Aug. 3, 1954 D. E. NORGAARD 2,685,660

TELEVISION TUBE

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Fig. 1.

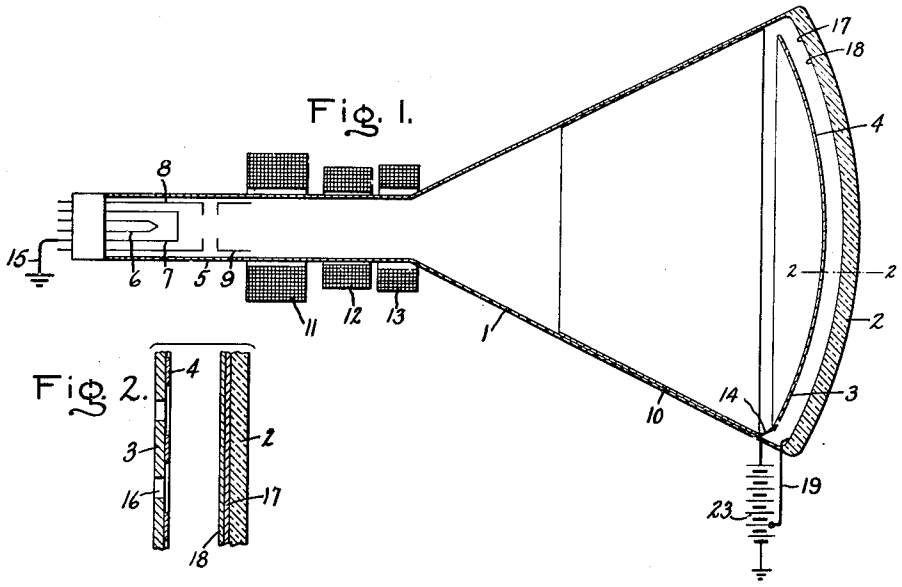
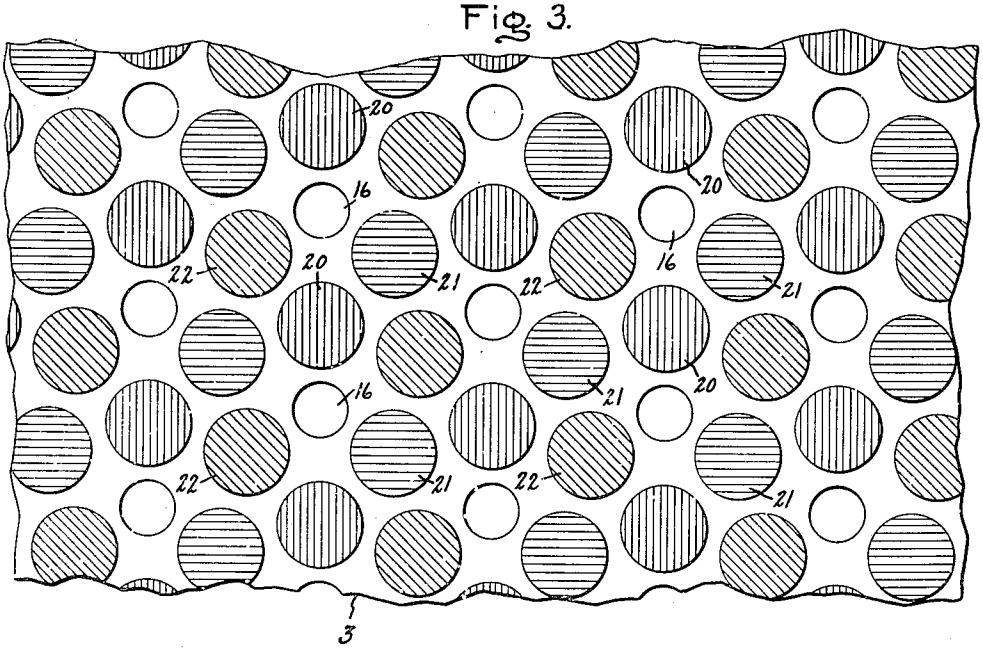


Fig. 2.

