United States Patent

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[33] **Great Britain**
[31] **26126/67**

[54] **COLOR TUBE HAVING SHADOW MASK WHOSE CENTER-TO-CENTER APERTURE SPACINGS INCREASE RADIALLY OUTWARD FROM MASK CENTER**

2 Claims, 3 Drawing Figs.

[52] **U.S. Cl.** **313/92,** 313/85, 96/1
[51] **Int. Cl.** **H01j 29/32,** H01j 29/06
[50] **Field of Search** ..... 313/92 B, 853

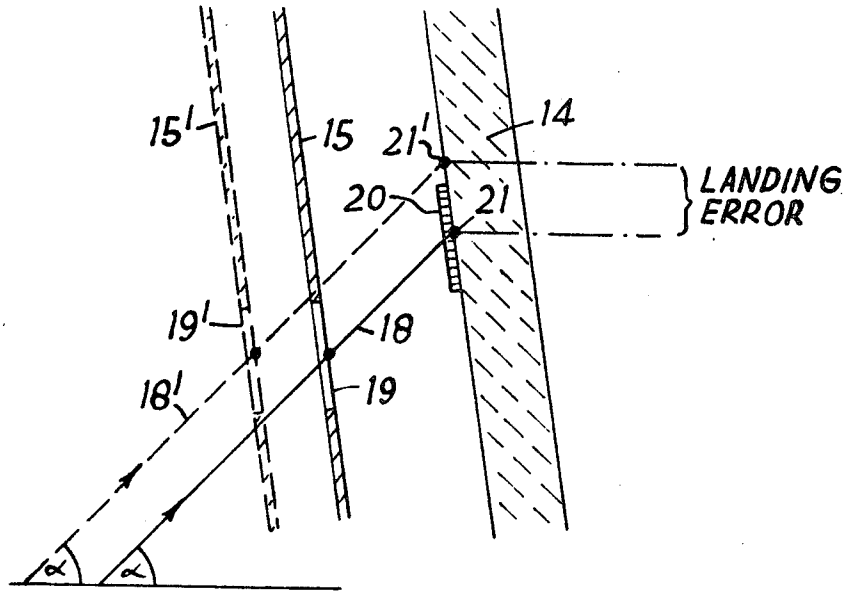
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ABSTRACT: There is disclosed a cathode-ray tube for a color television set employing a plurality of electron guns whose electron beams are arranged to be deflected over a screen on which a color picture is to be reproduced. Between the electron guns and the screen is interposed a shadow mask formed with a multiplicity of apertures through which the electron beams pass to the screen. The spacing of these apertures, measured along the surface of the mask, is so chosen as to be greater at the edge of the mask than at the center thereof. A method of making a shadow mask with this arrangement of apertures is also disclosed. A photosensitive surface is arranged so as to be tangential at its center E with respect to a smaller spherical mask having a uniform pattern of apertures formed therein, the center C of the spherical surface and the center A the spherical mask being disposed on a straight line passing through the point E. The photo sensitive surface is illuminated through the apertures in said mask from a point light source located at a point O on said line so selected that OD/OB is greater than unity, where D is any point on said photo sensitive surface impinged upon by light from O passing through an aperture at the point B.



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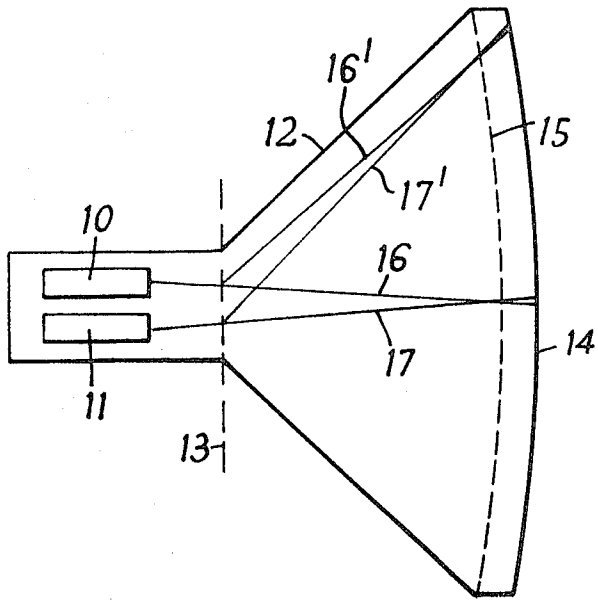


Fig. 1.

