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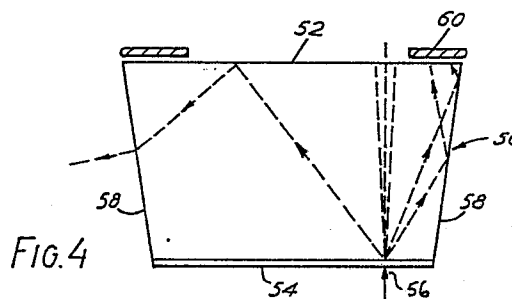
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① Improvements in cathode ray tubes.

② A face plate for a cathode ray tube comprises a plate (50) of transparent material, the thickness of which, relative to its transverse dimension is such that at least some of the light entering it at any point on one of its transverse surfaces (54), and internally reflected within the plate (50), is incident on the edge surface (58) of the plate before striking the surface (54) where it entered again. The edge surface (58) diverges away from the transverse surface (54) so that any light directly incident on it is reflected into a peripheral area of the opposite transverse surface (52) of the plate (50). The plate (50) may, for example, be frusto-conical or may have a plurality of triangular-section grooves (80) formed in its edge surface (78) (see Figure 6).



Description

IMPROVEMENTS IN CATHODE RAY TUBES

The present invention relates to cathode ray tubes ("CRT") and, in particular, to reducing flare in telecine apparatus utilising CRT scanning.

In a number of known forms of telecine, scanning of a light spot is effected using a CRT. The light spot formed on the face plate of the CRT is imaged by an objective lens onto the film frame which is to be analysed. The light is transmitted through the film medium with a degree of attenuation dependent on the characteristics of the area of the film being scanned at a given instant and is then collected by a photodetector which converts the light input into a video signal output. If a telecine of this kind is used to scan, for example, a film frame consisting of a small dense area at the centre of the frame, the remainder of the frame being relatively transparent, it would be expected that, when the spot from the CRT is imaged on the dark area, very little signal should be detected. However, in practice, a halo of light will be imaged around the dark spot on the clear area of the film. This light will be collected by the photodetector and, consequently, will reduce the contrast of the scene.

The halo effect is produced by total internal reflection occurring in the face plate of the CRT as is illustrated in Figures 1 and 2 of the drawings, which are, respectively a sectional and an elevational view of a CRT face plate 10.

The face plate of a CRT designed for use in a telecine is typically around 175mm in diameter, and approximately 10 mm thick. The interior surface of the face plate 10 is coated with a phosphor layer 12 which produces light when struck by an electron beam. Total internal reflection occurs at the interface of one medium with another, in this instance, at the external surface 14 of the face plate 10. Light reacting the interface at an angle of incidence greater than the critical angle ϕ is totally internally reflected at the interface. The critical angle ϕ is given by

$$\phi = \arcsin \frac{N_1}{N_2}$$

where N_1 is the refractive index of the medium into which the light is passing, typically for air $N_1 = 1$, and N_2 is the refractive index of the medium from which it has come. Typically, for glass $N_2 = 1.52$, so that

$$\phi = \arcsin \frac{1}{1.52} = 41.1^\circ$$

From Figure 1 it will be seen that light from the point 15 at which an electron beam 16 strikes the phosphor layer 12 is totally internally reflected from the exterior surface 14 so that it strikes the phosphor layer 12 again, producing a ring around the

point 15. The light will continue to be reflected back and forth between the two surfaces of the face plate 10 to produce a series of concentric flare rings as shown in Figure 2. For a face plate 10 of the dimensions outlined above, the first ring has a diameter of 34.9mm and the second ring, a diameter of 69.8mm. In fact, each point on the flare rings also gives rise to a secondary ring system as shown in Figure 2 and so on, so that the whole face plate 10 will be caused to glow by total internal reflection effects.

The flare ring effects cause a loss of contrast in CRT flying spot telecines and, given that extra again is frequently provided by non-linear gamma amplifiers, which may be 30 times more at the black end of the intensity range than for the bright, flare can have a significant detrimental effect on picture quality.

It has been proposed in order to overcome the flare ring problem, to reduce the transmission characteristic of the face plate to around 70%. In effect, this means that the light from the first flare ring has passed through the faceplate three times which results in a glass path length of at least 3.67 times the thickness of the plate. This will reduce the level of the flaring to less than 27% of the original light levels as compared with 70% for the direct path, assuming that the transmission factor chosen is 70%.

It has also been proposed in, for example, United Kingdom patent no. 1067186 to use a relatively thick face plate. Whilst this does, to a certain extent reduce flare as will be described below, some flare still occurs on the face plate.

The CRT face plate of the invention is characterised in that the thickness of the plate relative to its transverse dimension is such that at least some of the light entering the plate at any point on one transverse surface thereof, and internally reflected within the plate is incident on an edge surface of the plate before striking the said one surface again; at least a portion of the edge surface diverging away from the said one surface, whereby light directly incident on that portion of the edge surface is reflected towards a peripheral area of the opposite transverse surface of the plate.

