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FORMING PATTERNED PHOSPHOR SCREENS IN POST ACCELERATION CATHODE RAY TUBES

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FIG.1.

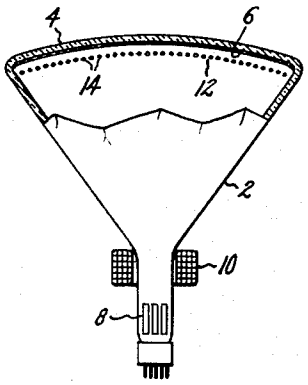


FIG.2.

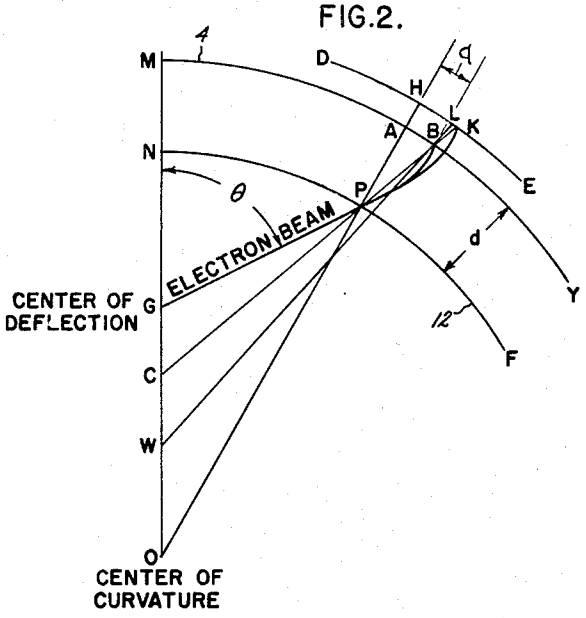


FIG.4.

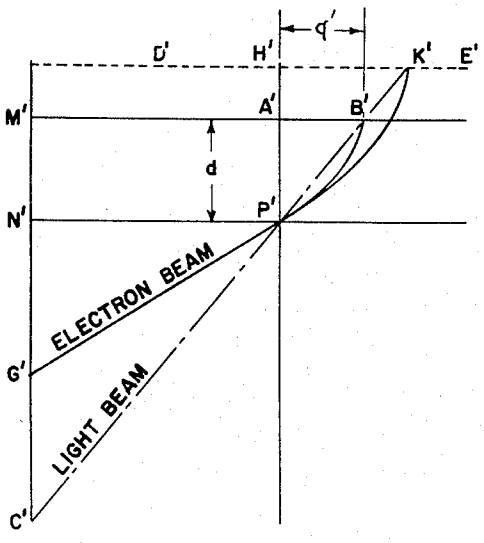
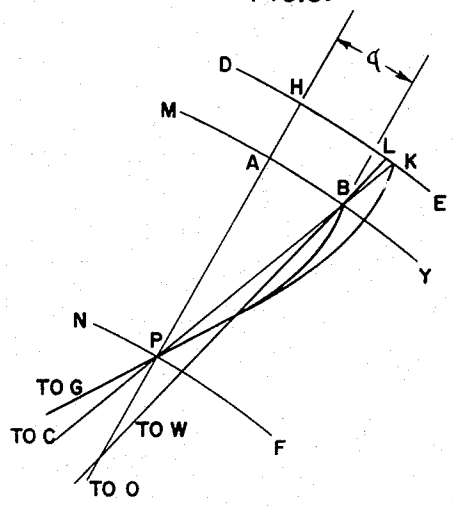


FIG.3.



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FORMING PATTERNED PHOSPHOR SCREENS IN POST ACCELERATION CATHODE RAY TUBES

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1 Claim. (Cl. 96—45)

The present invention relates to a method of printing patterned phosphor screens on the screen supporting plates of cathode ray tubes of the so-called post acceleration type, i.e. wherein the scanning electron beam is passed through an electric field for the purpose of varying its velocity or direction after deflections. The invention has particular utility in connection with the printing of tricolor phosphor screens on the face plates of color television post acceleration picture tubes.