Fig. 3.



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UNITED STATES PATENT OFFICE

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TELEVISION TUBE

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7 Claims. (Cl. 315—12)

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My invention relates to cathode-ray tubes and particularly cathode-ray tubes which are used in television receivers or monitors.

Cathode-ray tubes have been proposed for use in color television receivers which perform color selection by allowing an electron beam to pass through a multi-holed mask placed in register with a glass plate having corresponding groups of dots of color-producing phosphors. Selection of color is achieved by synchronous deflection of the beam prior to scanning deflection in order to vary the direction of arrival of the beam at the mask so that the desired color phosphor is excited by portions of the beam which pass through the holes in the mask. Among the many problems presented in the construction and use of such a tube is the problem of accurate registry of the masking plate and the color dot clusters. This problem is complicated by the fact that with flat parallel surfaces parallax must be compensated by the design of the mask and the deposited color dot clusters. This parallax arises because the scanning by the beam is performed in a non-orthogonal manner. The problem of thermal expansion over the normally encountered ambient temperature range also requires compromising the operation of such a tube. Again, the amount of brightness available from such a tube is limited because the area of the mask through which the electron beam may pass is theoretically not greater than 33⅓%, and is of the order of 10% to 15% when practical operating conditions are taken into consideration. Accordingly, one object of my present invention is to eliminate the problem of registry in a cathode-ray tube employed for the production of color television pictures.

It is another object of my invention to provide a new and improved cathode-ray tube which will produce brighter television pictures.

It is still another object of my invention to provide a new and improved cathode-ray tube for use in the reproduction of color television pictures through the use of secondary emission electrons to excite different color-producing phosphors.

In accordance with one embodiment of the present invention, a cathode-ray tube, having a transparent, electrically conducting end wall and a perforated electrode positioned in spaced relation with the end wall, has different color-producing phosphors supported on the surface of the electrode adjacent the end wall. A transparent conductive secondary electron-emitting coating is supported on the inner surface of the

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end wall and is excited by an electron beam passing through the perforations in the phosphor-bearing electrode, the secondary emission being utilized selectively to excite different of the color-producing phosphors in accordance with the color-synchronizing components of a received television signal.

The features of my invention which I believe are novel are set forth with particularity in the appended claims. My invention, itself, however, together with further objects and advantages thereof, may best be understood by reference to the following description taken in connection with the accompanying drawing in which Fig. 1 shows in schematic form a cathode-ray tube embodying my invention, Fig. 2 is an enlarged sectional view of a portion of the cathode-ray tube of Fig. 1, and Fig. 3 illustrates one arrangement of phosphors employed in a cathode-ray tube of the type of Fig. 1.

Referring to the drawing, in Fig. 1 I have shown a cathode-ray tube comprising an envelope 1, having a spherical viewing plate 2, which may be, and preferably is, the glass end wall of the cathode-ray tube. Concentric with the spherical end wall, there is provided a spherical mask structure comprising a perforated electrode 3 having arranged in regular recurring symmetrical patterns on its convex surface different color-producing phosphors or dot clusters 4. Supported within a neck 5 of the cathode-ray tube is an electron gun comprising a heater or filament 6, a cathode or electron-emitting surface 7, a control electrode 8, and a focussing anode 9. The usual second anode of the cathode-ray tube may comprise a conductive coating 10 along the inner wall of the large portion of the tube.

Surrounding neck 5 of the cathode-ray tube is a yoke 11 of a conventional type utilized for offsetting the beam in accordance with the color-synchronizing components of a received color television signal to obtain an effective new starting point of the beam, prior to the scanning deflection, synchronous with the color-synchronizing components of the signal. Through the coordinate operation of yoke 11 and convergence yoke 13 direction of arrival of the beam at the electrode 3 is varied in accordance with the color-synchronizing component so that the angle at which the beam enters the perforations in electrode 3 varies with the color to be produced. Also, surrounding neck 5 is a deflection yoke 13.