Two CRT face plates in accordance with the invention will now be described in detail, by way of example only, with reference to Figures 3 to 6 of the drawings, in which:

Figure 3 is a section through a modified CRT face plate

Figure 4 is a section through a first CRT face plate in accordance with the invention;

Figure 5 is a plan view of the face plate of Figure 4; and

Figure 6 is a section through a second face plate in accordance with the invention.

As shown in Figure 3, flare can be reduced considerably by making the face plate 30 sufficiently thick that light internally reflected off the front surface 32 of the face plate 30 is not reflected back

on to the phosphor layer 34. Light will, however, be reflected back via the perpendicular edge surfaces 38 over a limited angle of incidence (typically 41-49° assuming a refractive index of 1.52 and an external medium which is air or a vacuum). For a CRT face plate 30 of diameter 175mm, the thickness of the plate should be at least 100mm thick.

Whilst the use of a relatively thick face plate 30 improves the flare performance, flare still occurs over certain angles as previously described. This is shown in Figure 3. When the electron beam strikes the phosphor layer 34 at an extreme position 36' light is reflected off the front surface 32 of the face plate so that it strikes the edge 38 of the plate 30. It is in turn reflected by the edge surface 38 back towards the phosphor layer 34 which it strikes at the point 40. Similarly light from the point 36' which is directed towards the edge 38 of the face plate 30 will be internally reflected by the edge surface 38 and by the front surface 32 in turn, back towards the phosphor layer 34 which it will strike at the point 42. The reflected light incident on the phosphor layer 34 at the points 40 and 42 will give rise to unwanted flare, indicated by reference numeral 44.

Similarly, light from point 36 will be reflected from the edge surface 38 to a point on the phosphor layer 34 close to the point 36.

The flare effects illustrated in Figure 3 are those which would occur if the edges 38 of the face plate were optically polished. If the edges 38 were unpolished, light incident on the edges would be reflected in all directions, leading to diffuse flare over a wide undesired area of the face plate 30.

Flare arising from total internal reflection at the edges of the face plate can be reduced by shaping the face plate so that it tapers towards the phosphor layer. A face plate 50 of this shape is shown in Figures 4 and 5.

The face plate 50 is frusto-conical and has a phosphor layer 54 provided on its smaller circular surface. The conical edge surface 58 functions to reduce flare in two different ways. Firstly, if the angle of taper is suitably chosen, the face plate 50 can be constructed so that any light reflected from the front surface 52 of the face plate 50 will always be incident on the edge surface 58 at an angle less than the critical angle and will therefore be transmitted. Secondly, light from the point 56 at which the electron beam strikes the phosphor layer 54 which is incident on the edge surface 58 directly will be reflected towards the outer peripheral areas of the front surface 52, arriving at an angle of incidence less than the critical angle and will therefore be transmitted. This latter effect can be enhanced by fitting an opaque mask 60 over the peripheral areas of the front surface 52 as shown in Figure 5. The mask 60 covers all areas of the face plate which are not scanned by the electron beam raster. There will be some multi-path reflections within the face plate but these will not, in general, be within the acceptance angle of the telecine objective lens.

An alternative form of face plate 70 for reducing flare effects is shown in Figure 6. The face plate 70 which is again relatively thick is generally cylindrical but its edge surface 78 is provided with a plurality of

polished grooves 80. Preferably, these are of 45° isosceles triangle cross-section.

The grooves 80 may be formed by machining the edges of the plate 70 or may be moulded into a separate plastics sleeve of refractive index such that internal reflections are avoided. Such a sleeve is, preferably, dried or carbon loaded to absorb any light escaping from the edges of the face plate 70 or is coated with a light absorbing paint having a higher refractive index than the glass of which the face plate is constructed and must be optically bonded to the faceplate. The number and depth of the grooves 80 is not critical to the performance of the face plate 70. The edge of the raster scan effected by the CRT must, however, be spaced a sufficient distance from the edge of the face plate 70 that an angle of at least 3° is formed so as to ensure that light from the edges of the raster scan is not internally reflected.

The grooves may alternatively be replaced by pyramidal formations formed by cutting a second set of grooves perpendicular to the grooves 80 shown in Figure 6. These could be also formed by moulding.

Thus, flare arising from internal reflection within a CRT face plate can be reduced considerably by the use of a relatively thick face plate in accordance with the invention.

Claims

1. A face plate for a cathode ray tube comprising a plate (50;70) of transparent material, characterised in that the thickness of the plate (50;70) relative to its transverse dimension is such that at least some of the light entering the plate (50;70) at any point on one transverse surface (54) thereof, and internally reflected within the plate is incident on an edge surface (58;78) of the plate before striking the said one surface again; at least a portion of the edge surface (58;78) diverging away from the said one surface, whereby light directly incident on that portion of the edge surface (58;78) is reflected towards a peripheral area of the opposite transverse surface (52) of the plate (50;70).

2. Apparatus according to claim 1 in which the thickness y of the plate (50;70) is related to the lateral dimension d of the plate by the formula

$$y = x / \tan \phi$$

where ϕ is the critical angle at the boundary formed by the other transverse surface (52) of the plate and $x = 0.5d$.

3. Apparatus according to claim 1 or 2 in which the face plate (50;70) includes an opaque mask (60) overlying at least part of the peripheral area of the said other transverse surface (52).

