(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
01 February 2018 (01.02.2018)

WIPO | PCT

(10) International Publication Number
WO 2018/019369 A1

(51) International Patent Classification:
G03B 21/56 (2006.01)

(21) International Application Number:
PCT/EP2016/067885

(22) International Filing Date:
27 July 2016 (27.07.2016)

(25) Filing Language: English

(26) Publication Language: English

(71) Applicant: **BARCO N.V.** [BE/BE]; President Kennedypark 35, B-8500 Kortrijk (BE).

(72) Inventor: **VETSUYPENS, Arnout Robert Leontine**; Oosthinderstraat 9, B-8400 Oostende (BE).

(74) Agent: **IPLODGE BVBA**; Technologielaan 9, B-3001 Heverlee (BE).

(81) Designated States *(unless otherwise indicated, for every kind of national protection available)*: AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States *(unless otherwise indicated, for every kind of regional protection available)*: ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, ST, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

Declarations under Rule 4.17:
— *of inventorship (Rule 4.17(iv))*

Published:
— *with international search report (Art. 21(3))*

(54) **Title:** PROJECTION SCREEN SYSTEM AND METHOD FOR IMPLEMENTATION

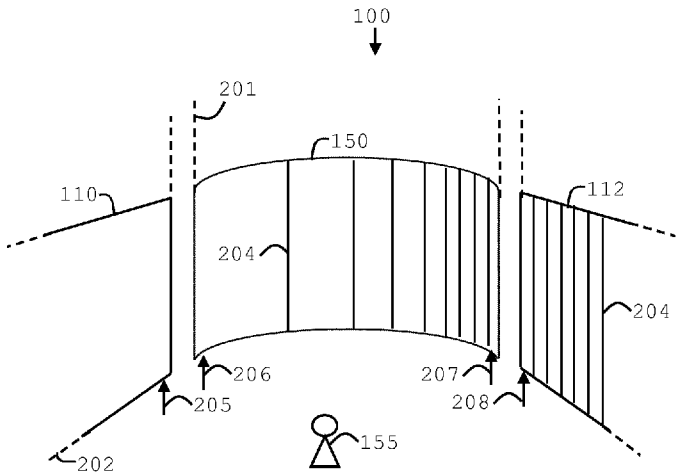

Figure 3

(57) **Abstract:** A projection screen system comprising a plurality of zones that can be configured and arranged to improve visual perception for the audience. A first zone have the same optical propertiesy within the zone but different optical properties compared to other side zone. An extension zone between the first zone and the side zone have gradient properties and can bridge the space between the first zone and the side zone.

WO 2018/019369 A1

Projection screen system and method for implementation

TECHNICAL FIELD

The present invention relates to projection display systems and in particular to a screen construction which minimizes a visual seam between adjacent screens, e.g. of a front projection display system.

BACKGROUND

Since the 1960s, specialized movie theaters began showing Cinerama-type motion pictures. Cinerama-type motion pictures provide wider screen images than first-run movies by using three projectors to project three separate screen images adjacently onto a wider movie screen, with the three screen images together forming a single frame or screen image for the motion picture. The three projectors are mounted in an arc which covers a very wide aggregate angle of view.

In a typical Cinerama or IMAX™ projection system, the screens are fixed and the geometry of the projection surface is not modified in function of the film being projected.

In a Cinerama projection system, the screen is composed of more than a thousand screen elements. The seams between panels are usually noticeable. Enthusiasts say the seams are not obtrusive; detractors disagree. For instance, Lowell Thomas, an investor in the company that exploited Cinerama, was still referring to it and promoting it in his memoires thirty years later.

An IMAX projection system comprises a single large projection screen. The projection screen consists of smaller screen fabric elements that are stitched or sealed together, leaving no space or seam visible between screen fabric elements.

