

SPECIFICATION

Directional front projection screen

5 This invention relates to a directional front projection screen. 5

A front projection screen receives a projected image from a lens and redirects this image to individual viewing zones which make up a larger viewing area.

Early front projection screens took the form of an opaque Lambertian white surface which reflected the projected image to a wide viewing area. Brighter portions of the image were reflected by the white surface to the viewers, whereas, the darker portions of the image were formed by the absence of light in the room. 10
Consequently, the contrast ratio of the image depended upon the reflectivity of the screen and the ambient light level in a viewing room. Although this type of screen allows uniform brightness, light is reflected outside of the normal viewing range and consequently was inefficient. 10

Next, small glass beads were incorporated onto the white surface which increased the reflectivity of the surface in the usable viewing area. This increase in reflecting efficiency is referred to as the gain of the screen. Although the beaded surface offered an improvement in optical performance, the material itself was subject to degradation with age and was easily injured. 15

The next development was the silver lenticular screen which had a reflective silvered surface corrugated for the purpose of expanding the horizontal viewing field by controlling direction of reflected light in the horizontal plane. This improved image contrast under high ambient light condition. The silvered lenticular screen offered lower gain than the beaded surfaces; however, it offered an improvement in terms of durability. This screen does not achieve the uniformity of brightness. 20

According to the present invention, a front projection screen comprises a sheet incorporating a translucent layer of light diffusing particles, said sheet having a first major surface with a matte finish for reducing specular reflection therefrom; and a second major surface configured as an incremental specular reflector for directing light to a plurality of viewing zones, such incremental specular reflector having a linear array of inclined facets arranged in a plurality of clusters, a particular inclined facet in each of said plurality of clusters serving to redirect projected light toward a particular one of said plurality of viewing zones. The screen can provide uniformity of both brightness and light intensity over a broad viewing region encompassing the plurality of viewing zones. The screen may also include an adhesive located on the second surface for mounting the screen on a substrate. 25
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The facets which form the reflector are oriented to direct an image to a relatively large audience occupying a wide viewing area consisting of a number of viewing zones. Each cluster consists of a specified number of adjacent facets. Each facet within a cluster is oriented to direct light toward a different location or zone within the viewing area. 35

The invention will now be described by way of example and with reference to the accompanying drawing wherein:-

Figure 1 is a cross-sectional view showing the structure used in a projection screen according to the present invention;

40 *Figure 2* is a cross-section showing how the construction of *Figure 1* is used to redirect a projected image towards a single viewing zone; and 40

Figure 3 is a broken cross-section showing a projection screen according to the present invention.

In the structure of *Figure 1* a screen 1 is formed from a sheet incorporating translucent layer 2 containing a large number of light diffusing particles. This layer may be located within the sheet or coated onto the sheet. 45
The first surface 3 of the sheet has a matte finish to reduce specular reflection at this surface. This surface may be embossed or coated to achieve the matte finish. 45

The second or rear surface 4 is configured as a linear incremental specular reflector. The facets 5 of this incremental surface are separated by riser steps 6. A reflective material 7 such as aluminium is coated onto the rear surface 4 of the sheet to achieve a specularly reflective surface. Each facet is inclined at an angle θ_N varying with respect to a base line 8 which is parallel to the front surface 3 of the sheet. 50

For design purposes, geometric ray tracing techniques are used to calculate the desired angle θ_N for each facet. For these calculations the effect of the diffusing particles is ignored. Once the geometry of screen has been established, the effect of the diffusing material is considered by superimposing a diffuse scattering lobe 9 around each of the design rays 10 at the exit point on the first surface of the screen. 55

Figure 2 shows how a plurality of facets 25, 26, 27 are oriented to reflect an image projected from a source 20 to one narrow viewing zone 21. The angle θ_N for each of these facets is different. Thus, rays 22, 23, 24 incident upon facets 25, 26, 27 located at various locations on screen 28 are directed toward viewing zone 21 by selection of an appropriate θ for each of these facets. The scattering effect represented by lobes 29, 33, 34 of the diffusion material of screen 28 defines the size of viewing zone 21. The angle θ_N for each of a different group of facets is similarly selected to reflect the image to another viewing zone. This is further explained hereinafter with reference to *Figure 3*. 60

In *Figure 3*, a plurality of viewing zones are defined for design calculations respectively by observers A, B, C, D to receive an image projected from a source 30. The aggregate of viewing zones defines the useful viewing area.

65 For a typical projection T.V. application the incremental facets would extend vertically up and down on the 65

screen. The screen itself may be slightly curved in the vertical plane to direct more light toward the audience. However, the horizontal distribution of light is determined by the facets. This simple one dimensional curvature is an advance over more complex compound curve screens.

