

Description

The present invention relates to a rear projection screen comprising light spreading means on the front surface of said screen for receiving rays from an image source and deflecting respective ones of said rays to display said image with substantial uniform brightness over a wide viewing angle; said light spreading means comprising a plurality of closely spaced generally parallel cylindrical lenses; at least some of said lenses being comprised of a base portion, a first side portion, a second side portion and a tip portion opposite said base portion, said tip portion comprising two convex cylindrical portions contiguous with said first side portion and said second side portion respectively, said tip portion comprising a concave cylindrical portion contiguous to both said convex portions; said tip portion being substantially refractive; said first side portion having a first average slope and said second side portion having a second average slope being selected so that said first side portion and said second side portion are substantially internally reflective; said first average slope being between 63° and 85° with respect to said base portion; said second average slope being between 63° and 85° with respect to said base portion.

Rear projection screens are utilized in various types of equipment, such as projection-based radar displays, flight simulators, avionic displays, traffic control lights, microfilm readers, video games, projection-based video monitors, and rear-projection film media displays for generating a user-viewable display. In such applications, an image source located behind the screen projects light forward along a projection axis toward the screen to form an image at the plane of the screen which is distributed to viewers on the front side of the screen.

Where multiple viewers are present, such viewers are typically spread out horizontally, and distribution of light through a large horizontal angle is desirable. This is particularly true in rear screen projection television receivers, where multiple viewers are generally present and seated throughout a relatively wide horizontal angle relative to the screen.

One problem encountered in rear projection systems is that more light energy is projected along the projector axis than elsewhere, so that the closer an observer is to the projection axis, the brighter the image appears to him. Rear screen projection colour video units typically utilize three cathode ray tubes, one for each of the primary red, green, and blue colours, which project through individual projection lens assemblies onto the projection screen. In a typical horizontal arrangement of

the cathode ray tubes, the green cathode ray tube is typically positioned in the centre along the projection axis, and the red and blue cathode ray tubes are positioned with their optical axes offset with respect to the green optical axis at an angle of 5° to 10° . These offsets, unless corrected for by the screen, give rise to a phenomenon known as colour shift. That is, if the red, green and blue light luminances for the centre of the viewing audience are normalized, the ratio of the luminances will vary with angular position throughout the horizontal viewing plane. Thus, the viewer's perception of the image depends upon the viewer's horizontal placement with respect to the screen.

In addition, when rear projection screens are operated in and exposed to ambient light, the contrast of the projected image is affected by the reflection of such light at the front side of the screen. Thus, it is desirable to reduce reflection of such light at the front side of the screen. Various masking techniques, wherein a black non-reflective surface is interposed between the lenticulas, have been proposed for minimizing light reflection.

Various rear projection screens have been proposed to increase the horizontal viewing angle range. One such system, which is described in U.S. Patent No. 3,578,841 to William R. Elmer, utilizes a screen having a rear surface, such as a Fresnel lens, capable of collimating light from the image source into parallel rays, and a front surface formed with a vertically-ribbed spreading lens to spread light throughout a specified horizontal viewing angle. The shape of the vertical ribs of the spreading lens is defined by an equation dependent upon the desired angle of spread from the centre line. However, ribs drawn in accordance with such an equation become seriously inefficient when spreading light through more than a 60° viewing angle, i.e. 30° on either side of the centre line, and necessitate positioning such ribs between a pair of sharply pointed side ribs to increase the viewing angle to 90° , i.e. 45° on either side of the centre line.

Another type of rear projection screen with a wide field of view is described in the European Patent Application no. 0 067 430. The tip portion of the lenticulas of this screen comprises two convex cylindrical portions with a concave portion in between. The side portions of the lenticulas have a slope angle between 70° and 80° . A drawback of the screen is that the lenticulas are foreshortened in cross-section, having a greater width than height, with the width of the tip portion larger than half the overall width of the lenticula, which limits the extent of black masking possible.

The present invention is directed to a rear screen construction which avoids these shortcomings. The projection screen according to the inven-

tion is characterized in that the ratio of the height of said lenses to the width of said base portion is greater than 1:1 and the ratio of the width of said base portion to the width of said tip portion is greater than 2:1.

In the rear projection screen of the present invention the tip region comprises two convex cylindrical elements and a central concave cylinder element of the lenticular array, which has been found to exhibit exceptional horizontal dispersion of light, without loss of internally reflected light. In addition, when utilized in a system having more than a single colour source, such as in a colour rear projection television system having three separate horizontally disposed cathode ray tubes, the lenticular array of the present invention has demonstrated minimal colour shift. Furthermore, the overall height to width ratio of the lenticula as well as the tip width to overall width ratio provides a rear projection screen which can have almost 60% of its area black masked. The mentioned advantages are maintained over a wide range of angles for the slope of the side portions, facilitating the manufacture of the screen.

The invention will now be described in detail and with reference to the accompanying drawings wherein:

Figure 1 shows a view in perspective of a rear projection screen constructed in accordance with the present invention showing the screen as utilized in a rear projection color television application.

Figure 2 is an enlarged perspective partial cross-sectional view of the lenticular array utilized in the preferred embodiment of the rear projection screen of the present invention.