In many cathode ray tubes the phosphor screen is formed directly on and supported by the interior surface of the tube faceplate, that is, the portion of the tube which serves as the closure for the front end of the envelope. Such faceplates of cathode ray tubes for use in color television are generally curved, and are manufactured by a pressing process. While pressing has certain advantages from the cost and production standpoints, the properties of glass are such that the internal surface of a pressed faceplate is usually not perfectly accurate but is likely to have small bumps, pockets, or other irregularities which cause the surface to be displaced above or below its theoretical ideal locus by, say, a few hundredths of an inch. To form a screen having a desired phosphor pattern on such a screen support plate, optical printing has heretofore been employed in which the support plate has been coated with a photosensitive resist able to retain a phosphor when exposed, and the desired pattern has been written on the resist by a light beam, the non-exposed portions of the coating being then removed and leaving a pattern of resist to which the phosphor is subsequently applied. In the use of this method heretofore to print screens for post acceleration tubes, the surface irregularities in the support plate have caused misplacement of the phosphor pattern, as defined by the locus of impingement of the printing light rays on the faceplate, with respect to the points at which the post accelerated electron beam strikes the faceplate during actual operation of the tube. Such misplacement causes misregistry of the electron beam and phosphor pattern which, in color television picture tubes, may cause objectionable color impurities. To minimize such misregistry it has heretofore been necessary to impose close tolerances on the amount by which the surfaces of tube faceplates may be deviated from the ideal configuration by such bumps or depressions. These close tolerances of course make the faceplates more expensive than they might otherwise be.

Accordingly, a principal object of the present invention is to eliminate the need for such close tolerances in the manufacture of faceplates for post acceleration cathode ray tubes.

Another object is to provide a method for photo printing a patterned phosphor screen for a post acceleration cathode ray tube which is not susceptible to the errors in beam-phosphor registry heretofore resulting from surface irregularities in the faceplate or other support plate on which the phosphor is deposited.

Another object is to provide a method for optically

printing a phosphor pattern in a post acceleration cathode ray tube which insures placement of the phosphor in the exact locus where the electrons will impinge regardless of minor inaccuracies in the surface configuration of the phosphor supporting plate.

These and other objects of our invention will be better understood from the description following hereafter, and the scope of the invention will be defined in the appended claim.

Briefly, the present invention arises from the discovery that in the optical printing of phosphor screens for post acceleration cathode ray tubes in which the surfaces of the screen supporting plates have minor irregularities causing deviations from an ideal surface configuration, the printing light rays can be directed to a screen supporting plate along certain paths such that they will strike its irregular surface and locate the phosphor pattern thereon at the exact locus where a scanning electron beam will land on the irregular surface in actual tube operation, such coincidence thereby insuring that substantially exact registration of the electron beam and phosphor pattern will be achieved during tube operation, regardless of the surface irregularities in the screen supporting plate.

In the accompanying drawing:

Figure 1 is a partially sectionalized view of a post acceleration cathode ray tube to which the present invention may be applied;

Figure 2 is an enlarged diagrammatic view showing in an exaggerated fashion the geometrical relations of a portion of the tube of Figure 1;

Figure 3 is a further enlarged diagrammatic view of a portion of Figure 2; and

Figure 4 is an enlarged diagrammatic view similar to Figure 2 showing the geometrical relations of corresponding parts of another type of post acceleration cathode ray tube to which the present invention may be applied.

Figure 1 shows a post acceleration color television cathode ray tube of a type to which the present invention is particularly applicable. The tube includes an envelope 2 closed at its front end by a substantially cylindrical faceplate 4. Formed directly on the inside surface of the faceplate is a phosphor screen 6 including primary color emitting phosphors arranged in a particular pattern, the instant pattern consisting of groups of one line or stripe each of three primary color emitting phosphors, the lines being deposited substantially parallel to the axis of the faceplate 4. The tube also includes three closely spaced electron guns 8 arranged side by side in a plane perpendicular to the faceplate axis, with the center gun being positioned so that its undeflected electron beam strikes the screen at the approximate center thereof. A deflection yoke 10 provides angular deflection of the electron beam sufficient to sweep the screen both horizontally and vertically. Spaced from the screen is a substantially concentric electron permeable grid or lens mask here shown as a grille 12 of fine wires 14 arranged substantially parallel to the phosphor stripes. The grille 12 is maintained at anode potential by a suitable power supply and the screen 6 is maintained at a potential substantially higher than the grille so that there is a substantial accelerating electric field between the grille and screen. The grille wires are so spaced and positioned with respect to the center of deflection of each scanning electron beam that the beam from each gun illuminates only the phosphor stripes of the particular primary color for which it is intended.