The facets of screen 31 in this embodiment are arranged in clusters. Each cluster, 32, for example, includes a specified number of facets 32A, 32B, 32C, and 32D. Each facet is inclined at an angle θ_N to direct a portion of the image to particular viewing zone. For example, facet 32A of cluster 32 is inclined at an angle θ such that it directs an incident ray toward viewing zone A. In a similar fashion facets 33A and 34A direct incident rays 36, 37 toward viewing zone A. In this manner individual facets located in various cluster located throughout the screen cooperate to selectively direct light to specified viewing locations.

The effect of the diffusing material incorporated in screen 31 is to blend the viewing zones into an approximately uniformly illuminated viewing area, such that the screen appears equally bright for all observers within the viewing area. The width of facets is dependent on the use of the screen. In general they are too small to be resolved by the viewer. This contrasts sharply with prior art Lambertian screens in which screen brightness drops off rapidly as one moves away from the principal axis of the screen.

The shape of the diffusion lobes 38, 39, 40 depict the angular distribution of light or brightness around a selected ray. The shape of these distribution lobes is determined by concentration and type of diffusing material incorporated in screen 31.

One suitable formulation for a screen according to this invention is given in the following example.

20 Example

A composition containing 95 percent by weight of a medium hard cellulose acetate butyrate polymer and 5 percent by weight of lamellar microform quartz particles, was extruded on a 1.91 cm (0.75 inch) extruder (manufactured by C. W. Brabender Instruments, Inc., Hackensack, NJ) into 0.0254 cm (0.010 inch), 0.0381 cm (0.015 inch) and 0.0508 cm (0.020 inch) thick film at the following temperature conditions;

Zone 1 at 180°C, Zone 2 at 195°C, Zone 3 at 210°C,
Zone 4 at 200°C and die at 200°C.

In a secondary platen pressing compression molding cycle, one side of each film was thermally embossed with a nickel electro-formed stamper containing a specially designed Fresnel lens while the opposite side was embossed with a chrome steel backplate containing a matte finish.

The compression molding was conducted in a steam heated - water cooled hydraulic press (Model 12-12-ST manufactured by Wabash Metal Products Company, Inc., Hydraulic Division, Wabash, Ind.) to a maximum temperature of 143°C (290°F) and 14.1 kg per square centimeter (200 pounds per square inch) with a complete cycle time of approximately five minutes. The sandwich was cooled to 60°C (140°F), removed from the press, and separated from the stamper and backplate. The grooved surface was vapor deposited with from 800 to 1000Å thickness of aluminum. An adhesive may be applied to the rear surface mechanically attaching the screen to a substrate.

The screen luminance and image contrast were determined according to ANSI/NMA MS-12 standard and compared to a metallic lacquer coated screen while mounted in a "Valiant" projector (manufactured by Realist).

LUMINANCE

	Cntr	Avg. Int*	Avg. Top	Corner* Bottom	Contrast
10 mil	200	53	18	18	47
15 mil	139	61	26	31	36
20 mil	91	73	43	44	42
Lacquer	43	33	8	25	19

*As a percentage of the center in foot lamberts.

This is in sharp distinction to conventional prior art screens in which image brightness drops off as one moves away from the principal axis or projection axis of the screen.

As the thickness or amount of silica increases, the center brightness decreases, but the screen becomes more uniformly illuminated. The screen contrast of the diffusion Fresnel lens screen, for all film thicknesses, is approximately double that of the conventional reflecting lacquer screen.

It is also important to note that the Fresnel lens is designed in such a manner that the average screen top and screen bottom luminance values become uniform, while in the reflecting lacquer screen the screen top luminance is only one third that of the bottom. Thus the Fresnel lens has redirected the majority of the

reflected light for off axis viewing.

To further enhance the uniformity of illumination, the screen of either embodiment may be curved slightly to control light distribution in the plane not controlled by the incremental surface.

Thus, to any single observer within the viewing area, the screen will appear uniformly bright, both from
5 side-to-side and from top-to-bottom.

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CLAIMS

- 10 1. A front projection screen comprising a sheet incorporating a translucent layer of light diffusing particles, said sheet having a first major surface with a matte finish for reducing specular reflection therefrom; and a second major surface configured as an incremental specular reflector for directing light to a plurality of viewing zones, such incremental specular reflector having a linear array of inclined facets arranged in a plurality of clusters, a particular inclined facet in each of said plurality of clusters serving to
15 redirect projected light toward a particular one of said plurality of viewing zones.
2. A front projection screen according to Claim 1 including an adhesive located on the second surface for mounting the screen on a substrate.
3. A front projection screen substantially as described herein with reference to Figure 3 of the accompanying drawing.

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The following corrections were allowed under Section 13 on 6 March 1984:

Front page, Heading (72), Inventors *below* Conder *insert* Dennis F. Vanderwerf.

THE PATENT OFFICE
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