Figure 3 is a cross-sectional view taken through the line 3-3 of Figure 2.

Figure 4 is an enlarged view of the tip portion of one of the lenticular lenses shown in Figure 3.

Figure 5 is a view similar to that of Figure 3 and shows rays of light being transmitted from the projection source to the viewing area through the lenticular lens of the present invention.

Figure 6 is a view similar to that of Figure 3 and shows incident ambient light rays striking the lenticular array of the present invention.

In order to facilitate understanding of the rear projection screen of the present invention, the general arrangement and operation of a projection assembly employing a rear projection screen embodying the present invention will first be described, and the shapes of various lens surfaces which may be employed in the screen, and the methods of deriving these shapes, will subsequently be described.

Accordingly, Figure 1 illustrates a rear projection color television system 10 employing a rear

projection screen 12 constructed in accordance with the present invention. In this arrangement, television video source signals are received by television receiver circuits 14 and are projected through individual red, green and blue projection cathode ray tube assemblies 16, 18 and 20, respectively, onto the rear surface 22 of the projection screen 12. The three cathode ray tubes (CRTs) 16, 18 and 20 are horizontally arranged with respect to the projection axis 23 and with the green CRT 18 in the center. Such a horizontal distribution results in the three CRTs 16, 18 and 20 having their optical axes 24, 26 and 28, respectively, angularly offset with respect to each other. Typically, the red optical axis 24 and the blue optical axis 28 are each angularly offset between 5 and 10 degrees with respect to the green optical axis 26.

The rear surface 22 of the rear projection screen 12 is planar and is normally provided with collimating lenses such as Fresnel lenses for converging the divergent light rays from the projectors 16, 18 and 20 into parallel rays in accordance with well-known principles of operation of Fresnel lenses. The front surface 30 of the screen 12 is generally planar and includes a plurality of closely spaced vertical lenticular lens elements 32 thereon. In accordance with the present invention the lenticular elements 32 are shaped to refract and spread light horizontally through a wide horizontal viewing angle α in the audience field 33.

In the past, rear projection screen assemblies such as that depicted in Figure 1 have utilized both two-piece screens and one-piece screens, depending upon the particular screen characteristics required. For instance, two-piece screens have been characterized by providing a reasonably broad horizontal distribution of light, but subject to decreased resolution of projected images and to ghost images. In addition, with the broad horizontal distribution of light of such constructions, precise manufacturing control of registration and thickness of the screen must be attained to minimize color shift. One-piece screens have been characterized as having improved resolution but a limited horizontal viewing angle typically in the range of approximately $\pm 30^\circ$. The vertical lens construction of the present invention can be employed in either a one piece type or two-piece type screen and effectively distribute light horizontally through a viewing angle of $\pm 85^\circ$ with perceptually uniform luminance and minimal color shift.

Referring to Figure 2, the front surface 30 of projection screen 12 is seen to include a plurality of parallel spaced vertically aligned lenticular lens elements 32. As shown in Figure 3, the center to center distance between lenticular elements 32, is the lenticular pitch. The lenticular pitch of a projection screen 12 constructed in accordance with the

invention can be changed to accommodate a particular application without changing the performance of the screen provided all dimensions of the lenticular elements 32 are changed in the same proportion. In practice, lenticular pitch is selected according to overall screen size and the number of lenticular cycles desired across the screen. For example, when utilized in a rear projection television screen, the pitch of the lenticular elements 32 may typically range from approximately 0.3 mm to 1.0 mm for diagonal screens ranging from approximately 26 inches to 72 inches. By forming the elements 32 sufficiently fine and close, the viewer observes essentially a smooth continuous picture, in much the same manner as the horizontal lines on a television screen appear from a normal viewing distance to merge into a continuous picture or image.

When constructing a lenticular array comprising the lenticular elements 32 of the present invention adjacent elements preferably touch so that the distance between elements is zero and the lenticular pitch equals the width of each element. However, in practice, some transition between elements 32 may be required. This can be accomplished in various ways such as by providing a simple radius. Preferably, the width of such a transition, if utilized, is less than one percent of the element width.

Each lenticular lens element 32 has side surfaces 34 and 36 and an upper tip surface 38. The side surfaces 34 and 36 may be linear, approximately linear, or of convexly outward shape. Preferably, the side surfaces are convexed outward. The side surfaces 34 and 36 have an average slope represented by θ and θ' , respectively (Figure 3). θ and θ' may range between approximately 43° and 85° and are selected to establish the degree of internal reflection desired. While θ and θ' need not be equal, in accordance with the present invention, θ and θ' are preferably each larger than 70° . Constructing side walls with these angles insures that light rays traveling through element 32 will be incident upon the side walls 34 and 36 at angles greater than the critical angle, derived by Snell's law, such that the light rays will be totally reflected back through the rib. Preferably, θ and θ' are equal and the ribs 32 are laterally symmetrical. If θ and θ' are not equal and a symmetrical audience field is desired, alternate lenticular lens elements 32 on the screen viewing surface 30 can be mirror images of each other. The side surfaces 34 and 36 can be constructed so as to both reflect and refract light rays but are preferably constructed so as to be almost entirely internally reflective and direct light from a projection source to the upper tip surface 38.

