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K. SCHLESINGER
ELECTRON OPTICAL SYSTEM
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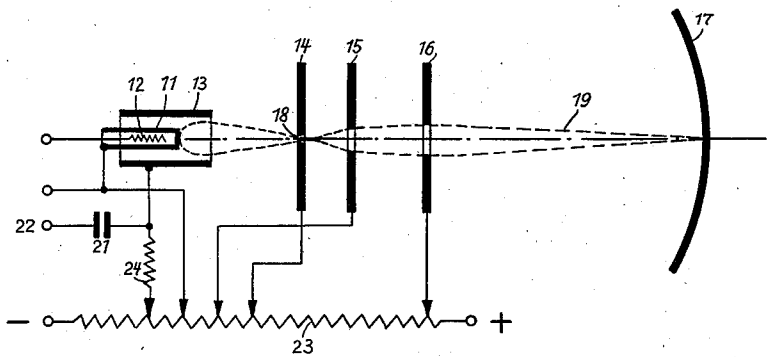


Fig. 1

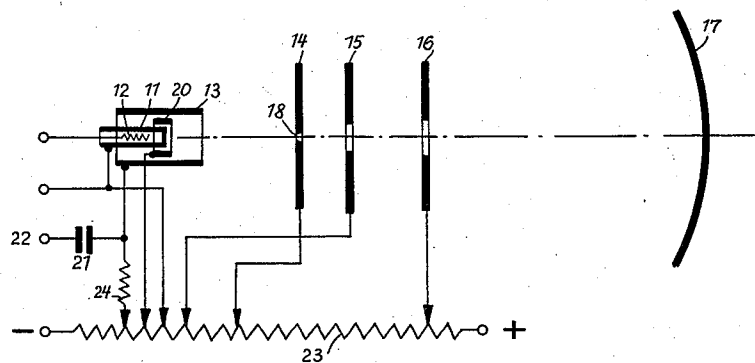


Fig. 2

Inventor:

Kurt Schlesinger

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ELECTRON OPTICAL SYSTEM

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

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5 Claims. (Cl. 250—27)

This application is a continuation-in-part of my copending application Serial No. 663,593 filed in the United States Patent Office on March 30, 1933. The present invention relates to cathode ray tubes as used for television and similar purposes in which the image point is moved over the screen and at the same time varied in intensity.

An object of the invention is a cathode ray tube which enables to produce image points or spots, the size and form of which are constant and are independent of their intensity.

A further object of the invention is to produce image points or spots of an exactly predetermined form and size.

A still further object is to produce image points or spots which are independent of the distribution of the emission on the cathode and in consequence also of the length of time for which the cathode has been in operation, so that the constancy of the image points or spots is maintained during the entire life of the tube.

It is an essential object of the invention that a preliminarily concentrated bundle of electron rays governed by space charge control is so projected by a subsequent or after-connected electron-optical system that the focus point of this bundle falls in the plane of the image screen.

Still further objects of the invention will be seen in the following description.

The invention may be more fully understood from the appended drawing, whereof—

Fig. 1 shows a part of a tube according to the invention and

Fig. 2 a modification of Fig. 1.

In the drawing, 11 is the equipotential cathode indirectly heated by the resistance heater 12 and provided at its right end with an electron emissive spot or coating. The usual Wehnelt cylinder 13 has a negative potential with respect to the cathode as indicated by a connection to the potentiometer 23. Between a target or screen 17 (preferably a fluorescent screen) and the cathode are arranged three apertured electrodes 14, 15 and 16. These electrodes are longitudinally spaced and axially aligned with the cathode 11 and Wehnelt cylinder 13, and the electrode 14 may be referred to as an "input anode" and the electrode 15 as an electrode intermediate the other apertured electrodes 14 and 16. (The deflecting plates and any additional electrodes which the tube may contain are not shown.) The electrode or input anode 14 is connected to a moderate positive potential, say $\frac{1}{3}$ of the full potential of the second anode 16

whilst the apertured electrode 15 is provided with a potential which, depending on the distances, forms and potentials of the other electrodes, may be slightly negative or positive relatively to the cathode 11. In the examples illustrated the electrode 15 is shown slightly positive with respect to the cathode, it being obvious from the figures that the potentials applied to the various electrodes may be varied by shifting the leads along the element 23 as indicated by the arrows on each of these leads.

By the action of the Wehnelt cylinder the cathode ray bundle (dotted lines 19) is concentrated upon the small aperture 18 of the apertured electrode or input anode 14 so that the rays have a crossing point at or in the vicinity of this aperture. According to the invention the subsequent or second electron-optical system focusses the bundle 19 on the screen 17 so that the bundle has two crossing points or points of convergence.