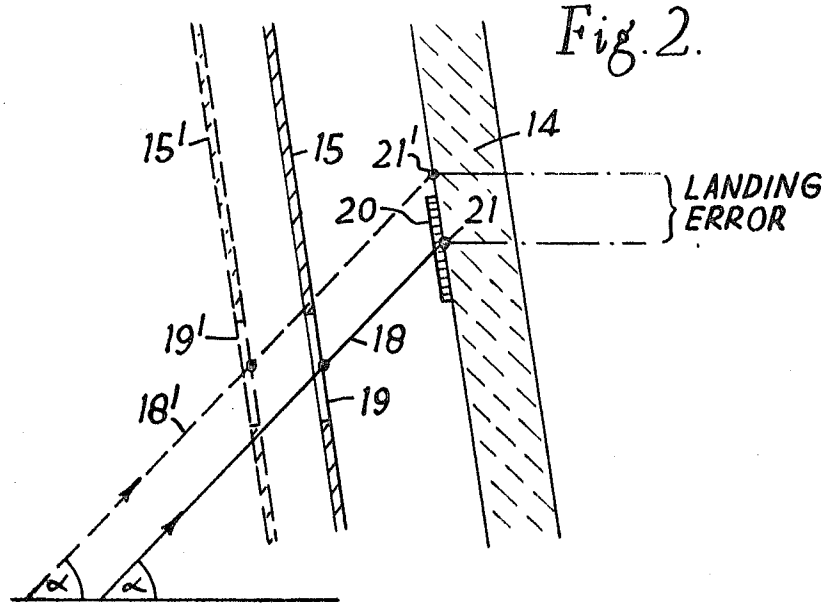
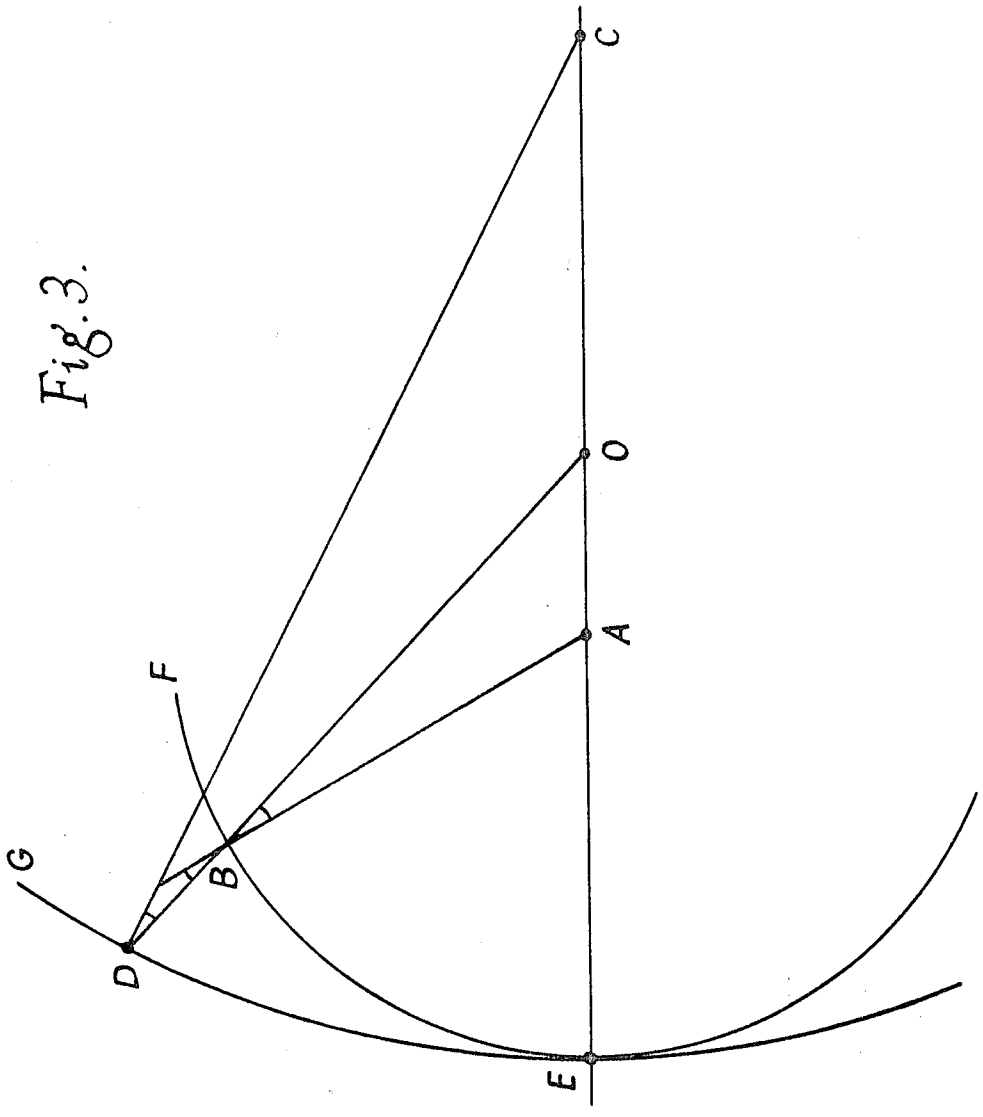