Since 2014 Barco Escape™ projection systems deliver a compelling immersive cinema experience. The Barco Escape™ system does not require replacing the screens installed in theaters, instead the

system can be retrofitted. Figure 1 shows a top view of a theatre deployed in Escape™ show mode. The existing front (or central) screen 10 has been complemented by lateral screens 11 and 12 on the sides, so that the audience 13 receives an immersive experience. The lateral screens in an Escape™ theater cannot be sealed or stitched permanently to the front screen and as a result, visible seams can exist between the front screen and the lateral screens.

US 3,514,871 "Wide angle visual display" discloses how large lenses are positioned between the screens and a viewer to reduce the visibility of the seams, yet, this approach has some drawbacks. Indeed, lenses large enough to be used in theater settings are not practical and require an additional support structure. Furthermore, the proposed solution operates only when the viewer occupies a favored position also known as sweet spot. In a regular theater setting most of the viewers will not be positioned at or near the sweet spot and hence they will perceive the seam.

US 6407798 discloses the use of flanges to minimize any gap. The method requires the screens to be positioned tightly together, which brings a risk of scratching the coating of the central screen. It also remains silent on the geometry of flanges (shape and dimensions).

German Industry Standard DIN 19045-4 titled "Projection of moving and still images", the 4th part is subtitled "Reflection- and transmission properties of screens; identity sizes, type of screen, measurement". The screens are subdivided into four main groups according to their respective properties of reflection and transmission. The so-called light density factor (or luminance factor) that is also called gain-factor serves as a basis for the evaluation of the properties of reflection and transmission of a screen. The gain factor indicates how a piece of screen radiates in comparison to a piece of a standard screen.

In order to describe all refection properties of a screen, the luminance factor is to be specified for the different emission directions. An optimal white surface diffuses the incident light uniformly to all directions, independently of the angle with which the light is incident on the screen surface. This white screen serves as a reference for other types of screen.

For a diffuse screen, the direction from which light is incident on the screen has little effect; the reflecting properties are almost constant. Although the reference white surface diffuses the incident light uniformly into all directions, this type of screen reflects a little more into the direction perpendicular to the screen surface, and a little less in direction of parallel to the screen. Such screens can have an amplification factor between 1,1 and 1,3. This amplification factor corresponds to the slightly amplified reflection in direction perpendicular to the screen surface.

Other screens have a preferential reflection direction that concurs with the direction of the incident light.

When a light source is incident on the screen in an inclined angle the reflected light is returning mainly in the direction of the incident light. A gain-factor can be in the range 1,5 up to 1,7. A screen of this type the incident light back in the same angle it falls on the screen. One way of achieving this is particles in the shape of cube corners or glass beads. Such as screen is called a pearl screen or a crystal screen.

In a further screen type the light that falls in an inclined angle on the screen is mirrored at the screen perpendicular and reflected with an angle of incidence that is exactly equal to the angle of reflection. A gain-factor is typically from 1,5 to 1,7. A thin film of metal or silver particles can be applied to the screen surface that are eventually additionally structured in a shape of grooves or lenses. Such screens are also called Metal screens or Silver screens.

Seams between screens are a striking imperfection. This is particularly the case when a clearly visible black border or seam exists between two adjacent screens. One way to overcome this imperfection could be to physically put the screens as close as possible to each other in order to reduce the visibility of the seam. However, the human visual system is unforgiving concerning differences in e.g. color or brightness between adjacent images when there is a border between them. Thus removing the seam will emphasize such differences between the screens.

SUMMARY OF THE INVENTION

A solution is required to make the seams between the lateral screens and the central screen of a multiscreen display such a Barco Escape™ display system less visible while retaining the possibility to easily dismantle or move the lateral screens. This must be done without deteriorating the coating on the central projection screen.

In an embodiment of the present invention there is provided a projection screen system comprising a first zone, a side zone and an extension zone, the first zone having a first proximal boundary being the boundary between the first zone and the extension zone, the extension zone having two mutually facing edges, the side zone having a distal edge and a second proximal boundary being the boundary between the side zone and the extension zone, the first and side zones being located adjacent to each other with the first proximal boundary of the first zone and the second proximal boundary of the side zone facing each other and at a distance to each other, the extension zone being located to bridge said distance, wherein the first proximal boundary of the first zone and a first proximal boundary of the extension zone which are being closest to each other have a matching first optical property, and the second proximal boundary of the side zone and a second edge of the extension zone being closest to each other,

have a matching second optical property, and the extension zone has a gradient of the first and second optical properties between its two edges.

