ABSTRACT: A cathode-ray tube for a color television receiver comprising three electron guns, a shadow mask having a plurality of holes, a shadow mask lens electrode arranged in the vicinity of said shadow mask and having electrically conductive portions in opposed relation to the holes in said shadow mask and a fluorescent screen, whereby an electron lens is formed in each hole in said shadow mask so that an electron beam from each of said electron guns may be subjected to focusing action at any position between each of said holes and said shadow mask lens electrode.
FIG. 7

FIG. 9a

FIG. 9b

FIG. 8

FIG. 10a

FIG. 10b

INVENTORS
TAKEO SEKI
MASAO SUGAWARA
SACHIO TAKAI
SACHIO MONOGAKI
MASAKAZU FUKUSHIMA

BY

ATTORNEY
FIG. 13b

FIG. 14a

To high-voltage rectifier tube

Boost voltage

FIG. 14b

To high-voltage rectifier tube

Boost voltage

INVENTORS

TAKEO SEKI
MASAO SUZUKA
SHUKO TAKI
SABURO HAGISAKI
Masakazu Fukushima

BY

Paul M. Craig, Jr.
ATTORNEY
COLOR TUBE HAVING SHADOW MASK LENS ELECTRODE

This invention relates to a cathode-ray tube for a color TV receiver and more particularly to improvements of a cathode-ray tube for a color TV provided with a shadow mask functioning as an electron lens.

In a conventional cathode-ray tube used so far in a color TV receiver, the utilization factor of the electron beam is, in general, lower compared with a black-and-white cathode-ray tube because of the presence of the shadow mask. This lowers the brightness on the screen. It will, therefore, be necessary to increase the diameter of each hole in the shadow mask to increase the utilization factor of the electron beam and brightness on the screen. It is also required to strongly focus the electron beam after it has passed through the shadow mask and apply it exactly to each spot of fluorescent element. In order to fit this need, there have been several methods proposed as a solution of this problem. For example, an electron lens may be formed in front of the fluorescent screen in a cathode-ray tube by means providing acceleration of the electron beam in the region between the shadow mask and fluorescent screen.

In actual application, however, some disadvantages may be created by the aforementioned solution. For example, the reproduced image on the screen will become indistinct to a great degree because of impact of the secondary electrons which are produced in the shadow mask by impact of the primary electron beam, emitted therefrom, accelerated further and dispersed before impact with the fluorescent screen because the potential of the shadow mask referenced to the cathode potential becomes one-third the potential of the fluorescent screen. The disadvantages also include decrease of the electron beam current.

One of the objects of the present invention is to increase the utilization factor of the electron beam by means of increasing the area of each hole in the shadow mask.

Another object of the present invention is to make the beam spot smaller by forming an electron lens in each hole in the shadow mask without causing the electron beam current to decrease and without considerably lowering the shadow mask potential with respect to the potential of the fluorescent screen.

The manner in which these objects are attained is to permit each of the holes in the shadow mask to form an electron lens by means of increasing the area of said hole, providing an electrode having or not having holes (to be referred to hereinafter as a shadow mask lens electrode), said electrode being electrically insulated from and located close to said shadow mask and giving a little potential difference between said shadow mask and said shadow mask lens electrode. As a result, the utilization factor of the electron beam can be improved and the electron beam can be strongly focused through said electron lens. This causes the fluorescent screen to become brighter and a clean natural color picture of high color purity can be reproduced on the screen.

One of the means suggested in the past for obtaining an electron lens by using a shadow mask lens electrode is to use a shadow mask lens electrode having holes arranged so that the center of each said hole is on the perpendicular passing through the center of the corresponding hole in the shadow mask, that is, said holes in the shadow mask lens electrode being arranged coaxially with the corresponding holes in the shadow mask, said shadow mask lens electrode being applied with a potential slightly lower or higher than the shadow mask potential thus forming an electron lens in that space.

In this case, however, there are some difficulties in application. For example, sparks are often caused because a considerably high potential difference is required between the shadow mask lens electrode and the shadow mask to obtain a sufficient degree of focusing action for the electron beam. The reason for requiring such a very high potential difference between the shadow mask lens electrode and the shadow mask is that the electric field produced in the space between the holes of said shadow mask and said shadow mask lens electrode provides a focusing action in some portions but a diverging action in other portions, and the resultant focusing action is obtained from only this small difference between said focusing and diverging actions.

