

PATENT SPECIFICATION

(11) 1369 684

1369 684

- (21) Application No. 41546/71 (22) Filed 6 Sept. 1971
 (31) Convention Application No. 69863 (32) Filed 4 Sept. 1970 in
 (33) United States of America (US)
 (44) Complete Specification published 9 Oct. 1974
 (51) International Classification G03B 21/56
 (52) Index at acceptance G2X 42
 (72) Inventor JAMES JOHN DEPALMA



(54) IMPROVEMENTS IN OR RELATING TO REAR PROJECTION SCREENS

(71) We, EASTMAN KODAK COMPANY, a Company organized under the Laws of the State of New Jersey, United States of America of 343 State Street, Rochester, New York 14650, United States of America do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to rear projection screens.

Conventional rear projection screens have a particular disadvantage in that they do not reject the ambient light to the extent necessary so that the projected image is one of high contrast and good colour quality. It is well known in the art that this situation can be somewhat improved by incorporating a light absorbing material along with a particular material in the screen for redirecting the ambient and/or image light. In a screen which has a light absorbing material embodied therein, a good proportion of the ambient light is reflected from the surface of the screen before the absorbing material has a chance to absorb any significant amount of the ambient light. As a result, little or no gain in effective ambient light absorption relative to image light absorption is realized with this technique. The ambient light reflected from the surface of the screen is due to the scattering type of light redirection caused by the actual screen structure and the type of surface on the side of the screen facing the viewer. Consequently, the projected image has low contrast, low colour saturation and appears to the viewer as a washed-out image. For example, it is very difficult to reproduce black in a rear projection system without selective attenuation of the ambient light relative to the image light.

According to the present invention, there is provided a rear projection screen comprising an image light scattering layer having light scattering particles dispersed in a transparent material, and an ambient light control layer

superposed on the image light scattering layer and having a plurality of light absorbing dyes in a generally transparent carrier medium, the light absorbing dyes comprising Toluidine Blue Colour Index No. 52040, Acid Brilliant Cyanine Blue as herein defined, Fast Light Red BA, Superchrome Yellow GN and Ethyl Orange.

The light scattering particles may be of chlorinated diphenyl resin.

Reference is now made to the accompanying drawings wherein:—

Figure 1 is a partial cross-section, to an enlarged scale through a conventional screen having light scattering particles embodied therein and illustrates the effect of ambient light incident on the viewing surface thereof;

Figure 2 is a similar view through a screen embodying the present invention in which a colour and ambient light control layer is applied to the viewing surface, and shows the manner in which ambient light is absorbed and redirected by such a layer;

Fig. 3 shows a number of transmittance-wavelength curves for various screens.

A conventional rear projection screen 10 is shown in Fig. 1 in which the support 11 has light scattering elements or particles 12 incorporated therein. As shown by the arrows 13, the projected image light is incident on the back surface 14 of the screen and the observer 15 views the image by looking at the surface 16. The ambient light is shown by the lines 17, with arrows indicating the direction of the incident light. The manner in which such light can be refracted by the surface 16 before it enters the support 11 and can be redirected by the elements or particles 12 therein is designated schematically by the weighted lines. At least a portion of the ambient light on the viewer's side of the screen is reflected as designated by the arrows 18. The ambient light which is refracted upon entry into support 10 is scattered when an element or particle 12 is struck. The portion of this light that is redirected to surface 16 is again refracted (line 18a) or totally re-

5 flected (line 18b) depending on the angle of incidence. In any case, this type of screen returns a large amount of the ambient light to the observer, as indicated by the weight and number of return lines 19. This results in an image of low contrast and low colour saturation. The image light distribution is generally symmetric about the projector axis and has a spread of the order of a plus or minus 20—30° or more.

10 Some screens use a material in which the particles embodied therein absorb the ambient light or in which a second component, which can be a light scattering or non-scattering component, is mixed with the material forming the primary component or support. This technique is only partly successful in that there is always back-scattered light from the particles and a good share of the ambient light is reflected, as mentioned above, because the reflection occurs at the surface 16 and before the absorbing material has a chance to act. In this case, an essentially equal amount or more of the image light 13 is also absorbed and therefore little or no gain in effective ambient light relative to image light absorption is realized.