Such an extension zone can for example comprise a change in the ratio of diffuse to specular reflectance.
Such extension zone can for example comprise a surface dot pattern.

Such an extension zone can for example comprise diffusing and/or absorbing particles on a surface.

The system can provide a smooth transition between different optical properties in different zones in the system. The viewer will not get disturbed by sudden discontinuities in optical appearance within the screen system but receive one large immersive image. For systems comprising zones with different ratio of diffuse to specular reflection, it is beneficial if the gradient can bridge this change.

In another embodiment the projection screen system comprises an extension zone which is curved in the direction of the gradient.

The gradient may be located between zones that have their main projection directions in an angle towards each other. A sharp step between the orientation of the zones can be perceived as a seam for the human eye. If the projected content moves across such interface, it will also appear to suddenly change direction, which further emphasizes the discontinuity. By having a curved extension zone, there will be a smooth transition between directions, and the projected content will move smoothly between the two directions.

In another embodiment the projection screen system comprises the first and side zones have coatings with different optical properties. Such optical property can for example be the optical

reflectance. The different zones may have a different angular dependent reflection profile.

It may be beneficial to adapt the optical properties to the different angles between the viewer and different zones on the screen system. If zones have their main projection in the direction of a viewer's peripheral vision, it may also be beneficial to adapt the screen properties hereto.

In another embodiment, the optical gradient of the extension zone comprises a continuous transition in the angular dependent reflection profile.

If reflectance in a specific direction (angle) is changed smoothly along the gradient, sudden changes in brightness in that direction is avoided.

In another embodiment of the projection screen system, the first and side zones have their planes of main extension at an angle to each other.

For example, there can be a first zone having its main projection direction straight towards the audience, and zones at the sides of the first zone, having their main projection direction turned towards the audience, to enhance the immersive experience.

In another embodiment there is provided a method for assembling a projection screen system comprising placing a first and a side zone with edges facing each other, the first zone having a first proximal boundary being the boundary between the first zone and an extension zone, the extension zone having two mutually facing edges, the side zone having a distal edge and a second proximal boundary being the boundary between the side zone and the extension zone, the first and second boundaries being at a distance to each other, placing the extension zone to bridge said distance, orienting the extension zone so that a first edge of the extension zone closest to the first proximal boundary with the

first screen has a matching optical property to a first optical property of a first region of the front screen, and a second edge of the extension zone closest to the proximal boundary with the side screen has a matching optical property to a second optical property of a second region of the side screen.

In another embodiment, the method for assembling a projection screen system comprises orienting the first and side zones so that their planes of main extension have an angle to each other.

In another embodiment, the method for assembling a projection screen system comprises orienting the extension zone with the gradient and/or a curvature extending from the first zone to the side zone.

In this way the gradient zone will bridge the two zones.

In another embodiment, the method for assembling a projection screen system comprises orienting the extension zone with the gradient being the ratio of diffuse to specular reflectance. This brings the possibility of having e.g. more diffuse reflectance on the side of the audience and more specular reflection in front of the audience.

In another embodiment there is provided a projection screen system comprising at least one projection screen having a gradient in an optical property or optical properties that is extending across a viewing area of the screen system with a screen, at least one area of the screen having a different optical property than the area of the rest of the screen.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows prior-art comprising a theatre deployed for immersive viewing.

Figure 2 shows an embodiment of the present invention comprising a top view of a projection screen system.

Figure 3 shows an embodiment of the present invention comprising a side view of a projection screen system.

Figures 4a and 4b show an embodiment of the present invention comprising a polar plot of primarily diffuse and primarily specular reflection.

Figure 5 shows an embodiment of the present invention comprising reflectance measurements of a gradient extension element or zone.