Fig. 2.

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Fig. 3.



COLOR TUBE HAVING SHADOW MASK WHOSE CENTER-TO-CENTER APERTURE SPACINGS INCREASE RADIALLY OUTWARD FROM MASK CENTER

The present invention relates to cathode-ray tubes for color television, the tubes being of the type employing a plurality (usually three) of electron guns arranged side-by-side and producing electron beams arranged to be deflected in common over a screen on which a color picture is to be reproduced, a shadow mask being arranged between the guns and the screen and formed with a multiplicity of holes through which the beams pass to the screen. Owing to the lateral displacement of the guns relative to one another, the parts of the beams from the guns (assumed hereinafter, for convenience, to be three) that pass through each hole in the shadow mask will produce a triad of electron beam spots on the screen. The screen carries colored phosphor dots arranged in corresponding triads so that at any instant each of the three beams impinges upon a differently colored phosphor dot.

Shadow masks are conventionally manufactured from flat "blanks" in which the spacing of the holes is uniform across the extend of the mask. The process of forming the mask into a spherical domed shape causes some distortion of this spacing, but it normally is still substantially constant, as measured along the surface in the finished mask.

It is conventional to grade the size of the holes so that those holes which are at the edge of the mask are smaller than those at the center. This decrease in size increases with distance from the mask center. The purpose of this is to make the electron beam spots in the finished tube relatively smaller at the edge of the screen, so that if the phosphor dots at the screen edge are printed the same size as those at the tube center, there is a greater tolerance for landing error of an electron spot on the appropriate phosphor dot at the screen edges. Various factors, which are well known, make this landing error more likely at the edge of the screen than near the center.

The mask-to-screen spacing will govern the size of the triad (assumed to be the size of the triangle which connects the spot centers) and there are three arrangements being used at present.

In the first the mask-to-screen spacing is made constant from center to edge. In this case, the radial shift in deflection centers (the apparent sources of the beams) due to dynamic convergence correction (that is the correction necessary to cause convergence of the beams over the whole screen surface) makes the size of the electron spot triad greater at the edge of the screen than at the center. This increase in size of the electron spot triad at the screen edge is known as the degrouping effect. Thus, if the screen consists of tangentially contacting phosphor dots of uniform spacing, as may be achieved by (e.g. optical) screen printing means, the electron spots cannot be concentric with the phosphor dots at both the screen center and edge. Normally parameters are adjusted for concentricity at the screen edge, where greatest tolerance is required.

The second known arrangement is one in which the mask-to-screen spacing is varied in such a manner that the electron triad size is constant despite the growth due to the convergence degrouping effect. This results in a mask-to-screen spacing smaller at the edge than at the center. Since the reduction in magnification at the edge applies to both the electron spots and to the screen printing means, and results in uniform electron spot spacing over the screen, the requirements for a tangentially contacting phosphor dot screen and for spot/dot concentricity may be met simultaneously.

The third known arrangement is so to vary the mask-to-screen spacing that it decreases towards the edge of the tube in such a manner that the electron spots will coincide, despite the above mentioned degrouping effect, with phosphor dots printed through adjacent apertures from a "second-order" optical source as explained in the specification of British Pat. No. 1,014,905. The effect is that the mask-to-screen spacing is less at the edges than at the center by an amount which is not so great as in the second arrangement.