As best shown by Figure 4, the upper tip surface 38 is preferably formed from three circular surfaces 40, 42 and 44 of equal radii. As shown, circular surfaces 40 and 44 are formed from circularly convex cylinders, while circular surface 42 is formed from a circularly concave cylinder. While the upper tip surface 38 can be constructed so as to both refract light, and reflect some light which is subsequently refracted into the audience, preferably the upper tip surface 38 is constructed so as to almost exclusively refract light into the audience field.

The width w' of the upper tip surface 38 depends in part on the average slopes θ and θ' of the side surfaces 34 and 36, in part on the refractive index of the material, and in part on the specific lens performance to be attained. In accordance with the objective of the present invention of providing a lenticular array which distributes light horizontally through virtually 180° with perceptually uniform luminance and minimal color shift, it has been found that certain pitch width w to lenticular height h ratios, and tip width w' to pitch width w ratios, are more desirous than others. Accordingly, preferably the lenticular height h to pitch width w is greater than 1:1, and more preferably, at least 3:2. Preferably, the ratio of the pitch width w to the tip width w' is greater than 2:1, and more preferably, at least 3:1.

It will be appreciated by those skilled in the art that a lenticular array can be constructed utilizing the lens element construction described herein in conjunction with other lenticular lens element constructions to optimize a rear projection screen for a particular purpose. However, it has been found that rear projection screens comprising only lenticular lens elements of the construction described herein have yielded excellent gain and efficiency values when distributing light through $\pm 85^\circ$.

Rear projection screens 12 made in accordance with the present invention can be manufactured by various processes, including compression molding, injection molding, extrusion, casting and photo-polymerization processes. Such screens can be constructed of optically transparent or translucent solid materials such as inorganic glasses and a variety of plastics. In addition, the screen composition can also be a mixture of materials. A preferred material is of poly-methylmethacrylate.

One-piece screens consisting of two optically functional surfaces can be prepared from two pieces which are suitably affixed together. Such one-piece screen construction enjoys the advantages of lower cost and simplicity. Also, the thickness of the screen is not critical and registration of optical patterns on opposite sides of the sheet is not required.

The vertical spread provided by the rear projection screen 12 of the present invention is relatively small. Consequently, the screen 12 may be provided with some type of diffusion medium. For instance, diffusion can be supplied by a bulk property of the refracting material from which the screen is constructed, can be due to surface texturizing of the rear surface (or in the case of two-piece designs any surface other than the front lenticular surface), can be a diffusion layer present in a composite sandwich assembly, or can be produced by some combination of these approaches. Typically, the diffusion will have a Gaussian form and will allow a vertical spread of about $\pm 10^\circ$ before experiencing a light intensity drop of 50%, i.e. diffusion will provide a vertical half angle of approximately $\pm 10^\circ$.

It should be noted that the orientation of the lens elements 32 on the front surface 30 of the rear projection screen 12 has been characterized as providing a wide horizontal distribution of light. One could easily rotate the rear projection screen 12 by a desired angle, for example by 90° , to provide a wide distribution of light in the vertical direction. In addition, if it is desired to distribute light both in a wide horizontal and a wide vertical plane, a rear projection screen could be constructed having an array of horizontal ribs in accordance with the present invention superimposed upon the vertical ribs of the present invention.

Figure 5 illustrates the horizontal dispersion of light through catadioptric lenticular lens elements 32 constructed in accordance with the invention. Light rays r_1 , r_2 and r_3 travel from the projection source and are collimated by a collimating lens, such as a Fresnel lens, into parallel rays which are distributed by the lenticular lens elements 32. As rays r_1 , r_2 and r_3 pass through the homogeneous medium of element 32, they travel in straight lines. When rays r_1 , r_2 and r_3 impinge upon side surfaces 34 and 36, which are constructed so as to be internally reflecting surfaces, the rays are reflected, the angle of incidence of the rays being equal to their angle of reflection. When rays r_1 , r_2 and r_3 strike the upper tip surface 38 at incident angles less than the critical angle of the lens-air interface, the rays are refracted in accordance with Snell's law.

As previously noted, the lens elements 32 are successively laterally adjacent and the adjacent side surfaces 34 and 36 are preferably contiguous on the front surface 30. Each element 32 is laterally spaced from an adjacent element so that the respective side surfaces 34 and 36 form between them a groove 46 resembling an outwardly bowed "V" shape. When elements 32 are constructed in accordance with the preferred embodiment of the invention, wherein the overall pitch width w to tip

width w' is at least 3:1, at least two-thirds of the surface area of the front surface 30 is available, if desired, for black masking. Black masking of screen 12 can be accomplished by utilizing a black masking which maintains the reflective characteristics of side surfaces 34 and 36. A preferred method for black masking is filling a substantial portion of the groove 46 with black discrete particles 48 capable of absorbing visible light, and by containing said articles by means of a skin 50 which extends between the ribs 32 and over the groove 46.