This invention provides a sufficiently strong focusing action affected on the electron beam with an improved construction of the shadow mask electrode designed so as to eliminate the aforementioned disadvantage by removing any possibility of production of an electric field, which may diverge the electron beam, from said shadow mask. The shadow mask lens electrode and also provides a low potential difference between said shadow mask and said shadow mask lens electrode, thus obtaining a sufficiently strong focusing action affected on the electron beam.

The first method of improving construction of the shadow mask lens electrode is to use a holeless shadow mask lens electrode and make the thickness of said electrode extremely thin, in the order of microns. By applying a potential slightly higher than the shadow mask potential, the electric field that is produced around each hole in the shadow mask causes the electrons in the beam to be accelerated in the direction of a line accessing the axis of the hole, thereby, the electron beam can be strongly focused.

The second way of improving construction of the shadow mask lens electrode is to use a mesh which is much finer than the shadow mask. The electron beam can efficiently pass through said mesh. If, in this case, potentials are applied to the shadow mask holes and the shadow mask lens electrode in the manner similar to the aforementioned first method, the field distribution in the space between them will be also identical to that of the previous method, thereby, the electron beam will be strongly focused.

In some cases, the second method is more advantageous than the first method because there will be no diffraction of the electron beam caused in the thin film layer.

The third method of improving construction of the shadow mask lens electrode is to provide an electrode plate having holes which are not extraordinarily smaller than the holes of the above-mentioned shadow mask, said holes at least partially coinciding with the holes of said shadow mask when observed in parallel with the direction of the normal axis which passes through the center of one of the holes of the shadow mask and arranged so that the center of each said hole is located at each vertex of a regular polygon the center of which is on the axis of the respective hole in the shadow mask. By applying the same potentials as that applied in the aforementioned first method to the shadow mask and shadow mask lens electrode of the above-mentioned structure, almost all electrons in the electron beam can be accelerated everywhere in the direction of a line accessing the center of each hole of the shadow mask in the same manner as described above. Thus, a sufficiently strong focusing action can be expected in the third method similarly to the previous methods. Most portions of the shadow mask lens electrode coinciding with holes of the shadow mask, when observed in parallel with the direction of the normal axis which passes through the center of one of the holes of the shadow mask, are holes. The remaining portions are the conductive portions. All these conductive portions including that located extremely close to the axis of the hole of the shadow mask provide electric fields so that lines of electric force may be diverged almost radially to conductive portions around the holes of said shadow mask. The electron beam passing through a hole having such an electric field distribution can be focused everywhere.

As a modification of the third method, a construction, in which additional holes considerably smaller than holes of the shadow mask are provided so that these holes are coaxially located on each of the portions of the shadow mask lens electrode, said each portion coinciding with a corresponding hole of the shadow mask when viewed in parallel with the direction
of the normal axis which passes through the center of one of the holes of the shadow mask, may be applied. This modified method is rather more complicated in construction than the previous methods but with this method it is possible to further slightly improve the utilization factor of the electron beam.

The aforementioned objects and other objects and advantageous features of the present invention will become more apparent from consideration of the following description when taken in conjunction with the accompanying drawings, in which:

FIG. 1 shows a diagrammatic form an embodiment of a cathode-ray tube for a color television according to this invention;

FIG. 2, and FIG. 3, show details of a shadow mask of the embodiment according to this invention;

FIG. 4 shows a sectional view at IV-IV of the construction of FIGS. 2 and 3;

FIG. 5 shows a section to illustrate distribution of lines of electric force in the construction of FIGS. 2 and 3;

FIGS. 6a, and 6b and 7 show relationship between arrangement of the electrode according to the present invention and voltage to be applied;

FIG. 8 shows in a concrete form an embodiment of a cathode-ray tube for a color TV receiver using construction shown in FIG. 2;

FIGS. 9a and 9b are a top plan view and a side sectional view, respectively, of another embodiment of the invention;

FIGS. 10a and 10b are a top plan view and side sectional view, respectively, of another embodiment of the present invention;

FIGS. 11a and 11b shows a sectional view of the construction of FIG. 10 illustrating distribution of lines of electric force;

FIGS. 12a and 12b are detail views of further embodiments of the present invention;

FIGS. 13a and 13b illustrate an operable embodiment of a cathode-ray tube for a color TV receiver using the construction shown in FIG. 10; and

FIGS. 14a and 14b shows in a diagrammatic form an embodiment of this invention illustrating means for supplying voltage.

Referring now to FIG. 1 which shows a diagrammatic section of an embodiment of a cathode-ray tube for a color TV receiver according to the present invention, 1 is an electron gun, 2 is an electron beam, 3 is a deflection coil, 4 is a fluorescent color screen in contact with a conductive layer 4' and 5 is an anode.