Figure 2 shows diagrammatically and in an exaggerated fashion the geometry of the tube of Figure 1. The line MY denotes the surface of a faceplate 4 having an ideal configuration, i.e. free of bumps, depressions, or other irregularities. NF denotes the grille, O represents the center of curvature of screen and grille, GNM the tra-

jectory of the undeflected center electron beam, and G the effective center of deflection of the beam, i.e. the intersection of the beam paths before and after deflection. P represents the point at which the electron beam passes through the grille after deflection through an angle θ in the horizontal plane, i.e. normal to the grille wires. B is the point at which the electron beam passing through point P strikes the screen. The path of the electron beam from P to B is curved toward line ONM due to the effect of the post acceleration electric field between grille and screen. The line DE represents in an exaggerated fashion a portion of the surface of the faceplate as displaced from its ideal position by a surface irregularity, the irregularity in the case illustrated being a slight depression in the faceplate surface. Alternatively, of course, the irregularity might be a bump or raised area in the surface in which case line DE would be located on the opposite side of line MY from that shown. The present invention embraces the printing of phosphor patterns on screen support plates having surfaces displaced in either or both directions from the ideal. K represents the point of intersection of the electron beam passing through the grille at point P with the line DE. As will be apparent from Figure 2 the curvature of the trajectory of the electron beam from P to K is slightly different than its curvature from P to B. This is due largely to the fact that the difference in spacing between the screen and grille when the screen occupies the position DE weakens the electric field between grille and screen and correspondingly weakens the forces which curve the electron beam.

For a better understanding of the merits of our invention, a brief description will now be given of the geometry involved in the printing of the phosphor lines on the screen by optical methods heretofore employed. In the prior art methods the printing light rays are caused to emanate from an effective source point or virtual source which may be represented by point W in Figure 2. The line WB of Figure 2 represents the path of a printing light ray used to locate the phosphor stripe intended to be illuminated by the electron beam passing through point P of the grille. Line WB is a straight line between the grille and screen because the light ray is not affected by the accelerating field between the grille and screen. When the surface configuration of the faceplate is ideal, as represented by line MY, light rays from point W may be caused to project the complete phosphor pattern desired on the faceplate by various means, such as for example a mask having a pattern of translucent and opaque areas similar to the desired phosphor pattern and interposed between MY and W, or a camera-like lens system arranged to project the proper pattern on the screen from a virtual source coincident with point W. Thus the phosphor stripes may be properly located on the ideal faceplate surface by illuminating the faceplate with light rays emanating from point W and positioning the phosphor stripes where the light rays strike the faceplate.

If the faceplate surface is not absolutely accurate, however, but is displaced by a bump or depression as exemplified by line DE, during printing by the prior art method a light ray from point W through point B will strike the faceplate at point L, the line WBL being a straight line. As has been seen, however, the electron beam strikes the line DE at point K which is displaced from point L, as best shown in Figure 3. Since L denotes the position at which the phosphor would be located if optically printed by the light ray, it will be appreciated that the phosphor stripes when so printed would be mislocated by the distance KL. Thus, with the exemplary prior art printing method described, if the surface irregularities in the faceplate are not kept small enough to make the distance KL negligible, the pattern written on the faceplate by the electron beam will not register with the phosphor pattern as located by the light rays, and objectionable color impurity will result during operation of the tube. To prevent such objectionable effects it has been necessary with the various printing arrangements used heretofore to impose sufficiently close tolerances on the surface configuration of the faceplate so that the distance KL will never be large enough to cause objectionable misregistering of the electron beam and the phosphor pattern.