Even without black masking the configuration of lenticular lens elements 32 reflects less ambient light back to the audience field than conventional one-piece screens. This occurs because a large portion of any ambient light strikes the grooved portion 46 of the screen, which comprises approximately two-thirds of the total surface area of surface 30, and passes into the screen. Figure 6 depicts an approximate path of an incident ambient light ray upon the side surfaces 34 and 36 of the ribs 32. As shown, the solid line indicates either the incident light ray or a reflective ray, while the dashed line indicates a refracted ray. If neutral tinting material is present in the screen composition, incident rays will be attenuated by passage through the screen. Any of these rays reflected from the rear surface 12 and returning back through the front surface 30 will travel, on the average, more than twice as far as rays from the projection sources, thereby providing good picture contrast.

A non-specular front surface 30 can be achieved, if desired, by texturing the front surface so as to provide additional diffusion. Depending upon the degree desired, the entire front surface 30 can be textured. Or, if the screen is black masked, it is only necessary to texture the upper tip portion 38 to provide a non-specular screen. Furthermore, in the case of a black masked screen, an anti-reflective coating can be applied to the exposed tip portions 38 to eliminate specular reflections and further improve screen contrast.

The following example describes a lens element construction in accordance with the present invention which provides good performance in a rear projection color television system. This example is set forth for purposes of illustration and is not to be construed as a limitation on the present invention. The coordinate reference points for the exemplary lens element are depicted in Figure 3, with the origin being designated as 0, the X-axis measuring position from the lower left hand corner of the reference element toward the right, and the Y-axis measuring position from the lower left hand corner upwards. The lenticular lens element has a pitch of .55mm and is symmetrical about $X=.275$ mm. All values of Y are greater than or

equal to 0 and the lens element is defined as a continuous function for Y and a slope of Y.

Each of the symmetrical side surfaces is constructed from 397 straight line segments which are defined by the expression: slope = $M_n = \text{TAN} [90^\circ - 0.5 \times \text{ARCTAN} [(.2888 - X_n) + (.9280 - Y_n)]]$ where:

$$X_1 = 0, Y_1 = 0.$$

$$D = .2131 + 397 = 5.371 \times 10^{-4}$$

$$M_1 = 6.5786$$

$$X_n = (n-1) \times D$$

$$Y_n = Y_{n-1} + D \times M_{n-1}$$

The end point of the 397th segment is $X_{398} = .21310$, $Y_{398} = .88438$. The shape of the side is determined by the following interpolation rule: given X, $X < .21310$ and $X_1 \leq X < X_1 + 1$ then $Y = Y_1 + (X - X_1) \times M_1 + D$.

The shape of the upper tip portion is defined as follows:

for $.21310 \leq x < .25735$ the shape is a circle with $X_1 = .23971$ and $YO_1 = .86896$ and $R = .03076$ mm in the formula $Y = - \text{SQRT} [R^2 - (X - XO_1)^2] + YO_1$, and

for $.25735 \leq X < .2750$ (the center of the reference lenticular) the shape is a circle with $XO_2 = .22750$ and $YO_2 = .91936$, R is again equal to .03076 mm in the formula $Y = + \text{SQRT} [R^2 - (X - XO_2)^2] + YO_2$.

The above expressions define one side of a symmetrical lenticular lens element constructed in accordance with the invention with a pitch of .55mm. As previously noted, the lenticular pitch can be changed without changing the performance of the lens, provided all dimensions of the lens are changed in the same proportion. When forming a lenticular screen of the noted lens elements it is preferable that the adjacent lenticular lens elements be touching or that if there is a transition region between the lenticulars that it be less than 1% of the lenticular width. The lenticular lens elements so formed are optically polished by conventional methods. The above lenticular design was actually tested to have a gain of greater than 2.5 and a measured efficiency of 79%. These values were realized with a diffusion sufficient to give half-intensity in the vertical direction of $+9.5^\circ$ about the direction of peak intensity. More vertical field can of course be achieved with more diffusion or the addition of a horizontal lens array surface but with a commensurate loss of screen gain.

Preferably, the lenticular array is tooled from state of the art devices such as diamond turning lathes and diamond tools. Where tooling limitations are an important consideration, minor deviations can be tolerated and the overall lenticular form, that is the ratios of the pitch to height and pitch to tip width as well as internally reflective side surfaces and refractive tip surfaces, is the primary factor in determining performance.

While in the foregoing specification certain embodiments of this invention have been described in detail, it will be appreciated that modifications and variations therefrom will be apparent to those skilled in the art. Accordingly, this invention is to be limited only by the scope of the appended claims.

Claims

1. A rear projection screen (12) comprising light spreading means on the front surface (30) of said screen for receiving rays from an image source and deflecting respective ones of said rays to display said image with substantial uniform brightness over a wide viewing angle; said light spreading means comprising a plurality of closely spaced generally parallel cylindrical lenses (32); at least some of said lenses being comprised of a base portion, a first side portion (34), a second side portion (36) and a tip portion (38) opposite said base portion, said tip portion (38) comprising two convex cylindrical portions (40, 44) contiguous with said first side portion and said second side portion respectively, said tip portion (38) comprising a concave cylindrical portion (42) contiguous to both said convex portions; said tip portion being substantially refractive; said first side portion having a first average slope and said second side portion having a second average slope being selected so that said first side portion and said second side portion are substantially internally reflective; said first average slope being between 63° and 85° with respect to said base portion; said second average slope being between 63° and 85° with respect to said base portion; characterized in that the ratio of the height of said lenses to the width of said base portion is greater than 1:1 and the ratio of the width of said base portion to the width of said tip portion is greater than 2:1.
2. The rear projection screen claimed in Claim 1, characterized in that all of said plurality of closely spaced generally cylindrical lenses (32) are of the same construction.
3. The rear projection screen of Claim 2, characterized in that said first average slope and said second average slope are each greater than 70° .
4. The rear projection screen of Claim 3, characterized in that said first average slope and said second average slope are substantially equal.



equal to 0 and the lens element is defined as a continuous function for Y and a slope of Y.

