated with approximately 5 volts. An important peculiarity of the tube is that this control leaves the size of the image point constant. This is due to the fact that the arrangement 3, 4, 1 acts as a "long grid." The equipotential surfaces in front of the cathode are, owing to the remoteness of the anode 1 and the weak field resulting therefrom, and further on account of the suitable shape of the field producer 4, already parallel to the emissive surface. The control accordingly takes up all parts thereof simultaneously. The control, therefore, is sensitive and the electron-optically visible cathode surface is always of constant size. The current in the tube may be modulated with grid potentials which pass slightly into the positive range, to the extent of about 3 volts.

In Fig. 1 the tube is shown with electrostatic deflection. In this connection, in agreement with earlier applications (for example: 694,135, filed October 18, 1933, and 754,048, filed Nov. 21, 1934), the least faults in deflection at the edge of the image have been obtained in those cases in which the distance 15 between the plates and their surroundings of different potential (anode, next pair of plates) is made to be at least three times as large as the minimum width 16 of a deflecting condenser. If the latter is equal to 5 mm., i. e., equal to the diameter of the aperture of the anode 7, there results as the preferred distance between the plates and their surroundings at least 15–20 mm. A deflecting plate may be produced particularly conveniently in the form of a closed conductive member from a piece of sheet metal. If the projections 9a, 9b, by means of which the plate 9 is mounted at a supporting member, are closed by a strip 9c, the entire structure 9—9c becomes a complete loop and may have the gas expelled therefrom by eddy current. Deflection of the push-pull type is essential if particular demands are placed on sharpness of the edges and rectangular shape of the line screen traced.

The degrees of sharpness of the image spot accomplished by the tubes in the presence of a diaphragm having a diameter of the aperture amounting to .5 mm. are set forth in the following table:

| Distance between anode and luminous screen | Length of the tubular member 5 | |
|---|---|---|
| | 50 mm. | 90 mm. |
| 100 | 05 | 02 |
| 200 | 1 | 05 |
| 400 | 2 | 1 |

The high control sensitivity of these tubes permits of the operation with direct carrier high frequency (use of the tube as a rectifier).

I claim:

1. In a cathode ray tube comprising means for producing, controlling, focussing and deflecting a cathode ray: a cathode, a frusto-conical electrode the smaller aperture of which is arranged close to said cathode at a distance of less than one millimeter, a diaphragm having a fine aperture in front of the larger aperture of said frusto-conical electrode and a long tubular electrode having a diameter at least ten times larger than said fine aperture close to said diaphragm on the side away from said cathode, said tubular electrode being closed by a second frusto-conical electrode the larger diameter of which is about equal to that of said tubular electrode and the smaller end of which is inside of it, and an anode consisting of a second diaphragm nearly closing the larger opening of said second frusto-conical electrode and having a larger aperture than the first diaphragm.

2. In a cathode ray tube comprising means for producing, controlling, focussing and deflecting a cathode ray: a cathode, a frusto-conical electrode the smaller aperture of which is arranged close to said cathode at a distance of less than one millimeter, a diaphragm having a fine aperture in front of the larger aperture of said frusto-conical electrode and a long tubular electrode having a diameter at least ten times larger than said fine aperture close to said diaphragm on the side away from said cathode, said tubular electrode being closed by a second frusto-conical electrode the larger diameter of which is about equal to that of said tubular electrode and the smaller end of which is inside of it, and an anode consisting of a second diaphragm nearly closing the larger opening of said second frusto-conical electrode and having a larger aperture than the first diaphragm, said first frusto-conical electrode being provided with a small negative bias against the cathode, said first diaphragm with a positive bias of about one-fifth of the bias of said tubular electrode, the latter bias being about one-third of the voltage of said anode.

3. In a cathode ray tube comprising means for producing, controlling, focussing and deflecting a cathode ray: a cathode, a frusto-conical electrode the smaller aperture of which is arranged close to said cathode at a distance of less than one millimeter, a diaphragm having a fine aper-

ture in front of the larger aperture of said frusto-conical electrode and a long tubular electrode having a diameter at least ten times larger than said fine aperture close to said diaphragm on the side away from said cathode, said tubular electrode being closed by a second frusto-conical electrode the larger diameter of which is about equal to that of said tubular electrode and the smaller end of which is inside of it, and an anode consisting of a second diaphragm nearly closing the larger opening of said second frusto-conical electrode and having a larger aperture than the first diaphragm, said first frusto-conical electrode being provided with a small negative bias against the cathode, said first diaphragm with a positive bias of about one-fifth of the bias of said tubular electrode, the latter bias being about one-third of the voltage of said anode, and means to adjust the bias of said first diaphragm.