Construction and functioning of these parts are identical to that of a conventional color cathode-ray tube of the three gun shadow mask system publicly known so far. Six is a lens mask located near the fluorescent color screen 4 similarly to the shadow mask used in the aforementioned conventional color cathode-ray tube and consists of a shadow mask and a shadow mask lens electrode arranged extremely close to said shadow mask.

FIG. 2 is a plan view of said lens mask 6 viewed from the electron gun 1.

FIG. 3 shows a modification of the construction of FIG. 2. A sectional view at IV-IV of FIGS. 2 and 3 is illustrated in FIG. 4.

Referring to FIG. 2, 8 is a shadow mask provided with a number of holes 7 for passing the electron beam. 9 is a shadow mask lens electrode provided corresponding to said shadow mask. An insulating plate 10 with holes is placed between said two electrodes. The shadow mask lens electrode 9 is a thin film (for example, aluminum thin film) which permits the electron beam 2 to pass through it with extremely minimized velocity loss and current loss and which will not be damaged by the electron beam.

As shown in FIG. 3, the shadow mask lens electrode 9 may be constructed with a fine mesh. For example, a mesh of 10 mesh/mm. or so may be applied. Two terminals are provided for both electrodes 8 and 9 of the lens mask 6 having the above-mentioned construction. A terminal of the shadow mask lens electrode 9 facing the fluorescent screen 4 is connected to said fluorescent screen 4 and anode 5 and an anode voltage $E_a$ is applied. A voltage $E_a$ slightly lower than said anode voltage $E_a$ is applied to the terminal connected to the side of the shadow mask 8 facing the electron gun 1.

In this way, lines of electric force (shown with arrows 8 and 9) flowing from the shadow mask lens electrode 9 to the circumference of the hole 7 of the shadow mask 8 are generated as shown in FIG. 5.

As a result, an electric field affecting the electrons passing through the space to be focused in the direction of the axis of the hole 7 is generated throughout the hole 7, thus providing an electron lens having a very strong focusing action. Since the above-mentioned electrostatic lens functions to cause the electron beam to be focused to the axis of the hole 7 over the entire period of the passing of the electron beam through the hole 7, a sufficiently strong and efficient focusing effect can be expected even when the potential difference between both of the electrodes 8 and 9 is not so high. Therefore, deterioration in the insulation between the both electrodes 8 and 9 will rarely occur.

FIG. 6a is a partially magnified view of the shadow mask for a color TV receiver according to the present invention and illustrates the relationship among the shadow mask 8, shadow mask lens electrode 9, and fluorescent screen 4 as well as the voltage applied thereto. In this figure, $E_a$ is an anode voltage, $E_b$ is a voltage slightly lower than $E_a$, FIG. 6 (a) represents the construction shown in FIG. 2, in which 9 is a helotless conductive thin film. FIG. 6 (b) represents the construction shown in FIG. 3, in which 9 is a shadow mask lens electrode made of a fine mesh. Both of them function as a focusing lens for focusing the electron beam 2 onto the fluorescent screen 4.

Described above in detail are the methods in which a shadow mask lens electrode 9 is provided between the shadow mask 8 and fluorescent screen 4 and the anode voltage $E_a$ is applied thereto, however, it should be noted that this novel invention is not limited to the disclosed methods.

For example, if the shadow mask lens electrode 9 consists of a fine mesh, the focusing action can be provided by arranging the shadow mask electrode 9, shadow mask 8, and fluorescent screen 4 as shown in FIG. 7 and applying an anode voltage $E_a$ to the shadow mask lens electrode 9 and a voltage $E_b$, which is slightly lower than $E_a$ to the shadow mask 8. In FIG. 7, potential of the electrode facing the electron gun side is higher. This makes it possible to provide a picture of good contrast on the screen because the secondary electrons emitted from the shadow mask 8 are absorbed by this electrode and the amount of electrons reaching the fluorescent screen will decrease, thus eliminating undesired radiation of light from the fluorescent screen.