Each of the symmetrical side surfaces is constructed from 397 straight line segments which are defined by the expression: slope = $M_n = \tan [90^\circ - 0.5 \times \arctan [(2888 - X_n) + (.9280 - Y_n)]]$ where:

$$X_1 = 0, Y_1 = 0.$$

$$D = .2131 + 397 = 5.371 \times 10^{-4}$$

$$M_1 = 6.5786$$

$$X_n = (n-1) \times D$$

$$Y_n = Y_{n-1} + D \times M_{n-1}$$

The end point of the 397th segment is $X_{398} = .21310$, $Y_{398} = .88438$. The shape of the side is determined by the following interpolation rule: given X, $X < .21310$ and $X_1 \leq X < X_1 + 1$ then $Y = Y_1 + (X - X_1) \times M_1 + D$.

The shape of the upper tip portion is defined as follows:

for $.21310 \leq x < .25735$ the shape is a circle with $X_1 = .23971$ and $YO_1 = .86896$ and $R = .03076$ mm in the formula $Y = -\sqrt{R^2 - (X - XO_1)^2} + YO_1$, and

for $.25735 \leq X < .2750$ (the center of the reference lenticular) the shape is a circle with $XO_2 = .22750$ and $YO_2 = .91936$, R is again equal to .03076 mm in the formula $Y = +\sqrt{R^2 - (X - XO_2)^2} + YO_2$.

The above expressions define one side of a symmetrical lenticular lens element constructed in accordance with the invention with a pitch of .55mm. As previously noted, the lenticular pitch can be changed without changing the performance of the lens, provided all dimensions of the lens are changed in the same proportion. When forming a lenticular screen of the noted lens elements it is preferable that the adjacent lenticular lens elements be touching or that if there is a transition region between the lenticulars that it be less than 1% of the lenticular width. The lenticular lens elements so formed are optically polished by conventional methods. The above lenticular design was actually tested to have a gain of greater than 2.5 and a measured efficiency of 79%. These values were realized with a diffusion sufficient to give half-intensity in the vertical direction of $+9.5^\circ$ about the direction of peak intensity. More vertical field can of course be achieved with more diffusion or the addition of a horizontal lens array surface but with a commensurate loss of screen gain.

Preferably, the lenticular array is tooled from state of the art devices such as diamond turning lathes and diamond tools. Where tooling limitations are an important consideration, minor deviations can be tolerated and the overall lenticular form, that is the ratios of the pitch to height and pitch to tip width as well as internally reflective side surfaces and refractive tip surfaces, is the primary factor in determining performance.

While in the foregoing specification certain embodiments of this invention have been described in detail, it will be appreciated that modifications and variations therefrom will be apparent to those skilled in the art. Accordingly, this invention is to be limited only by the scope of the appended claims.

Claims

1. A rear projection screen (12) comprising light spreading means on the front surface (30) of said screen for receiving rays from an image source and deflecting respective ones of said rays to display said image with substantial uniform brightness over a wide viewing angle; said light spreading means comprising a plurality of closely spaced generally parallel cylindrical lenses (32); at least some of said lenses being comprised of a base portion, a first side portion (34), a second side portion (36) and a tip portion (38) opposite said base portion, said tip portion (38) comprising two convex cylindrical portions (40, 44) contiguous with said first side portion and said second side portion respectively, said tip portion (38) comprising a concave cylindrical portion (42) contiguous to both said convex portions; said tip portion being substantially refractive; said first side portion having a first average slope and said second side portion having a second average slope being selected so that said first side portion and said second side portion are substantially internally reflective; said first average slope being between 63° and 85° with respect to said base portion; said second average slope being between 63° and 85° with respect to said base portion; characterized in that the ratio of the height of said lenses to the width of said base portion is greater than 1:1 and the ratio of the width of said base portion to the width of said tip portion is greater than 2:1.
2. The rear projection screen claimed in Claim 1, characterized in that all of said plurality of closely spaced generally cylindrical lenses (32) are of the same construction.
3. The rear projection screen of Claim 2, characterized in that said first average slope and said second average slope are each greater than 70° .
4. The rear projection screen of Claim 3, characterized in that said first average slope and said second average slope are substantially equal.