The above explanations ignore certain further distortions of the triads such as "foreshortening misregister" and electron triad distortion due to astigmatic deflection error in scanning coils, which do not basically affect the description of the present invention.

There have been certain proposals to change the shape of shadow mask apertures to overcome certain defects such as foreshortening error, or "azimuth" shape correction. These involve a certain change in the center-to-center aperture spacing, but only as required to restore the "packing" of phosphor dots whose shape has been altered. These changes have been suggested in the radial direction only, and in the case of "azimuth" correction in certain radial directions only.

According to the present invention there is provided a cathode-ray tube of the type set forth in which the spacing between the centers of the holes of the shadow mask, measured along the surface of the mask, is greater at the edge of the mask than at the center thereof. Preferably the increase in hole spacing, proceeding outwards from the center of the screen, is both radial and circumferential, so that the spacing is substantially uniform over any small area.

The mask-to-screen spacing is preferably made such that the mask will produce on the screen electron spot triads which combine to form a uniform spot pattern as measured over a small area. In other words, the spacing of the apertures having been decided at center and edge of the mask, the mask-to-screen spacing will be so chosen that the consequent magnification, in combination with convergence correction degrouping experienced in operation of the finished tube, causes the three guns, in combination, to produce a substantially uniform electron spot pattern. The size of the holes may also be adjusted to give whatever overall mask transmission is required at the center and edges of the mask. This choice is governed by considerations of brightness and electron spot/phosphor dot tolerance.

The higher transmission efficiency of larger holes favors brightness, but at the expense of spot/dot landing tolerance. The best compromise differs from the center to the edge of the screen because of the greater likelihood of landing errors at the edge.

It might be thought that a disadvantage of the arrangement of the present invention would be that the screen structure is more coarse at the screen edges than at the screen center and that this coarsening of the dot structure causes poorer resolution at the corners of the image. However, such a drop in resolution should be perfectly acceptable as interest is normally concentrated at the image center. In cathode ray tubes corner resolution is normally poor because of deflection defocusing of the beam, and in shadow mask tubes poorer still because of corner convergence errors. Thus, no significant loss in image quality should occur.

If the phosphor dot sizes are increased at the tube edges by suitable means when printing the screen, so that tangential contact of the dots is maintained, the overall effect will be of a screen whose phosphor dot and electron spot triads are larger at the edges than at the center.

Certain advantages of the present invention over the prior art are:

1. The tube can be made more tolerant to certain mechanical distortions which tend to degrade spot/dot register near the screen edges.
2. A tube can be manufactured with a constant mask-to-screen spacing, in which the spots and dots are concentric at screen center and edge, and the screen consists of substantially tangentially contacting phosphor dots.
3. A tube can be manufactured in which the edge tolerance to landing errors of the shadow mask with graded hole size is obtained without grading the hole sizes.
4. A tube can be manufactured in which there is both a constant mask-to-screen spacing and in which the shadow

mask holes are of constant size and which retains most of the advantages of a variable mask-to-screen spacing using graded hole size.

5. A tube of wider scan angle than normal can be manufactured without the tolerance to certain mechanical distortions becoming less than at present experienced on normal tubes.

The invention will be described, by way of example, with reference to the accompanying drawings in which:

FIG. 1 is somewhat diagrammatic view of a color television tube to which the present invention can be applied;

FIG. 2 is a much enlarged view of a part of the mask and screen of the tube of FIG. 1, near the edge of the screen; and

FIG. 3 is a diagram illustrating one method of making a tube according to the present invention.

Referring to FIG. 1, two of the three electron guns are shown at **10** and **11** mounted in the neck portion of the tube envelope **12**. The dotted line **13** is the deflection plane in which means for deflecting the three beams in common are disposed. The screen is a faceplate **14** on the inside of which are formed, in well known manner, a pattern of colored phosphor dots. These dots are, as usual, in triads each including dots in three differently colored phosphors. A shadow mask **15** is disposed spaced by the required distance from the screen **14**, this mask having the multiplicity of holes formed in it.

The two electron beams from the guns **10** and **11** are shown at **16** and **17** respectively in the central positions and at **16'** and **17'** in their positions of maximum deflection.