4. Apparatus according to any preceding claim in which the plate (50) is frusto-conical.

5. Apparatus according to any preceding claim in which the edge surface diverges at such an angle that light internally reflected by

the said other transverse surface is incident on the edge surface (50;70) of the plate at an angle less than the critical angle and is transmitted out of the plate.

6. Apparatus according to claim 1, 2 or 3 in which the edge surface of the plate (50;70) is formed with a plurality of grooves (80) of triangle-section.

7. Apparatus according to claim 6 in which the grooves (80) are formed by moulding on a separate sleeve member which is optically bonded to the edge surface (78) of the plate (70).

8. Apparatus according to claim 7 in which the sleeve member is dyed or carbon-loaded so as to absorb any light transmitted by the edge surface of the plate (70).

9. Apparatus according to claim 7 in which the surfaces defining the grooves (80) are coated with light absorbing paint of higher refractive index than the material of which the face plate (70) is constructed.

10. Apparatus according to claim 6, 7, 8, or 9 in which the grooves (80) are of 45° isosceles triangle cross-section.

11. A cathode ray tube having a face plate according to any preceding claim.

12. A flying spot telecine including a cathode ray tube in accordance with claim 11.

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FIG. 1

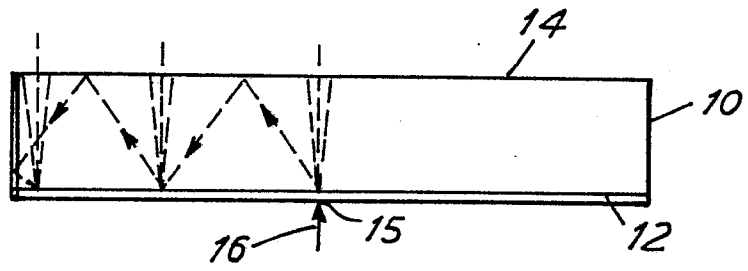


FIG. 2

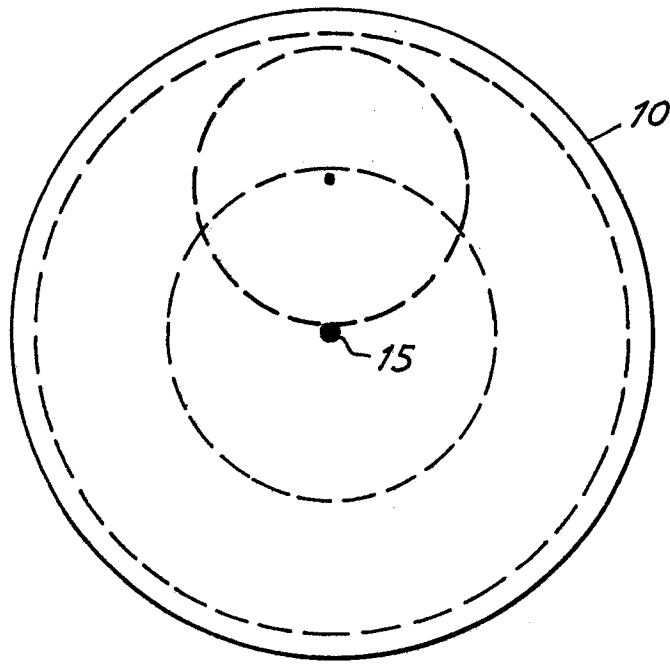
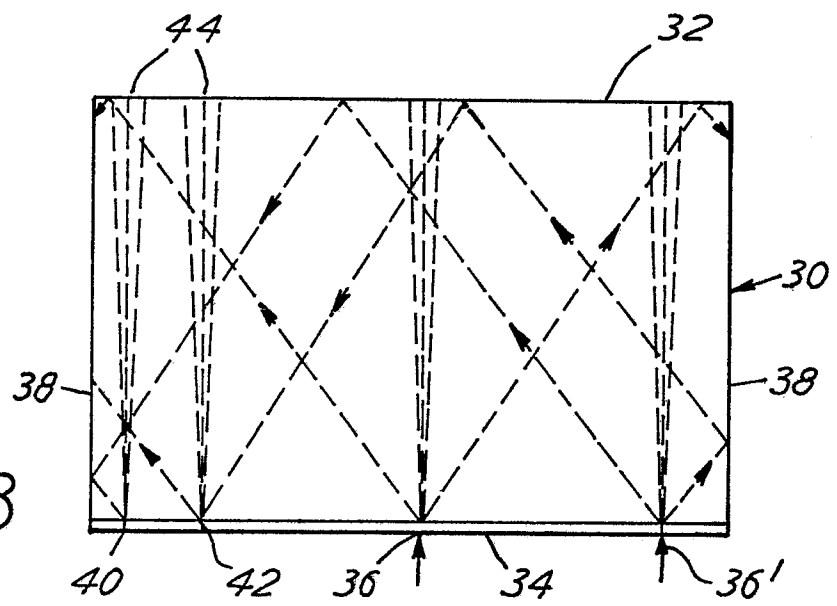


FIG. 3



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