5. The rear projection screen of Claim 1, characterized in that said two convex cylindrical portions (40, 44) and said concave cylindrical portion (42) have substantially equal radii.
6. The rear projection screen of Claim 5, characterized in that said cylindrical lenses (34) are symmetrical about a central plane extending perpendicular to the base portion.
7. The rear projection screen of Claim 1, characterized in that said height to width ratio is greater than 3:2.
8. The rear projection screen of Claim 7, characterized in that said width to width ratio is greater than 3:1.
9. The rear projection screen of Claim 6 having said first side portion, said second side portion and said tip portion substantially proportional to a cylindrical lens defined as having a width equal to 0.55 mm and symmetry at $x = 0.275$ mm, and each of said symmetrical side portions being constructed from 397 straight line segments which are defined by the expression:

$$\text{slope} = M_n = \text{TAN} [90^\circ - 0.5 \cdot \text{ARCTAN} [(0.2888 - X_n) + (0.9280 - Y_n)]]$$

where:

$$X_1 = 0, Y_1 = 0$$

$$D = 0.2131 + 397 = 5.371 \cdot 10^{-4}$$

$$M_1 = 6.5786$$

$$X_n = (n - 1) \cdot D$$

$$Y_n = Y_{n-1} + D \cdot M_{n-1}$$

the end of the point of the 397th segment being $X_{398} = 0.21310$, $Y_{398} = 0.88438$;

the shape of said first side portion being determined by the following interpolation rule: given X , $X < 0.21310$ and $X_1 \leq X < X_{i+1}$, then

$$Y = Y_1 + (X - X_1) \cdot M_1 + D;$$

the shape of said tip portion being defined as follows:

for $0.21310 \leq X < 0.25735$ the shape is a circle with $XO_1 = 0.23971$ and $YO_1 = 0.86896$ and $R = 0.03076$ mm in the formula

$$Y = -\text{SQRT} [R^2 - (X - XO_1)^2] + YO_1, \text{ and}$$

for $0.25735 \leq X < 0.2750$ the shape is a circle with $XO_2 = 0.22750$ and $YO_2 = 0.91936$ and R is again 0.03076 mm in the formula

$$Y = +\text{SQRT} [R^2 - (X - XO_2)^2] + YO_2; \text{ and}$$

wherein all values of Y are greater than or equal to 0 and the rib is defined as a contiguous function for Y and a slope of Y .

10. The rear projection screen of Claim 1, characterized in that said cylindrical lenses (32) define grooves (46) there between and said screen further comprises absorbing means (43), disposed in said grooves, for absorbing visible light, the absorbing means comprising an amount of light-absorbent discrete particles, whereby reflection of visible light impinging on the screen is reduced.
11. The rear projection screen as claimed in Claim 10, characterized by skin means (50) for containing the particles within the grooves.
12. The rear projection screen as claimed in Claim 1, characterized in that the screen further comprises diffusing means.
13. The rear projection screen as claimed in any of the preceding Claims, characterized by light collimating means on a rear portion of the screen for receiving divergent light rays from an image projector and collimating said rays into parallel rays representative of an image to be displayed by said screen.

Patentansprüche

1. Rückprojektionsschirm (12) mit Lichtstreuungsmitteln an der Vorderfläche (30) des Schirms zum Empfangen von Strahlen aus einer Bildquelle und zum Ablenken einzelner Strahlen zum Wiedergeben des Bildes mit wesentlich einheitlicher Helligkeit über einen breiten Betrachtungswinkel; wobei die Lichtstreuungsmittel eine Anzahl im allgemeinen paralleler zylindrischer Linsen (32) mit kleinerem gegenseitigem Abstand enthalten, wenigstens einige dieser Linsen aus einem Basisteil, einem ersten Seitenteil (34), einem zweiten Seitenteil (36) und einem Spitzenteil (38) gegenüber dem Basisteil bestehen, der Spitzenteil (38) zwei konvexe zylindrische Teile (40, 44) neben dem ersten Seitenteil bzw. dem zweiten Seitenteil und einen konkaven zylindrischen Teil (42) neben den beiden konvexen Teilen enthält und im wesentlichen reflektierend ist, der erste Seitenteil eine erste mittlere Neigung und der zweite Seitenteil eine zweite mittlere Neigung haben und so gewählt werden, daß der erste Seitenteil und der zweite Seitenteil im wesentlichen inwendig reflektierend sind, die erste mittlere Neigung zwischen 63° und 85° gegen den Basisteil und die zweite mittlere Neigung



zwischen 63° und 85° gegen den Basisteil beträgt, dadurch gekennzeichnet, daß Verhältnis der Höhe der Linse zur Breite des Basisteils größer ist als 1:1 und das Verhältnis der Breite des Basisteils zur Breite des Spitzenteils größer ist als 2:1.

2. Rückprojektionsschirm nach Anspruch 1, dadurch gekennzeichnet, daß alle Linsen der Anzahl von nahe beieinander liegenden im allgemeinen zylindrischen Linsen (32) auf gleiche Weise aufgebaut sind.

3. Rückprojektionsschirm nach Anspruch 2, dadurch gekennzeichnet, daß die erste mittlere Neigung und die zweite mittlere Neigung je größer sind als 70°.

4. Rückprojektionsschirm nach Anspruch 3, dadurch gekennzeichnet, daß die erste mittlere Neigung und die zweite mittlere Neigung im wesentlichen gleich sind.