25 The screen 20 shown in Fig. 2 has a dyed, transparent (non-scattering), absorbing layer 21 on the viewer's side of the screen. The ambient light is designated by lines 22 with arrows indicating the light direction and, upon striking the surface 23 of layer 21, most of this light is refracted rather than reflected. A very small portion of the ambient light is reflected by surface 23 as indicated by lines 27. The light travels through the layer 21, usually obliquely, and in most instances, the remaining light is for the most part absorbed by the dyes incorporated in the layer 21. A good share of the ambient light remaining after the initial transit through the dye layer 21 is also absorbed but in the following manner. The ambient light remaining after the first pass through the dye layer 21 strikes the screen particles 24 and is redirected more or less randomly in all directions, so that a significant fraction might re-enter the dyed layer 21 due to the back-scattering in all directions. The light which has re-entered layer 21 in this manner again travels through the dye layer 21 and has another chance to be absorbed and substantially reduced (lines 28). It should be pointed out that the spreading of the back-scattered ambient light allows a relatively large share of the light to go through the dye layer at high angles, thus travelling through proportionately more of the dye layer and, equally important, strikes the dye-layer-air surface at all angles with a good share of the light incident at angles greater than the critical angle. This means that most of this light is reflected back through the dye layer (line 29) a third time and the process is repeated over and over.

Relatively very little of this light action occurs to the image light 25 that is incident on the surface 26 of screen 20. The image light in its transit through the screen 20 is redirected by the screen elements before layer 21. In addition, the forward scattered light is generally much larger than the backward scattered light and further is incident upon the particular layer at, or close to, normal angles of incidence and therefore travels through the dye layer 21 in a more normal and shorter path than the ambient light.

All of these factors add up to a significantly more efficient screen in terms of brightness, contrast and image colour saturation compared to a screen having no ambient light control or with an ambient light control using absorbing material in situ with the light scattering particles.

The system in the subject invention provides excellent ambient light control for a scattering type projection screen. The density of the dye, the thickness of the dye layer or the preference of optical or physical control of the dyed layer with the screen material or support depends on the characteristics of the screen material per se. The amount and kind of ambient light, the intensity of the image light as well as other factors also affect the resultant image. One of the very important advantages of the use of a non-scattering dye layer is that while it is being used as an efficient ambient light control element it can also be used to control the colour quality of the light in the projected image. It has proven to be desirable to correct the colour temperature of the light source used in such rear projection devices which are typically thermal in nature and therefore too warm in colour quality, to a more desirable and cooler quality. The dye layer 21 can accomplish this in a position relative to the screen support as shown in Fig. 2. Also, if required, a spectral energy match to any desired colour quality can be made.

The following Examples illustrate the invention:—

Example 1

A standard, commercially available rear projection screen as described with reference to Figure 1, was cleaned, subbed and overcoated with a layer having a composition as set forth hereinbelow at 80.4 cc per 11 1/2" square samples.

240 cc	15%	gelatin	
16.8 cc	1%	Toluidine Blue	
11.4 cc	1%	Acid Brilliant Cyanine Blue BLI	
6.0 cc	1%	Fast Light Red BA	125
31.2 cc	0.1%	Superchrome Yellow GN	
36.9 cc	0.1	Ethyl Orange Dye 319	
Total	600 cc	water to make	

Approximately 180 cc of 0.10% Aerosol OT in water was added to this solution as a coating aid (Aerosol OT being a registered trademark of American Cyanamid Co. for a wetting agent and surface-tension depressant). After coating and drying for 24 hours, the surface was sprayed lightly with a layer of transparent lacquer. On practical visual tests using the screen in a commercial film reader, it was found the ambient light control was enhanced as evidenced by the blackness of the screen with the projection lamp off in a room with 150 foot candles of ambient light. The colour control was indicated by measurement with a colour temperature meter. Colour saturation was retained in the projected image

and the brightness range extended; that is, blacks were blacker and whites were whiter when compared with the standard rear projection screen.

Example 2

Example 1 was repeated using a polypropylene screen, such as that disclosed in Patent Application No. 14875/70 (Serial No. 1308984). The ambient light control and image colour were enhanced, as in Example 1. An additional advantage was realized in that this screen system exhibited not only good brightness and contrast but essentially no scintillation. The dye layer can be readily affixed to this non-scintillating type of screen.

Examples 3—6

The following formulae were used on a rear projection screen of the type used in Example 1 and on a polypropylene screen of the type used in Example 2 to control both ambient light and colour temperature.