In operation of the cathode-ray tube 1, a high unidirectional voltage is supplied to the anodes 9

and 10 from a source illustrated conventionally as a battery 23. Preferably, electrode 3 is maintained at the same potential as anode 10 by a conductive connection 14 internally of the tube. Cathode 7 is connected to ground by a conductor 15.

In Fig. 2 there is illustrated an enlarged sectional view of a portion of the end wall 2 and the phosphor-bearing electrode 3. The electrode 3 is provided with symmetrically spaced apertures 16, the phosphors of the dot clusters 4 symmetrically surrounding apertures 16 in accordance with a pattern of the type described later in connection with the discussion of Fig. 3. The inner surface of end wall 2 is coated with a first layer 17 of transparent conductive material such as, for example, a thin tin chloride film which is evaporated on the glass end wall of the tube. The conducting surface 17, in turn, supports a layer 18 of secondary electron-emitting material. Any suitable transparent secondary electron-emitting material which obtains a secondary emission ratio of the order of 5 or 10 to 1 may be used to form coating 18 and may be applied to surface 17 by evaporating the material and condensing it on surface 17. Materials which I have found suitable for such a coating include magnesium oxide, magnesium fluoride, aluminum oxide, and calcium fluoride. The conductive coating 17 is supplied with a positive unidirectional potential intermediate the potential of electrode 3 and the cathode 7. This potential may be obtained from the unidirectional source 23 by means of a conductor 19, as illustrated in Fig. 1.

In Fig. 3 I have illustrated one type of phosphor arrangement suitable for use in constructing a phosphor-bearing electrode 3. This figure, which illustrates a portion of the electrode 3 facing end wall 2, shows the arrangement of apertures 16 in a symmetrical hexagonal pattern, adjacent apertures being separated by the same distance. Color dots 20, 21, 22 for the red, blue, and green phosphors respectively are positioned at equal angles with respect to each hole 16. In one phosphor-bearing electrode constructed as illustrated in Fig. 3, the holes 16 were 5 mils in diameter and spaced 19 mils center to center. The color dots were approximately 8 mils in diameter and each dot was centered at an 8-mil radius from the center of its respective hole or aperture 16.

In the cathode-ray tube described above, the center of the spherical mask or electrode structure 3 and of concentric spherical end wall 2 is located at the center of deflection in the deflection yoke 13. In operating the cathode-ray tube, the electrode 3 is preferably maintained at the high potential of the second anode 10, a unidirectional voltage of the order of 10,000 volts. The conducting layer 17 on the inside of end wall 2 is operated at a potential with respect to the potential of cathode 7 which will give maximum secondary emission yield. Usually, this potential is of the order of 400 to 600 volts. The electrons in the primary beam from cathode 7, after rotation through the action of the beam rotating yoke 11, penetrate the apertures or holes 16 and are decelerated by the retarding field between electrode 3 and secondary emission surface 18 so that they strike the secondary emission surface with an intermediate velocity of the order of 500 volts. The field between the two concentric surfaces 3, 17 has a uniform gradient so that a negligible effect on focus is produced. Moreover, this field is in such a direction as to accelerate the secondary electrons liberated by the primary beam so that they strike electrode 3 in a position opposite the excited surface with a velocity which is only 500 volts less than the velocity of the initial beam. It has been noted that the majority of secondary electrons have very small initial velocities in random directions so that there is a slight spreading of the beam because of this effect.

Since each aperture 16 in electrode 3 is surrounded by color-producing dots of phosphor, color selection is achieved by controlling the angle at which the primary beam enters the apertures 16. Thus, dependent upon the angle at which the beam enters a particular aperture 16, excitation of radially corresponding areas of the secondary emitting surface 18 and subsequent radial acceleration toward the proper color dot on the front surface of electrode 3 is effected to excite the color dot by the secondary electrons. It is apparent that since each hole in the mask is surrounded by identical clusters of color dots all in proper register on the same metal plate with the proper hole, the problem of register is nonexistent.