5. Rückprojektionsschirm nach Anspruch 1, dadurch gekennzeichnet, daß die zwei konvexen zylindrischen Teile (40, 44) und der konkave zylindrische Teil (42) im wesentlichen gleiche Radien haben.

6. Rückprojektionsschirm nach Anspruch 5, dadurch gekennzeichnet, daß die zylindrischen Linsen (34) um eine Zentralebene symmetrisch sind, die sich senkrecht zum Basisteil erstreckt.

7. Rückprojektionsschirm nach Anspruch 1, dadurch gekennzeichnet, daß das Höhen/Breitenverhältnis größer als 3:2 ist.

8. Rückprojektionsschirm nach Anspruch 7, dadurch gekennzeichnet, daß das Breiten/Breitenverhältnis größer als 3:1 ist.

9. Rückprojektionsschirm nach Anspruch 6 mit dem ersten Seitenteil, dem zweiten Seitenteil und dem Spitzenteil im wesentlichen proportional zu einer zylindrischen Linse, definiert durch eine Breite gleich 0,55 mm und symmetrisch um $x = 0,275$ mm, und jede der symmetrischen Seitenflächen aus 397 geraden Zeilensegmenten aufgebaut, die durch folgenden Ausdruck definiert werden:

$$\text{Neigung} = M_n = \text{TAN} [90^\circ - 0,5 \times \text{ARCTAN} [(0,2888 - X_n) + (0,9280 - Y_n)]]$$

worin:

$$X_1 = 0, Y_1 = 0.$$

$$D = 0,2131 + 397 = 5,371 \times 10^{-4}$$

$$M_1 = 6,5786$$

$$X_n = (n-1) \times D$$

$$Y_n = Y_{n-1} + D \times M_{n-1},$$

wobei der Endpunkt des 397. Segment $X_{398} = 0,21310$, $Y_{398} = 0,88438$ ist,

die Form des ersten Seitenteils durch folgende Interpolationsregel bestimmt wird: wenn $X, X < 0,21310$ und $X_1 \leq X < X_{i+1}$ sind, so ist

$$Y = Y_i + (X - X_i) \times M_i + D,$$

die Form des Spitzenteils wie folgt definiert wird:

für $0,21310 \leq X < 0,25735$ ist die Form ein Kreis mit $XO_1 = 0,23971$ und $YO_1 = 0,88896$ und $R = 0,03076$ mm in der Gleichung

$$Y = -\text{SQRT}[R^2 - (X - XO_1)^2] + YO_1 \text{ ist, und}$$

für $0,25735 \leq X < 0,2750$ ist die Form ein Kreis mit $XO_2 = 0,22750$ und $YO_2 = 0,91936$ und R wieder gleich 0,03076 mm in der Gleichung

$$Y = +\text{SQRT}[R^2 - (X - XO_2)^2] + YO_2 \text{ ist, und}$$

worin alle Werte von Y größer oder gleich 0 und die Rippe als durchgehende Funktion für Y und eine Neigung von Y sind.

10. Rückprojektionsschirm nach Anspruch 1, dadurch gekennzeichnet, daß die zylindrischen Linsen (32) zwischenliegende Rillen (46) definieren und der Schirm außerdem Absorbiermittel (43) in den Rillen zum Absorbieren von sichtbarem Licht enthält, wobei die Absorbiermittel eine Menge lichtabsorbierender diskreter Teilchen enthalten, und Reflexion des auf den Schirm fallenden sichtbaren Lichts verringert wird.

11. Rückprojektionsschirm nach Anspruch 10, dadurch gekennzeichnet, daß der Schirm eine Haut (50) enthält, die die Teilchen in den Rillen festhält.

12. Rückprojektionsschirm nach Anspruch 1, dadurch gekennzeichnet, daß der Schirm außerdem Diffusionsmittel enthält.

13. Rückprojektionsschirm nach einem oder mehreren der vorangehenden Ansprüche, dadurch gekennzeichnet, daß er Lichtkollimiermittel auf einem Rückteil des Schirms zum Empfangen divergierender Lichtstrahlen aus einem Bildprojektor und zum Kollimieren der Strahlen in parallele Strahlen als Darstellung eines am



Schirm wiederzugebenden Bildes enthält.