4. A cathode ray tube comprising a cathode, a first anode consisting of an apertured diaphragm, a frusto-conical electrode mounted between said cathode and said anode, the smaller aperture of said frusto-conical electrode facing said cathode, an image screen, an electron-optical system for reproducing the aperture of said first anode on said screen, said electron-optical system comprising a second anode consisting of a diaphragm, a cylindrical electrode mounted between said first and said second anode, and a further frusto-conical metallic element mounted within said cylindrical electrode at its end facing said second anode, the diameter of the larger aperture of said further frusto-conical element being substantially equal to the diameter of said cylindrical electrode, the smaller aperture of said further frusto-conical element facing said cathode.

5. A cathode ray tube comprising a cathode, a first anode consisting of an apertured diaphragm, a frusto-conical electrode mounted between said cathode and said anode, the smaller aperture of said frusto-conical electrode facing said cathode, an image screen, an electron-optical system for reproducing the aperture of said first anode on said screen, said electron-optical system comprising a second anode consisting of a diaphragm, a cylindrical electrode mounted between said first and said second anode and having a diameter approximately equal to the diameter of the base of said frusto-conical electrode, and a further frusto-conical metallic element mounted within said cylindrical electrode at its end facing said second anode and being mechanically as well as electrically connected with said cylindrical electrode, the diameter of the larger aperture of said further frusto-conical element being substantially equal to the diameter of said cylindrical electrode, the smaller aperture of said further frusto-conical element facing said cathode.

6. In a television device: a cathode ray tube comprising a cathode, a pre-concentrating electron-optical system consisting of said cathode, a first apertured anode diaphragm and a frusto-conical electrode mounted between said cathode and said first anode, the smaller aperture of said frusto-conical electrode facing said cathode, an image screen, a further electron-optical system comprising a second apertured anode diaphragm, a cylindrical electrode mounted between said first and said second anode and having a diameter approximately equal to the diameter of the base of said frusto-conical electrode, and a further frusto-conical metallic element mounted within said cylindrical electrode at its end facing said second anode and being mechanically as well as electrically connected with said cylindrical electrode, the smaller aperture of said further frusto-conical element facing said cathode; means for deflecting the cathode ray beam produced in said cathode ray tube to scan said luminescent screen, means for supplying said first frusto-conical electrode with varying potentials to control the intensity of said cathode ray beam.

7. In a television device: a cathode ray tube comprising means for producing, controlling and focussing a cathode ray beam, said means comprising a cathode, a frusto-conical electrode the smaller aperture of which is arranged close to said cathode at a distance of less than one millimeter, a diaphragm having a fine aperture in front of the larger aperture of said frusto-conical electrode and a long tubular electrode having a diameter at least ten times larger than said fine aperture close to said diaphragm on the side away from said cathode, said tubular electrode being closed by a second frusto-conical electrode the larger diameter of which is about equal to that of said tubular electrode and the smaller end of which is inside of it, and an anode consisting of a second diaphragm nearly closing the larger opening of said second frusto-conical electrode and having a larger aperture than said first diaphragm; means for supplying said first frusto-conical electrode with controlling potentials, means for providing said first frusto-conical electrode with a small negative bias against said cathode, said tubular electrode with a positive potential of about one-third of the potential of said anode with respect to said cathode, said first diaphragm with a bias of about one-fifth of the bias of said tubular electrode with respect to said cathode, and means for deflecting said cathode ray.

8. In a television device: a cathode ray tube comprising means for producing, controlling and focussing a cathode ray, said means comprising a cathode, a frusto-conical electrode the smaller aperture of which is arranged close to said cathode, at a distance of less than one millimeter, a diaphragm having a fine aperture in front of the larger aperture of said frusto-conical electrode and a long tubular electrode having a diameter at least ten times larger than said fine aperture close to said diaphragm on the side away from said cathode, said tubular electrode being closed by a second frusto-conical electrode the larger diameter of which is about equal to that of said tubular electrode and the smaller end of which is inside of it, and an anode consisting of a second diaphragm nearly closing the larger opening of said first frusto-conical electrode and having a larger aperture than said first diaphragm; means for supplying said first frusto-conical electrode with controlling potentials, means for providing said first frusto-conical electrode with a small negative bias against said cathode, said tubular electrode with a positive potential of about one-third of the potential of said anode with respect to said cathode, said first diaphragm with a bias of about one-fifth of the bias of said tubular electrode with respect to said cathode, means for adjusting the bias of said first diaphragm and means for deflecting said cathode ray.

KURT SCHLESINGER.