In actual production process of the lens masks, for example, the holeless thin film for the shadow mask lens electrode 9 can be produced, in the same manner as the conventional metal back process, by vaporizing a conductive material onto the collodion film then removing said collodion film through heat treatment. Thickness of this film is in the order of several microns to several millimeters depending on anode voltage applied and the diameter of the hole in the metal mesh used for the shadow mask lens electrode 9 may be produced in the same manner as production of a conventional metal mesh. The insulating film 10 with holes may be formed by applying a coat of photoceramic on the shadow mask 8, then making holes 7 by means of optical etching.
FIG. 8 shows an exemplary embodiment of a color cathode-ray tube provided with lens mask shown in FIG. 2, in which, 1 is an electron gun, 2 is an electron beam, 4 is a fluorescent screen, 6 is a part of the shadow mask, and 9 is an electron beam. The electron beam will not impinge on a hole under the electron beam. In the figure, the distance between the fluorescent screen 4 and shadow mask lens electrode 9 is 20 millimeters, the distance between the shadow mask 8 and shadow mask lens electrode 9 is 0.25 millimeters, the thickness of the shadow mask 8 is 0.15 millimeters, the diameter of the hole 7 is 0.5 millimeters and the shadow mask lens electrode 9 is a 100 A thick aluminum thin film. At the cathode potential of the electron gun 1 is 0 volts, E1 is 20 kilovolts and E2 equals 18.9 kilovolts, the electron beam spot on the fluorescent screen 4 will have a diameter of 0.25 millimeters. That is, the electron beam spot on the fluorescent screen 4 has a diameter of one-half the diameter of the hole 7 by the focusing action of an electron lens formed in the hole 7 of the lens mask 6. In a conventional color cathode-ray tube, the electron passage in the mask has a diameter of 0.25 millimeters or so and the utilization factor of the electron beam is about 13 percent. In this embodiment, the diameter of the electron passage in the mask may be increased to, for example, 0.5 millimeters. This makes the utilization factor of the electron beam increase to some 52 percent and brightness on the screen will be increased by four times that of a conventional color cathode-ray tube. Diameter of the electron beam spot on the fluorescent screen may be, of course, optionally varied by controlling the voltages E1 and E2.

FIG. 9 (a) and FIG. 10 (a) show plans of another embodiment of this invention viewed from the electron gun side. FIG. 9 (b) and FIG. 10 (b) show sectional views at 9b-9b and 10b-10 of the embodiment shown in FIG. 9 (a) and FIG. 10 (a), respectively.

In the figures, 8 is a shadow mask, 9 is a shadow mask lens electrode consisting of a conductive plate having a plurality of holes, said conductive plate with holes is provided with holes of which the diameter is not so extraordinarily small as a fine mesh or is slightly larger compared with the hole 7 of said shadow mask 8. That is, it is provided with holes 11 having a diameter slightly smaller than the hole 7 in FIG. 9a, in turn, with holes 11 having a diameter slightly larger than the hole 7 in FIG. 10 (a). When viewed in parallel with the direction of the normal axis of the hole 7 of the shadow mask 8, the holes 11 of said conductive plate 9 are at least partially overlapped with the holes 7 of the shadow mask 8 and arranged so that center of each said hole of the conductive plate is located at a vertex of a regular polygon the center of which is on the axis of one of the shadow mask 8.

In this arrangement, a voltage E2 which is slightly lower than the anode voltage E1 is applied to the shadow mask 8 and the anode voltage E1 is applied to the shadow mask lens electrode 9. In this way, lines of electric force (shown with arrows) flowing from the shadow mask lens electrode 9 to the circumference of the hole 7 of the shadow mask 8 are produced, for example, as shown in FIG. 11 (a).

These lines of electric force causes an electric field affecting the electrons to be focused in the direction of the axis of the hole 7 throughout the hole 7, thereby an electron lens having a very strong focusing force can be formed inside of the hole 7 and the electron beam passing therethrough can be sufficiently focused.

FIG. 11 (a) illustrates an arrangement of a shadow mask 8, shadow mask lens electrode 9 and fluorescent screen 4 in order.

It should, however, be noted that this invention is not limited to the arrangement shown in this figure. For example, an electron lens for focusing the electron beam may also be formed by arranging a shadow mask lens electrode 9, shadow mask lens electrode 8 and fluorescent screen 4 as shown in FIG. 11 (b) and applying a voltage E3 to the shadow mask 8. This voltage E3 is slightly lower than the voltage E1 applied to the shadow mask lens electrode 9.

In addition, size of the hole 7 of the shadow mask 8 is larger than that of a conventional color cathode-ray tube but is selected so that the electron beam focused by the electron lens will not impinge on the undecorated part of the fluorescent screen emitting light. If the shadow mask lens electrode 9 has the construction shown in FIG. 10 (a), it is desirable to make the area of the conductive portion of the electrode 9 overlapped with the hole 7 of the shadow mask 8 as small as possible to obtain a higher utilization factor of the electron beam.