Revendications

1. Ecran de projection par transparence (12) comportant des moyens de dispersion de lumière disposés sur la surface avant (30) dudit écran pour recevoir des rayons issus d'une source d'image et pour dévier des rayons correspondants desdits rayons pour visualiser ladite image sur un angle de vision large avec une luminosité sensiblement uniforme, lesdits moyens de dispersion de lumière comportant une multitude de lentilles cylindriques généralement parallèles étroitement espacées (32), au moins quelques-unes desdites lentilles comportant une partie inférieure, une première partie latérale (34), une seconde partie latérale (36) et une partie supérieure (38) située à l'opposé de ladite partie inférieure, ladite partie supérieure (38) comportant deux parties cylindriques convexes (40, 44) contiguës à ladite première partie latérale respectivement à ladite seconde partie latérale, ladite partie supérieure (38) comportant une partie cylindrique concave (42) contiguë auxdites deux parties convexes, ladite partie supérieure étant sensiblement réfractive; ladite première partie latérale présentant une première pente moyenne et ladite seconde partie latérale présentant une seconde pente moyenne choisies de manière que lesdites première et seconde parties latérales sont sensiblement réfléchissantes à l'intérieur, ladite première pente moyenne étant comprise entre 63° et 85° par rapport à la partie inférieure; ladite seconde pente moyenne étant comprise entre 63° et 85° par rapport à la partie inférieure; caractérisé en ce que le rapport de la hauteur desdites lentilles à la largeur de la partie inférieure est supérieur à 1 : 1 et que le rapport de la largeur de ladite partie inférieure à la largeur de ladite partie supérieure est supérieur à 2 : 1.
2. Ecran de projection par transparence selon la revendication 1, caractérisé en ce que toutes les lentilles de ladite multitude de lentilles généralement cylindriques étroitement espacées (32) présentent la même construction.
3. Ecran de projection par transparence selon la revendication 2, caractérisé en ce que ladite première pente moyenne et ladite seconde pente moyenne sont chacune supérieures à 70°.
4. Ecran de projection par transparence selon la revendication 3, caractérisé en ce que ladite

première pente moyenne et ladite seconde pente moyenne sont sensiblement égales.

5. Ecran de projection par transparence selon la revendication 1, caractérisé en ce que lesdites deux parties cylindriques convexes (40, 44) et ladite partie cylindrique concave (42) présentent sensiblement le même rayon.
6. Ecran de projection par transparence selon la revendication 5, caractérisé en ce que lesdites lentilles cylindriques (34) sont symétriques autour d'un plan central s'étendant perpendiculairement à la partie de base.
7. Ecran de projection par transparence selon la revendication 1, caractérisé en ce que ledit rapport de hauteur (h) à la largeur (w) est supérieur à 3 : 2.
8. Ecran de projection par transparence selon la revendication 7, caractérisé en ce que ledit rapport de largeur (w) à la largeur (w') est supérieur à 3 : 1.
9. Ecran de projection par transparence selon la revendication 6, présentant ladite première partie latérale, ladite seconde partie latérale et ladite partie supérieure sensiblement proportionnelles à une lentille cylindrique définie comme ayant une largeur égale à 0,55 mm et une symétrie à $x = 0,275$ mm et chacune desdites parties symétriques latérales étant construite à partir de 397 segments de ligne droite définis par l'expression:

$$\text{pente} = M_n = \text{TAN} [90^\circ - 0,5 \times \text{ARCTAN} [(0,2888 - X_n) : (0,9280 - Y_n)]]$$

où:

$$X_1 = 0, Y_1 = 0.$$

$$D = 0,2131 : 397 = 5,371 \cdot 10^{-4}$$

$$M_1 = 6,5786$$

$$X_n = (n-1) \cdot D$$

$$Y_n = Y_{n-1} + D \cdot M_{n-1}$$

l'extrémité du point du 397^{ème} segment étant $X_{398} = 0,21310$, $Y_{398} = 0,88438$;

la forme de ladite première partie latérale étant déterminée par la règle d'interpolation suivante: donné X , $X < 0,21310$ et $X_i \leq X < X_{i+1}$ alors

$$Y = Y_i + (X - X_i) \cdot M_i + D;$$

la forme de ladite partie supérieure étant définie comme suit: pour $0,21310 \leq x < 0,25735$ la forme est un cercle avec $XO_1 = 0,23971$ et $YO_1 = 0,86896$ et $R = 0,03076$



mm dans la formule

$$Y = -\sqrt{R^2 - (X - XO_1)^2} + YO_1, \text{ et}$$

pour $0,25735 \leq X < 0,2750$ la forme est un cercle avec $XO_2 = 0,22750$ et $YO_2 = 0,91936$, R est à nouveau égal à $0,03076$ mm dans la formule

$$Y = +\sqrt{R^2 - (X - XO_2)^2} + YO_2; \text{ et}$$

où toutes les valeurs de Y sont supérieures ou égales à 0 et où la nervure est définie comme une fonction continue pour Y et une pente de Y.

10. Ecran de projection par transparence selon la revendication 1, caractérisé en ce que lesdites lentilles cylindriques (32) définissent des rainures (46) pratiquées entre lesdites lentilles et que ledit écran comporte en outre des moyens d'absorption (43), disposés dans lesdites rainures, pour absorber de la lumière visible, les moyens d'absorption comportant une quantité de particules discrètes d'absorption de lumière, la réflexion de lumière visible heurtant l'écran étant réduite.

11. Ecran de projection par transparence selon la revendication 10, caractérisé par des moyens de peau (50) maintenant les particules dans les rainures.

12. Ecran de projection par transparence selon la revendication 1, caractérisé en ce que l'écran comporte en outre des moyens de diffusion.

13. Ecran de projection par transparence selon l'une quelconque des revendications précédentes, caractérisé par des moyens de collimation de lumière disposés sur une partie arrière de l'écran pour recevoir des rayons de lumière divergents issus d'un projecteur d'image et pour collimater lesdits rayons en rayons parallèles représentatifs d'une image à visualiser par ledit écran.

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