From an analysis of the geometry involved, it will be seen that electrons which pass through the holes 16 in electrodes 3 and into the decelerating field must strike the secondary surface at a point opposite the phosphor dot to be excited. Because of the deceleration of the electrons between electrode 3 and surface 18, electrons penetrating an aperture 16 at an angle differing from the normal to the surface of electrode 3 follow curved paths and strike surface 18 approximately twice as far from the terminus of this normal on surface 18 as would be the case if the electron trajectories were straight lines in the region between electrodes 3 and 18. As a result, the deflection required to be given to the beam to accomplish color selection is considerably reduced over color television tubes which use a multiholed mask placed in register with a plate upon which are positioned the color-producing phosphors. My improved structure, therefore, minimizes the amount of power required to deflect the primary electron beam to obtain color selection in accordance with the color-synchronizing components of the received color television signal.

Many important advantages in my color television tube result from the use of spherical surfaces for the electrode 3 and the conducting layer 18. Among these are included the fact that the average direction of arrival of the beam at the electrode 3 is normal to the surface and all holes and color dot clusters have identical geometry. Again, this construction simplifies the problem of maintaining uniform electron focus over the entire scanned area and permits more linear scanning deflection to be obtained than where flat surfaces are employed.

One radius of curvature which I have found satisfactory for a cathode-ray tube constructed in accordance with my invention is approximately 24 inches for a tube having an end wall 16 inches in diameter.

While I have described my invention in conjunction with a color television tube, the principles thereof may be used likewise in conventional cathode-ray tubes known as "black and white" tubes. By suitably arranging the holes and the phosphors on the electrode 3 of such a tube, an improvement in brightness of the order of four times is achieved by employing a secondary elec-

tron-emitting material having a secondary emission ratio of 5.

While my invention has been described by showing a particular embodiment thereof, it will be understood that numerous modifications may be made by those skilled in the art without departing from the invention. I, therefore, aim in the appended claims to cover all such modifications and variations as come within the true spirit and scope of my invention.

What I claim as new and desire to secure by Letters Patent of the United States is:

1. A cathode-ray tube comprising an envelope having a transparent end wall, an electron gun supported within said envelope for projecting electrons toward said end wall, a transparent conductive secondary electron-emitting coating on the inner surface of said end wall, and a perforated electrode positioned between said end wall and said gun, said electrode being adjacent said end wall and spaced therefrom and having a phosphor on its surface facing said end wall whereby secondarily emitted electrons from said coating may excite said phosphor.

2. A cathode-ray tube for reproducing color television signals comprising an evacuated envelope having a transparent end wall and a cathode, said end wall having a transparent conductive coating on its inner surface, a secondary electron-emitting material supported on said coating, a perforated electrode supported between said cathode and said wall, said electrode having different color-producing phosphors supported on its side adjacent said end wall and arranged in a symmetrically recurring pattern relative to the perforations of said electrode, means for maintaining said electrode at a high unidirectional potential relative to said cathode and said coating at a unidirectional potential intermediate those of said cathode and said electrode, whereby electrons from said cathode are accelerated toward said electrode to pass through said perforations and strike said material and secondary electrons emitted by said material are attracted to said electrode to excite said phosphors, and means intermediate said cathode and said electrode for controlling the angle at which said beam passes through said perforations selectively to excite said phosphors.

3. A picture tube for the reproduction of color television signals comprising an evacuated envelope having a transparent end wall, a conductive secondary electron-emitting coating on the inner surface of said end wall, an electron beam source, means for directing a beam of electrons toward said wall, an electrode positioned in the path of said electrons adjacent said end wall, said electrode having symmetrically arranged perforations therein, different color-producing phosphors supported on said electrode on the side adjacent said end wall, said phosphors being arranged symmetrically relative to said perforations, means for maintaining said electrode at a potential positive relative to said electron means and for maintaining said coating at a potential intermediate the potentials of said electrode and said electron means whereby secondary electrons emitted by said coating when excited by electrons passing through said perforations are directed to said electrode, and means for controlling the angle at which said beam of electrons passes through said perforations selectively to control the excitation of said phosphors.