FIGS. 12a and 12b show other improved embodiments permitting to increase the utilization factor of the electron beam. In FIG. 12 (a), a shadow mask lens electrode 9 is composed of conductors arranged in the form of hexagonal mesh. In FIG. 12 (b), a shadow mask lens electrode 9 having conductive portion with small holes is illustrated. With either of these two types of shadow mask lens electrode, a very high utilization factor of the electron beam may be obtained.

FIGS. 13a and 13b show an exemplary embodiment of color cathode-ray tube provided with lens mask shown in FIG. 10a in which; 1 is an electron gun, 2 is an electron beam, 4 is a fluorescent screen, 8 is a shadow mask, 7 is an electron beam pass hole, and 9 is a shadow mask lens electrode. Suppose the distance between the fluorescent screen 4 and the shadow mask lens electrode 9 is 10 millimeters, the distance between the shadow mask 8 and the shadow mask lens electrode 9 is 0.33 millimeters, thickness of the shadow mask 8 and the shadow mask lens electrode 9 is 0.15 millimeters and the diameter of the electron beam pass hole 7 is 0.33 millimeters, as shown in the drawing, if the cathode voltage of the electron gun 1 is 0 volts, E1 is 20 kilovolts and E2 is 18.7 kilovolts, the electron beam spot on the fluorescent screen 4 will have a diameter of 0.2 millimeters.

In FIG. 14 (a), an embodiment of the voltage supplying means of present invention is illustrated, in which; 4 is a fluorescent screen of the cathode-ray tube, 5 is an anode, 8 is a shadow mask with a voltage E3, 9 is a shadow mask lens electrode to which a voltage of E2 is applied, 12 is a high-voltage rectifier tube, and 13 and 14 are resistors.

In this arrangement, the anode voltage from the high voltage rectifier tube is applied to the anode 5 and the shadow mask lens electrode 9. A part of the anode voltage divided by the resistors 13 and 14 is applied to the shadow mask 8, thus easily providing a voltage supplying means. For example, if the anode voltage required E1 is 20 kilovolts and E2 is 18.7 kilovolts, the resistors 13 and 14 should have resistance of 1.3 megohms and 18.7 megohms, respectively, at a current value of 1 milliampere.

It should be noted that although the aforementioned means is based on a voltage dividing network providing the voltage E2 from the anode voltage E1, other methods may be applied. For example, two separate electric power sources will be acceptable for providing the two voltages.

In FIG. 14 (b), an alternate arrangement of FIG. 14 (a), in which the positions of the shadow mask 8 and shadow mask lens electrode 9 are opposite to that shown in FIG. 14 (a).

It is apparent that the above-mentioned improvement of the color cathode-ray tube can be achieved in the same manner.

As described in detail, this invention provides a color cathode-ray tube in which the hole area of the shadow mask can be increased without any trouble by means of using a lens mask having electron lenses formed in the holes in the shadow mask, said electron lens having a sufficiently strong focusing force. This makes it possible to provide a color image with brightness increased by several times that of a conventional color cathode-ray tube.

Furthermore, in this invention there is very little potential difference between the shadow mask and the shadow mask lens electrode, both are the constituent components of the lens mask. In addition, voltages applied to both electrodes are almost equal to the anode voltage, therefore, trouble with the insulation between the two electrodes will rarely occur.

It will be apparent that many modifications and variations may be effected without departing from the scope of the novel
concepts of the present invention. It should be, therefore, noted that, although the present invention has been described herein with reference to many examples thereof, the invention is not restricted only thereto.

What we claim is:

1. A cathode-ray tube for a color television comprising: an evacuated envelope; a triad-type fluorescent screen in contact with a conductive layer positioned at one end of said envelope; an electron beam source positioned adjacent to the other end of said envelope; an anode electrode positioned between said electron beam source and said fluorescent screen and being connected to said conductive layer; a shadow mask with circular holes positioned between said electron beam source and said anode screen, each of said holes being aligned with a triad of said screen adjacent to said screen; a shadow mask lens electrode having apertures and being positioned between said shadow mask and said screen closer to said shadow mask than to said screen, the portions of said shadow mask lens electrode defined by the axially projected images of the respective holes of said shadow mask thereon providing an electrically conductive part of said shadow mask lens electrode at least in the center of these portions; and means supplying to said shadow mask lens electrode and said screen the same DC voltage and supplying to said shadow mask a DC voltage slightly lower than that applied to said shadow mask lens electrode, whereby said electron beam can be focused throughout each hole in said shadow mask by an electric field produced between said shadow mask and said shadow mask lens electrode.