It is essential that the potential of the bundle entering the second electron-optical device be constant. Preferably the arrangement is so dimensioned, that the diameter of the bundle of rays falling on the aperture 18 is not greater than the (preferably very small) diameter of that aperture.

As explained above the tube is based on the conception that the second electron-optical system under all circumstances does not reproduce on the image screen the cathode itself, but the aperture of the input anode 14. Careful investigations have shown that this assumption is certainly correct, but only if applied to tubes which operate with relatively low strengths of ray current, and that when employing tubes with greater strengths of ray current (approximately more than $\frac{1}{2}$ milliamperes, and in particular more than 1 milliamperes) entirely different conditions prevail.

It was ascertained that the system in the case of tubes of this nature behaves in the same manner as if the radiating surface (i. e., the surface acting virtually as electron-emitting means) varied its distance from the electron-optical system in accordance with the intensity of the ray, viz., in such fashion that an increase in the intensity corresponds with an apparent withdrawal from and a decrease in the intensity with an apparent approach of the radiating surface towards the subsequent or after-connected electron-optical system, so that in point of fact in tubes of this nature the state of independence between intensity of the image point and sharp-

ness of the image point or spot is no longer ensured to full extent.

Accordingly the system illustrated in Fig. 1 is only able to supply an image point which is equally sharp in the case of every strength of light when the distance of the object point (i. e., the point to be reproduced) from the system is the same in the case of each intensity. As object point there may be regarded the point of intersection of the trajectories of the individual electrons comprising the cathode ray bundle between the cathode and the input anode 14. The position of this intersection point varies with changes in the intensity of the cathode rays. With the usual form of cathode, the main emission surface or level surface will in the case of strong or "bright" rays extend along the surface of the cathode, i. e., such level surface will coincide with the surface of the cathode, and the level surface in this position assumes the form of the cathode surface, but in the case of weak or "dark" rays the said level surface will differ greatly from the cathode surface. Thus, a variation takes place in the form of the level surface upon change over from the dark to the light condition, and accordingly also a shifting of the position of the object point which, as set forth above, is dependent on the form of the level surface. In consequence the tube, generally speaking, is unable to supply the image points or spot with the same sharpness in the case of every intensity. Although the variation in the diameter of the image point is relatively small upon change over from dark to light, the same is nevertheless found to be disturbing, particularly if the tube is employed for television purposes.

The cathode is preferably constructed as a flat surface, which is arranged exactly perpendicularly and symmetrically to the axis of the tube. In order to produce a completely flat emissive layer, it is convenient to furnish the front of the cathode with a recess, and to fill out this recess with the emissive material (for example barium or strontium oxide, or a mixture of these oxides), in such fashion that the surface of the emissive layer is situated in exactly the same plane as the surface of the equipotential plane. It is possible in this manner to employ considerable quantities of the highly emissive material, and thus to increase appreciably the life of the cathodes. The recess receiving the emissive layer may conveniently be provided with a rectangular form (corresponding with the form of the image point to be produced).

Now, it is very difficult, however, to provide a cathode with exactly defined surface form by the use of purely mechanical means.

I have found that it is possible by generation of a suitable electrical field in the immediate vicinity of the cathode to provide emissive surfaces (referred to in the following as "virtual cathode surfaces"), which behave in exactly the same manner as if a cathode with an exactly defined geometric surface were employed. The requisite field according to the present invention may be produced in many different ways, for example by applying a suitable potential between a preferably annular additional electrode arranged in the vicinity of the cathode surface and the cathode itself.

On the other hand it is possible with the arrangement according to the invention to compensate the error entirely when the virtual cathode surface is varied in accordance with the

particular strength of ray current, which may be done without difficulty by corresponding variation of the field defining the virtual surface.

A cathode ray tube provided with this additional electrode 20 is shown in Fig. 2, the remaining elements of the tube being the same as in Fig. 1.

If there is imparted to the electrode 20 a weak negative bias as compared with the cathode 1, a virtual cathode surface results, which possesses a concave form and behaves exactly in the manner of a cathode surface, which is exactly defined geometrically, but from a mechanical standpoint is extremely difficult to produce with the requisite precision. The arrangement has the additional advantage that the structure of the virtual surface is also capable of being varied without difficulty in connection with finished tubes, if necessary during the operation. This may be accomplished by imparting an intensity-controlling variable potential to one of the cylindrical electrodes 13, 20, for instance to the electrode (Wehnelt cylinder) 13, as by means of the elements 21, 22, 24.

The arrangement according to the invention possesses the following essential advantages.

1. The intensity control and the concentration of the ray are separated, and are, therefore, entirely independent.

2. The working interval is considerably extended; it is possible to obtain a control ranging from the maximum intensity of light capable of being obtained down to absolute darkness.