Our present invention arises from the discovery that the point B, at which the electron beam strikes the surface of the ideal faceplate or other screen support plate, and the point K at which it strikes a faceplate displaced from the ideal by slight surface irregularities, lie on a straight line which passes through point P and a point C on the axis ONM which is substantially common for all angles of beam deflection. This means that if a printing light ray is directed at the faceplate along the line CPBK it will strike the faceplate at either K or B depending on whether the faceplate deviates from the ideal or not, and will thus properly locate the phosphor on the faceplate in coincidence with the point of impingement of the electron beam regardless of the surface irregularities in the faceplate. In other words, according to the present invention, optical printing of the screen can be performed in such a way as to insure that the phosphor elements are deposited on an irregular screen support plate surface exactly where the electron beam will impinge on that irregular screen support plate surface.

Turning again to Figure 2 it will now be shown mathematically that the points B and K lie on a straight line which passes through point P. The line OPAH designates the radial to the grille and screen from the center of curvature thereof. Representing by q the displacement on a screen of the point of impact of the electron beam on the screen from the radius through the point P, from an analysis of the electron trajectories in the electric field between the grille and faceplate, it can be shown mathematically that

$$q=\frac{2\tan\beta}{g+1}d+\left\{1-\frac{2(g-1)}{3g}\left[\frac{3}{\gamma}+\frac{3+g}{g+1}\right]\right\}\frac{\tan\beta}{(g+1)D_0}\cdot d^2+\ldots$$

where d is the perpendicular distance between the screen and grille, D_0 is the radius of curvature of the grille, β is the angle of incidence of the electron beam at the grille at point P, i.e. angle GPO, $g=\sqrt{1+a}$, a equals γ divided by $\cos^2\beta$, and γ is the ratio of the difference between screen and grille voltage to grille voltage. From a consideration of the geometry of the tube it will be seen that in the above expression the terms following the first are relatively quite small. Thus it may be seen that, to a good first approximation,

$$q=\frac{2\tan\beta}{g+1}\cdot d$$

or q varies substantially in direct proportion to d. Then as d approaches zero, q approaches zero, and

$$\frac{q}{d}\approx\frac{AB}{AP}\approx\frac{HK}{HP}$$

which means that the points B and K lie on a straight line which passes through point P. In other words a light ray passing through point P and traveling in the direction PBK will strike the faceplate at the same place the electron beam will strike the faceplate regardless of whether the faceplate surface coincides with line MY or is displaced to a position such as line DE.

Thus, to print the phosphor pattern on the faceplate in proper registry with the points of impingement of an electron beam regardless of surface irregularities all that is required is that the printing light rays be directed toward the faceplate along paths such as the line PBK. It is within the contemplation of the present invention that various optical arrangements may be employed to impart this directivity to the printing light rays. For example, a point source of light may be positioned at the common point C, which is the point of intersection of the line PB with the line MNO and may be located for

example by construction or analysis of the tube geometry. It will be evident, for example, that point C may be located by construction by taking any point P on the grid, drawing the radial line OPA as shown in Fig. 2, computing from the above equation for q the distance AB and thereby locating point B, and then extending the line BP back to the tube centerline OM, where it intersects at point C. Alternatively a different location for the light source may be used and suitable lenses may be employed to form a virtual source from which the light rays have the proper directivity such that their paths to the various elements of the pattern to be printed coincide with lines such as the line PBK. Shadow mask printing may also be employed. That is, an optical master having a pattern of opaque and translucent areas corresponding to the desired phosphor pattern may be inserted between the light source and the faceplate and the desired phosphor pattern printed by light rays directed as above defined. Alternatively, a camera-type printing arrangement may be employed in which no shadow mask is used but instead a suitable phosphor pattern image is converged by a lens system to the point C and diverged therefrom to the faceplate, the point C thus being a virtual source from which the image-carrying light rays travel along lines such as the line PBK.