4. A cathode-ray tube for reproducing color television signals comprising an evacuated envelope having a transparent end wall and a cathode, said end wall having a transparent conductive coating on its inner surface, a secondary electron-emitting material supported on said coating, a perforated electrode supported between said cathode and said wall, said electrode having different color-producing phosphors arranged in a symmetric recurring pattern relative to the perforations on its side adjacent said end wall, means for maintaining said end wall at a potential positive relative to said cathode and said electrode at a potential positive relative to said end wall whereby electrons from said cathode are accelerated towards said electrode to pass through the perforations therein and strike said end wall and secondary electrons emitted by said material are attracted to said electrode, means for offsetting the beam of electrons from said cathode to control the angle at which said electrons enter said perforations in accordance with the color-synchronizing components of a received color television signal, the position of the different color-producing phosphors on said electrode being arranged relative to said angle of the electron beam to reproduce a color television picture in accordance with a received signal.

5. A cathode-ray tube for reproducing color television signals comprising an evacuated envelope having a transparent end wall and a cathode, said end wall having a conductive coating of tin chloride on its inner surface, a transparent coating of secondary electron-emitting material deposited on said tin chloride coating, a perforated electrode supported between said cathode and said end wall, said electrode having different color-producing phosphors arranged in symmetrically recurring patterns relative to the perforations therein, means for maintaining said electrode at a unidirectional potential positive relative to said end wall and said cathode, the potential of said end wall relative to said cathode being sufficiently positive that electrons from said cathode accelerated by said electrode penetrate the perforations therein and strike said material to emit secondary electrons therefrom, the potential difference between said conductive coating and said electrode being such as to cause emitted secondary electrons to strike said electrode with sufficient force to excite the phosphors thereon, and means for varying the angle of incidence of electrons from said cathode into the perforations in said electrode in accordance with the color synchronizing components of a color television signal selectively to energize said phosphors.

6. A cathode-ray tube comprising an evacuated envelope having a spherical end wall and a cathode, said end wall having a transparent conductive coating on its inner surface, a transparent secondary electron-emitting material supported on said coating, a spherically shaped perforated electrode supported between said cathode and said wall, said electrode having different color-producing phosphors arranged in a symmetrically recurring pattern relative to the perforations therein, said phosphors being supported on the side of said electrode adjacent said end wall, means for establishing a retarding field between said electrode and said end wall whereby electrons from said cathode are accelerated towards said electrode to pass through the perforations therein and strike said end wall and secondary electrons emitted by said material are attracted

to said electrode, means for offsetting the beam of said electrons from said cathode to control the angle at which said electrons enter said perforations in accordance with a predetermined color effect, means for focusing electrons from said cathode, and means for deflecting electrons from said cathode repeatedly to pass said electrons across said electrode in a predetermined pattern, the center of the radius of curvature of said end wall and said electrode being substantially coincident with the center of said deflecting means.

7. A cathode-ray tube comprising an evacuated envelope having a spherical end wall and a cathode, said end wall having a transparent conductive coating on its inner surface, a secondary electron-emitting material supported on said coating, a spherically shaped perforated electrode supported between said cathode and said wall, said electrode having a phosphor supported on its side adjacent said wall, means for establishing a retarding field between said electrode and said end wall whereby electrons from said cathode are accelerated towards said electrode to pass through the perforations therein and strike said end wall and secondary electrons emitted by said material are attracted to said electrode, scanning means for repeatedly deflecting electrons from said cathode across said electrode, the center of the radius of curvature of said end wall and said electrode being substantially coincident with the center of said scanning means.

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