	Ex. 3	Ex. 4	Ex. 5	Ex. 6
Gelatin 15% in water	80 cc	80 cc	80 cc	80 cc
Toluidine Blue (1%)	2.8 cc	3.5 cc	4.2 cc	4.90 cc
Acid Brilliant Cyanine Blue (1%)	1.9 cc	2.38 cc	2.85 cc	3.33 cc
Fast Light Red BA (1%)	1.0 cc	1.24 cc	1.50 cc	1.75 cc
Superchrome Yellow GN (0.1%)	5.2 cc	6.50 cc	7.80 cc	9.100 cc
Ethyl Orange Dye 319 (0.1%)	4.48 cc	5.60 cc	6.72 cc	7.84 cc
Glycerine 50%	20 cc	20 cc	20 cc	20 cc
Water to	200 cc	200 cc	200 cc	200 cc
Aerosol OT 0.1% in Water	13.1 cc	13.1 cc	13.1 cc	13.1 cc

The colour temperature conversion for each screen is in the range of approximately 2850—3400°K and the series contains increasing amounts of non-selective, non-scattering absorption dyes for controlling higher ambient light levels. These screens all showed improved contrast and brightness range.

Example 7

The solution of Example 5 was diluted to 300 cc total and the amount of glycerine was increased to 30 cc. This solution was coated on (1) a specular surfaced screen of the type used in Example 1, and (2) a semi-matte overcoating sprayed over the dye layer on a screen of the type used in Example 1, both being cleaned and subbed prior to coating. After drying, the screens were placed in experimental viewers and compared with a conventional coated screen as a test screen. It was noted the ambient light was reduced considerably and the image colour quality was much enhanced.

Example 8

Two 8×10" optically flat glass plates were each coated on one surface with a dispersion of a standard Arocolor resin in gelatin as described in Patent Application No. 14884/70 (Serial No. 1308984). On the opposite surface of one glass plate, which surface will be the front surface of the screen, a layer of dyes in gelatin of the following formula was coated using 48.6 cc of the solution for the plate. (Arocolor is a registered trademark of Monsanto Chemical Co. for a resin used to impart moisture and chemical resistance).

80 cc 15% gelatin in water	85
0.88 cc 1% Toluidine Blue	
0.60 cc 1% Acid Brilliant Cyanine Blue	
BLI	
0.32 cc 1% Fast Light Red BA	
1.64 cc 0.1% Superchrome Yellow	90
1.40 cc 0.1% Ethyl Orange	
20 cc 50% Glycerine	
Water to 200 cc, then 14.59 of 0.1% Aerosol OT was added as a coating aid.	

The coating was dried and then sprayed with a layer of transparent lacquer. The plates were then assembled with a layer of silicone rubber therebetween as described in Patent Application No. 14884/70 (Serial No. 1308984) with the dye layer on the viewing side of the screen. The plates were then mounted in an orbiting device as described in Patent Application No. 14883/70 (Serial No. 13060090) and set in motion. The results were similar to those reported above and particularly to those noted in Example 2.

Example 9

Example 8 was repeated except that the dye layer was coated in half the concentration on each glass plate, so that half the dye layer was, in effect, on the inside of the viewer and orbited with the rear plate forming the screen. The lacquer overcoat was omitted from the rear plate as no protection was needed. The results noted were substantially the same as those of Example 8.

With reference to Fig. 3, curve A shows the transmittance-wavelength characteristics for a test screen that provided a comparison basis. The screen comprised a glass plate having a light scattering layer coated on one surface thereof, the layer comprising a dispersion of gelatin and chlorinated diphenyl resin (Aroclor). The screen with such a layer transmits about 70-85% of the light incident thereon, the higher percentage being in the frequency of the yellow-orange-red colours. As a result, white does not appear as such in the projected image, but rather yellowish. Likewise black appears to be hazy and not a true black. When the reflected ambient light is added to such a projected image, the contrast is still further reduced.

Curves B to F show the transmittance-wavelength characteristics of screens having light control layers in accordance with the invention showing that more light is transmitted in the blue frequency range. Although less light is actually transmitted, the contrast is enhanced because the yellow-orange-red frequencies do not predominate, the contrast being enhanced because of the absorption of the ambient light.

Curve G shows such characteristics for a screen constructed in accordance with Example 8. The screen transmits primarily in the blue-green frequency range with a higher percentage of total transmittance.

In instances where the projection screen is such that it permits a much higher than normal ratio of forward to back-scattered light in the screen material, it may be advantageous to use in addition a non-scattering dye system in a separate layer on the screen surface facing the light source.

The screen support 30 can consist of particles of plastics material embedded in a clear resin coated on glass or a suitable transparent, plastics material, such as a vinyl or methylacrylate, or the carrier resin itself may be self-supporting. It is conceivable therefore that the non-scattering dye layer 32 can be dispersed in any number of non-scattering carrier media such as gelatin, methylacrylate, glass or polystyrene, and subsequently coated on or placed as a separate sheet in physical contact with the screen support 30.

The dyes referred to herein may be identified as follows:

Toluidine Blue	Colour Index No. 52040
Fast Light Red	
BA	Colour Index No. 17045
Superchrome	
Yellow GN	Colour Index No. 14905

Acid Brilliant Cyanine Blue is the blue dye described in U.S. Patent Specification No. 3220925.