While for economy the foregoing analysis has been directed only to beam deflection in the horizontal mid-plane, i.e. the plane perpendicular to the phosphor lines and containing the line ONM, it will be apparent to those skilled in the art that the principles developed apply also to deflection of the beam in planes above and below the mid-plane. Minor distortions may have to be introduced into the pattern of the optical master to take into account the various second order effects on the trajectory of the electron beam due to its horizontal and vertical deflection from the line ONM, during scanning, but such corrections are of such small magnitude as to produce no significant deviation of the light rays from paths such as the line PBK. Also the above analysis applies as well to the off-center electron guns, provided the faceplate, optical master, or light source is correspondingly shifted during printing to allow for the displacement of the electron beam axis.

The present invention also applies to a tube of the type in which the phosphor screen is deposited on a support plate which is flat and may be either the closure for the front of the tube envelope or, as in the so-called "sandwich" type of tube, a separate plate disposed within the envelope, and in which a flat grille is employed. The geometry of this type of tube is shown in Figure 4, wherein corresponding points bear the same letter designations as those in Figure 2, primed. As shown in Figure 4 the electron beam will pass through the grille at point P' and arrive at the surface of an ideal screen support plate at the point B' and at the surface of an incorrect support plate at the point K'. It may be shown mathematically that the displacement of the point B' from the intersection A' of a normal to the faceplate through point P' is

$$q'=\frac{2\tan\beta}{g+1}d'$$

where d' is the distance between the grille and screen support plate and the other terms are as defined hereinbefore. Since

$$\frac{2\tan\beta}{g+1}$$

is a constant for any one point P' in a tube, it may be seen that points B' and K' lie on a straight line passing through P'. Thus, if optical printing is performed by means of light rays directed at the support plate along lines such as the line P'B'K', exact registry of the phosphor pattern with the points of impingement of the electron beam will be obtained regardless of whether the screen support plate is correct or is deviated from the ideal by surface irregularities. Optical printing with a tube of this type, as with the curved faceplate tube, may be carried out in a variety of ways such as by means of a shadow mask arrangement or a camera-type lens arrangement, so long as the light rays are directed to the faceplate along lines such as the line P'B'K'.

Thus, it may be seen that when a phosphor pattern is printed in accordance with the present invention, surface irregularities in the phosphor support plate will no longer create misregistration between the phosphor pattern and the pattern traced by the electrons, and hence substantially wider tolerances are permissible for the support plate surface than have heretofore been possible without encountering objectionable color impurity or other display distortions due to beam-phosphor misregistry. Experiments have shown, in fact, that a curved faceplate which was previously required to be held within ±30 mils of the ideal surface can, using the printing method of the present invention, be printed and mismounted in a tube of the type shown in Figure 1 with one edge deviating as much as 200 mils from its correct position and no color impurity results. The present invention therefore enables faceplates to be manufactured to substantially wider tolerances, and thereby makes possible a considerable reduction in tube cost.

It will be appreciated by those skilled in the art that while specific embodiments have been shown and described, the invention may be carried out in various ways and may take various embodiments without departing from the principles of the invention. It is to be understood therefore that the scope of the invention is not limited by the details of the foregoing description, but will be defined in the following claim.

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

In the art of forming a screen phosphor pattern for a post-acceleration cathode ray tube having an electron beam permeable grid between which and a spaced parallel screen support member the post-acceleration field is adapted to be formed and in which the screen support member has undesired random irregularities of surface configuration causing deviations from the locus of a surface free from such irregularities, the method of locating the phosphor pattern on the irregular screen support member in registry with the pattern of impingement of the tube electron beam on the irregular screen support member comprising coating the screen support member with a light sensitive resist, and projecting an image of the phosphor pattern on the resist with light rays, the light rays falling on any one point on the irregular screen support member passing in a straight line through a first point and a second point relative to the support member, said first point corresponding to a point of intersection of the electron beam with the grid, and said second point corresponding to the point at which the post-accelerated electron beam passing through the first point intersects the locus of the irregularity-free surface, the intersection of extensions of such straight lines defining a location for a source of light rays.

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