FIG. 1 shows that with such a wide-angle tube employing a faceplate **14** with a relatively large radius of curvature, the beams pass through the shadow mask and strike the screen at an appreciable angle to the normal near the screen edges.

FIG. 2 shows an enlarged view of mask **15** and screen **14** in such a tube near the screen edge. One beam, a hole **19** which defines this beam, and a phosphor dot **20** on which the beam lands are shown. The solid line **18** indicates the center line of this beam under normal conditions with normal beam landing at **21**. In a 90° tube the maximum value of the angle α, shown in FIG. 2, is approximately 45°. A common form of mechanical error in shadow mask tubes is an axial movement of the mask concentrated at the screen edges between the time of screen deposition and the operation of the finished tube, due to processing, mask distortion, etc. The dotted lines show the effect of such an error, the mask being at **15'** with its hole at **19'** and the beam being at **18'** and landing on the screen at **21'**. It can be seen that the effect of the error on beam landing is greater, the smaller the scale of the dot structure and the larger the scanning angle. Advantages **1** and **5** above follow from the fact that the invention may be used to increase the scale of the dot structure near the edges of the tube in a normal tube, or to match the scale of the dot structure near the edges of the tube to the increased scanning angle of a wide-angle tube.

Advantage **2** is a special case of the above, in which a tube which would otherwise have varying mask-to-screen spacing, as in the second of the known arrangements above mentioned, has the dot structure increased in scale at the screen edge by such an amount that the mask-to-screen spacing becomes constant. For a 90° **63** cm. tube the dot size would increase from about 0.42 to 0.48 mm. at the tube corners, so the advantage **1** also obtains.

Advantage **3** is a special case of **1**, in which the dot structure is increased in scale to such an extent at the tube edge that the appropriately increased hole size at the edge equals that at the center. Again, the advantage **1** also obtains.

Advantage **4** follows from the fact that the two previous cases involve a very similar amount of increase in scale at the edge, and the case of constant mask-to-screen spacing involves an almost constant hole size, when applied to a conventional 90° tube. Thus a compromise with constant hole size would be acceptable.

A mask for use in carrying out the invention may be produced in various ways; e.g. by manual preparation of a master negative, or by photographic modification of a uniform spacing master.

FIG. 3 shows one possible method of producing a master negative optically. EC is the axis of the system. GE represents a cross section of a spherical photosensitive surface. EF represents a cross section of spherical mask of smaller radius of curvature than EG. A and C are the centers of the spheres EF and EG respectively. EG and EF are in contact at E. D represents a point on EG which corresponds to the corner of the mask which will eventually be prepared from it. O is a point light source and B the point on EF at which light passes from the source to meet EG at D. EF has a pattern of apertures uniform across its surface and of the spacing required at the screen center. The curvatures are so chosen that OD/OB equals the required pattern expansion at the screen corner, and O is so placed that OB makes the same angle with AB that OD does with CD.

This arrangement ensures that the image of EF cast on EG varies in magnification from 1 at the center to OD/OB at D. The foreshortening effect due to EF not being normal to the light rays at B is compensated by an equal lack of orthogonality at D so that the image of B is expanded equally in radial and tangential directions.

The mechanical error referred to previously gives a movement in a radial direction so that radial expansion only is required, but a uniform expansion has the advantage that circular dots may still be brought into tangential contact.

The negative produced from EG as above described may be treated in various ways well known in the art, for example to adjust hole size or produce intermediate negatives.

What I claim is:

1. In a cathode-ray tube comprising a plurality of electron guns, and guns being disposed in side-by-side relationship and each producing an electron beam, a screen on which a color picture is to be reproduced, said screen being provided with phosphor dots, means for deflecting said beams in common over said screen, and a shadow mask located between said guns and said screen, said mask being apertured at a multiplicity of points to define passages through which said beams can pass to said screen, the improvement according to which the center-to-center spacing of said passages in both the radial and circumferential directions is greater at the edge of said mask than at the center thereof, and the center-to-center spacing of said phosphor dots in both the radial and circumferential directions is likewise greater at the edge of said screen than at the center thereof.

2. A cathode-ray tube as claimed in claim 1, wherein said phosphor dots increase in size from the center of said screen and are substantially tangential to one another.