WHAT WE CLAIM IS:—

1. A rear projection screen comprising an image light scattering layer having light scattering particles dispersed in a transparent material, and an ambient light control layer superposed on the image light scattering layer and having a plurality of light absorbing dyes in a generally transparent carrier medium, the light absorbing dyes comprising Toluidine Blue Colour Index No. 52040, Acid Brilliant Cyanine Blue as herein defined, Fast Light Red BA, Superchrome Yellow GN and Ethyl Orange.
2. A screen as claimed in Claim 1, wherein the light scattering particles are of chlorinated diphenyl resin.
3. A rear projection screen substantially as hereinbefore described with reference to any one of examples 1 to 9.

L. A. TRANGMAR B.Sc. C.P.A.,
Agent for the Applicants.

The coating was dried and then sprayed with a layer of transparent lacquer. The plates were then assembled with a layer of silicone rubber therebetween as described in Patent Application No. 14884/70 (Serial No. 1308984) with the dye layer on the viewing side of the screen. The plates were then mounted in an orbiting device as described in Patent Application No. 14883/70 (Serial No. 13060090) and set in motion. The results were similar to those reported above and particularly to those noted in Example 2.

Example 9

Example 8 was repeated except that the dye layer was coated in half the concentration on each glass plate, so that half the dye layer was, in effect, on the inside of the viewer and orbited with the rear plate forming the screen. The lacquer overcoat was omitted from the rear plate as no protection was needed. The results noted were substantially the same as those of Example 8.

With reference to Fig. 3, curve A shows the transmittance-wavelength characteristics for a test screen that provided a comparison basis. The screen comprised a glass plate having a light scattering layer coated on one surface thereof, the layer comprising a dispersion of gelatin and chlorinated diphenyl resin (Aroclor). The screen with such a layer transmits about 70—85% of the light incident thereon, the higher percentage being in the frequency of the yellow-orange-red colours. As a result, white does not appear as such in the projected image, but rather yellowish. Likewise black appears to be hazy and not a true black. When the reflected ambient light is added to such a projected image, the contrast is still further reduced.

Curves B to F show the transmittance-wavelength characteristics of screens having light control layers in accordance with the invention showing that more light is transmitted in the blue frequency range. Although less light is actually transmitted, the contrast is enhanced because the yellow-orange-red frequencies do not predominate, the contrast being enhanced because of the absorption of the ambient light.

Curve G shows such characteristics for a screen constructed in accordance with Example 8. The screen transmits primarily in the blue-green frequency range with a higher percentage of total transmittance.

In instances where the projection screen is such that it permits a much higher than normal ratio of forward to back-scattered light in the screen material, it may be advantageous to use in addition a non-scattering dye system in a separate layer on the screen surface facing the light source.

The screen support 30 can consist of particles of plastics material embedded in a clear resin coated on glass or a suitable transparent, plastics material, such as a vinyl or methylacrylate, or the carrier resin itself may be self-supporting. It is conceivable therefore that the non-scattering dye layer 32 can be dispersed in any number of non-scattering carrier media such as gelatin, methylacrylate, glass or polystyrene, and subsequently coated on or placed as a separate sheet in physical contact with the screen support 30.

The dyes referred to herein may be identified as follows:

Toluidine-Blue	Colour Index No. 52040
Fast Light Red BA	Colour Index No. 17045
Superchrome Yellow GN	Colour Index No. 14905

Acid Brilliant Cyanine Blue is the blue dye described in U.S. Patent Specification No. 3220925.

WHAT WE CLAIM IS:—

1. A rear projection screen comprising an image light scattering layer having light scattering particles dispersed in a transparent material, and an ambient light control layer superposed on the image light scattering layer and having a plurality of light absorbing dyes in a generally transparent carrier medium, the light absorbing dyes comprising Toluidine Blue Colour Index No. 52040, Acid Brilliant Cyanine Blue as herein defined, Fast Light Red BA, Superchrome Yellow GN and Ethyl Orange.
2. A screen as claimed in Claim 1, wherein the light scattering particles are of chlorinated diphenyl resin.
3. A rear projection screen substantially as hereinbefore described with reference to any one of examples 1 to 9.

L. A. TRANGMAR B.Sc. C.P.A.,
Agent for the Applicants.

Printed for Her Majesty's Stationery Office, by the Courier Press, Leamington Spa, 1974.
Published by The Patent Office, 25 Southampton Buildings, London, WC2A 1AY, from which copies may be obtained.



* C L M S *