Figure 6 shows how an observer perceives two adjacent screens with the same reflectance profile under a different angle as used in an embodiment of the present invention.

Figure 7 shows a mechanical shape matching of an extension zone or element between the two screens by bending in accordance with an embodiment of the present invention.

Figure 8 shows adjacent screens with different optical reflection properties in accordance with an embodiment of the present invention.

Figure 9 illustrates a soft edge blending of two images that can be used in embodiments of the present invention.

Figure 10 illustrates images projected on two screen zones or elements that are angled towards each other.

Figure 11 illustrates overlapping images projected on two screen zones that are angled towards each other.

Definitions

A "**gradient**" is an increase or decrease in the magnitude of a property (e.g. color, reflectance, concentration) observed in passing from one point or moment to another. The "direction" of a gradient is the direction of the greatest rate of increase or decrease of such property.

"**Reflectance**" is an optical property of a surface that comprises specular (directional with a small angular spread) and/or diffuse reflection (scattered with a broad angular spread). Reflected light can propagate from a surface in a symmetric or asymmetric manner.

A viewer can perceive a location on the screen with an "**angle of view**" which is the angular deviation from the normal of the surface emitting the image. Thus, if the viewer is positioned straight in front of the surface with the image, aligned with the normal of the surface, the angle of view would be 0 degrees.

Terms front zone or screen, side zone or screen include in any embodiment that the front zone or screen is a first zone or screen and the side zone or screen is a second zone or screen which is explicitly here introduced for each or any of the embodiments of the present invention and in the description and claims.

Terms extension zone or screen can refer in any or each embodiment to a separate element of the multiscreen

Reference is made in this application to optical properties of a screen such as "specular" or "diffusion". Optical properties of screens can be defined by German Industry Standard DIN 19045-4 titled "Projection of moving and still images" e.g. can be diffuse, crystal, pearl or silver screens as appropriate.

DETAILED DESCRIPTION

As can be seen in figure 1 there can be gaps between the front screen and the side screens. One way of overcoming those gaps is to insert a structure in it.

A projection screen system according to embodiments of the present invention comprises at least two screen zones, the screen zones having different optical properties. The projection screen system can be used with at least one front view projector. Embodiments of the present invention provide a multi-screen projection screen system for a cinema environment, for example.

A screen zone can comprise of a single, monolithic, member or be part of a larger single monolithic display screen. A zone can include a flexible screen film or material that is held flat by a

frame, for example by being stretched across the frame although this is less preferred. In the screen system each screen zone has a shape suitable for viewing, e.g., substantially flat, and is preferably sufficiently rigid to maintain flatness in operation.

At least one of the screen zones is located between two other zones, e.g. an extension zone located between a front zone and a side zone. The extension zone may have a mechanism which allows relative rotation or pivotal motion of the front screen zone relative to a side screen zone, so the front and side screen zones stay connected to each other while reorienting them. The extension zone may function as a hinging device. Embodiments of the present invention provide a solution to make seams between side or lateral screen zones and a central or front screen zone of a Barco Escape™ display system less visible while retaining the possibility to easily fold up, dismantle or move the lateral or side screens. This has to be done without deteriorating the coating on the projection front screen zone.

A zone edge defines a boundary of a zone. A projection screen system comprising a multiple of physical screens may comprise that such a boundary coincides with the physical edge of a screen. In a system comprising one large (flat or curved) projection screen, there can be zone edges which do not coincide with a physical edge, e.g. they overlap or underlap.

A proximal boundary can run through a screen zone and can function as an alternative delimiter of a screen zone, different from an actual edge of the screen zone. For example, the top view of a screen system in figure 7 shows how one of the zone edges of the extension zone 313 meets the side screen zone 311 at a proximal boundary of side screen zone 311.