3. The form of the image point or spot may be made independent of the distribution of the emission on the cathode, and in consequence also of the length of time for which the cathode has been in operation, so that the constancy of the image point or spot is maintained during the entire life of the tube.

4. Since the electrode 14 screens off the cathode against the field of the after-acceleration anode 16, the life of the cathode is considerably increased.

5. The energy required for controlling the tube is extremely small.

I claim:

1. In a cathode ray tube comprising an indirectly heated equi-potential cathode, a Wehnelt cylinder surrounding said cathode, a screen on to which a bundle of cathode rays is to be focused, three apertured electrodes spaced longitudinally between said cathode and said screen and in co-axial alignment with said cathode and Wehnelt cylinder, means to impart to the one of said electrodes adjacent the cathode and Wehnelt cylinder a moderate positive potential with respect to said cathode, means to impart to the second of said apertured electrodes from said cathode and Wehnelt cylinder a potential substantially equal to the potential of said cathode, and means to impart to the third of said apertured electrodes a high positive potential with respect to said cathode.

2. In a cathode ray tube comprising an indirectly heated equi-potential cathode to emit electrons, a Wehnelt cylinder surrounding said cathode to form said electrons into a bundle of cathode rays, and a screen on to which the bundle of said rays is to be focused, three apertured electrodes positioned with their apertures in co-axial alignment and spaced one from another between said Wehnelt cylinder and said screen, the apertured electrode nearest said Wehnelt cylinder having a very small aperture, means to impart

to the said adjacent electrode a moderate positive potential with respect to said cathode, means to impart to the intermediate electrode of said three electrodes a potential close to the potential of said cathode but lower than said moderate potential, and means to impart to the remaining of said three electrodes a high positive potential with respect to said cathode, so that the electron optical system formed by said three electrodes projects an image of said small aperture on to said screen.

3. In a cathode ray tube comprising an indirectly heated equi-potential cathode having an electron emissive area, a Wehnelt cylinder having a negative bias with respect to said cathode, and a screen adapted to receive a focused bundle of cathode rays from said cathode, an electrode consisting of an annular inner cylinder which is surrounded by said Wehnelt cylinder and itself closely surrounds the electron emissive area of said cathode, three apertured electrodes between said Wehnelt cylinder and said screen with their apertures in axial alignment with the electron emissive area of said cathode and said Wehnelt cylinder, means to impart to said cylinder which closely surrounds the electron emissive area of said cathode a slight negative potential with respect to said cathode, means to apply a potential substantially equal to that of the cathode to the intermediate electrode of said three apertured electrodes, means to apply a moderate potential to the apertured electrode between said intermediate electrode and said Wehnelt cylinder, and means to apply a high positive potential to the remaining electrode of said three apertured electrodes.

4. In a cathode ray tube comprising an indirectly heated cathode, a Wehnelt cylinder surrounding said cathode and a screen on to which a bundle of cathode rays may be focused, a cylindrical electrode surrounding said cathode and positioned between said cathode and said Wehnelt cylinder and three apertured electrodes with their apertures in co-axial alignment with one

another and with said cathode, Wehnelt cylinder and said cylindrical electrode, means to impart to said cylindrical electrode surrounding said cathode a potential negative with respect to said cathode and positive with respect to said Wehnelt cylinder, means to impart to the one of said three apertured electrodes adjacent the Wehnelt cylinder a moderate positive potential with respect to said cathode, means to maintain the next adjacent apertured electrode at substantially cathode potential, and means to maintain the remaining electrode of said three apertured electrodes at a high positive potential with respect to said cathode.

5. In a cathode ray tube comprising an indirectly heated equi-potential cathode, a Wehnelt cylinder surrounding said cathode and a screen on to which a bundle of cathode rays may be focused, a cylindrical electrode co-axial with said cathode and Wehnelt cylinder and between said cathode and said Wehnelt cylinder and three apertured electrodes axially aligned with said cathode, cylindrical electrode and Wehnelt cylinder, and longitudinally spaced between said Wehnelt cylinder and said screen, the aperture of the one of said three electrodes closest to said Wehnelt cylinder being a small beam limiting aperture, means to impart to said cylindrical electrode and said Wehnelt cylinder negative biases with respect to said cathode so as to focus electrons emitted from said cathode upon said limiting aperture, means to impart to said Wehnelt cylinder a beam intensity controlling variable potential, means to impart to the said one of said three apertured electrodes a moderate positive potential with respect to said cathode, means to impart to the electrode of said three apertured electrodes nearest said screen a high positive potential with respect to said cathode and means to impart to the electrode between the other two of said three electrodes a potential which is approximately cathode potential.

KURT SCHLESINGER.