2. A cathode-ray tube as defined in claim 1, wherein said shadow mask lens electrode has a plurality of apertures each being out of registration and each only partially overlapping with the axially projected image of any one hole of said shadow mask.

3. A cathode-ray tube as defined in claim 2, wherein said apertures of said shadow mask lens electrode are positioned at a vertex of a regular polygon the center of which is on the axis of a hole of said shadow mask.

4. A cathode-ray tube as defined in claim 3, wherein said apertures of said shadow mask lens electrode further include holes positioned between, and of smaller diameter than, said apertures in the shadow mask lens electrode.

5. A cathode-ray tube as defined in claim 2, wherein said shadow mask lens electrode has approximately the same number of apertures as the number of holes in said shadow mask, said apertures being larger than the holes of said shadow mask.

6. A cathode-ray tube for a color television comprising: an evacuated envelope; a triad-type fluorescent screen in contact with a conductive layer positioned at one end of said envelope; an electron beam source positioned adjacent to the other end of said envelope; an anode electrode positioned between said electron beam source and said fluorescent screen and being connected to said conductive layer; a shadow mask having holes and being positioned between said electron beam source and said screen, each of said holes being aligned with a triad of said screen adjacent to said screen; a shadow mask lens electrode positioned between said screen and said shadow mask adjacent to said shadow mask, said shadow mask lens electrode being formed as a conductive structure having apertures, said shadow mask and said shadow mask lens electrode being arranged with the conductive part of said shadow mask lens electrode positioned at least at the locations of the centers of the electron beam paths through the respective holes of said shadow mask; and means supplying to said shadow mask lens electrode and said screen the same DC voltage and for supplying to said shadow mask a DC voltage slightly lower than that applied to said shadow mask lens electrode, whereby said electron beam can be focused throughout each hole in said shadow mask by an electric field produced between said shadow mask and said shadow mask lens electrode.

7. A cathode-ray tube for a color television as defined in claim 6, of which said shadow mask lens electrode is formed of a solid conductive plate with holes.

8. A cathode-ray tube for a color television as defined in claim 7, in which said conductive plate with holes has a plurality of holes, each hole being out of registration and at least partially overlapping with the axially projected image of a hole of said shadow mask, said hole of said conductive plate being located at a vertex of a regular polygon the center of which is on the axis of a hole of said shadow mask.

9. A cathode-ray tube for a color television as defined in claim 8, of which said conductive plate with holes has approximately the same number of holes as the number of holes of said shadow mask, said holes of said conductive plate being larger than the holes of said shadow mask.

10. A cathode-ray tube for a color television as defined in claim 6, wherein said shadow mask lens electrode further includes in said conductive structure between the apertures additional holes greatly smaller than said apertures.

11. A cathode-ray tube for a color television as defined in claim 6, of which said shadow mask lens electrode is made of a fine mesh.

12. A cathode-ray tube for a color television comprising: an evacuated envelope; a triad-type fluorescent screen in contact with a conductive layer positioned at one end of said envelope; an electron beam source positioned adjacent to the other end of said envelope; an anode electrode positioned between said electron beam source and said fluorescent screen and being connected to said conductive layer; a shadow mask with circular holes positioned between said electron beam source and said screen, each of said holes being aligned with a triad of said screen adjacent to said screen; a shadow mask lens electrode in the form of a solid conductive plate having a plurality of holes therein positioned between said shadow mask and said screen closely adjacent to said shadow mask; the holes in said conductive plate being larger than the holes in said shadow mask and being out of registration and at least partially overlapping with the axially projected image of a hole of said shadow mask to provide a conductive electron barrier at least at the locations of the centers of the electron beam paths through the respective holes of said shadow mask; and means supplying to said shadow mask lens electrode and said screen the same DC voltage and for supplying to said shadow mask a DC voltage slightly lower than that applied to said shadow mask lens electrode, whereby said electron beam can be focused throughout each hole in said shadow mask by an electric field produced between said shadow mask and said shadow mask lens electrode.

13. A cathode-ray tube as defined in claim 12, wherein said shadow mask lens electrode includes additional holes smaller than the other holes in said shadow mask lens electrode and the holes in said shadow mask, said additional holes being provided in the portion of the shadow mask lens electrode forming said conductive electron barriers at the locations of the centers of the electron beam paths through the respective holes of said shadow mask.