Embodiments of the present invention include a screen system comprising a front screen zone which viewers see more or less directly in front of them; a left screen zone which viewers see on their left side; and a right screen zone that viewers see on their

right side. Extension zones are located between the front and the left and right screen zones respectively. Some of these embodiments of the present invention include a fixed screen system comprising a rigid front screen zone which viewers see more or less directly in front of them; a rigid left screen zone which viewers see on their left side; and rigid a right screen zone that viewers see on their right side with extension zones located between the front and the left and right screen zones respectively. The zones may each be a separate screen.

Embodiments of the present invention provide a multi-screen projection screen system comprising at least one projection screen comprising a gradient in an optical property or optical properties that is extending across the viewing area of the screen system so that the area of the screen has different optical properties than an area of the rest of the screen.

Figure 2 shows an embodiment of the present invention being a top view of a multi-screen cinema environment, or projection screen system 100. The projection screen system can have one or more flat screens, one or more curved screens. The projection screen system can at least partially surround the viewer 155 as shown in Figure 2. If the viewer 155 looks towards the front screen zone 110, he has a left side screen zone 111 to his left and a right side screen zone 112 to his right. In one embodiment of the present invention, in each corner, there is an angle and a distance between the front screen zone and each side screen zone where an extension zone 150 can be placed. Each extension zone 150 is limited by the dashed lines. The extension zone can be a separate extension element. Such an extension zone can be curved in order to make the projected image content move between the screen zones and the extension zones in a smooth movement. This can decrease the impression that objects which move between a front screen zone and a side screen zone are jumping or changing direction. However, in other embodiments the extension zones, e.g. elements can be flat and can be placed in another position than in figure 2, for

example inside (towards the viewer) and in front of the front- and side screen zone.

In any of the embodiments of the present invention the screen zones can be separate monolithic screens that are located or joined together.

Most cinema theatres are arranged so that the distance between the first (closest to the front screen) and last row of seats is larger than the width of the row of seats. The seat position influences the angle of view of a screen area. For example, in figure 1, a large angle of view for the front screen zone can be that of a person in a corner front seat looking at something in the opposite corner of the front screen zone, e.g. angle 14 (the vector 16 being the normal to the front screen zone assumed flat). A large angle of view for a side screen zone can be e.g. a person sitting on a back corner seat, looking at the opposite corner of the side screen zone closest to him, e.g. angle 15 in figure 1 (the vector 17 being the normal to the side screen zone assumed flat). In reality this is a three dimensional situation since the arrows indicating the angles in figure 1 are vectors in three dimensions, and the seat rows are located at different heights. Due to the shape of the theatre, however, the possible angles of view for the front screen zone are for most theatres narrower than the angles of view for the side screen zones.

To provide high brightness in the direction of the direct viewing of the audience, the front screen zone can be given a high amount of specular (directional) reflection, i.e. a first reflectance. This is possible since the spread of angles of view for the viewers can be limited. Since the side screen zones typically have a higher spread of angles of view, some seats might receive very low brightness (while others would perceive a much higher brightness) if the side screen zone has a high amount of specular reflection. Thus, the performance of the screen system would not be uniform for all viewers. Therefore it is preferred to increase the ratio of diffuse (scattered) to specular reflectance on the

side screen zones to give the screen a second reflectance. The higher amount of diffuse reflectance gives a more uniform perceived brightness across the screen system.

If the extension zone, e.g. extension element 150 has the first reflectance of the front (or side) screen zone, there will be a visible difference in brightness at the interface towards the side (or front) screen zone. To remove this artefact it is advantageous if the extension zone, e.g. extension element has a gradient of at least one optical value, e.g. a gradient of reflectance with end values at the edges of the extension zone e.g. extension element of the first and second reflectance values.

Figure 3 shows an embodiment of the present invention illustrating an exploded and enlarged side view of a projection screen system 100. The viewer 155 is not necessarily to the same scale as the screens. Figure 3 comprises the right side of the top view shown in figure 1, with a front screen zone 110 which can be placed in an angle to a side screen zone 112. There is also a distance between the front screen zone 110 and the side screen zone 112 where an extension zone, e.g. extension element 150 can be placed. The extension zone, e.g. extension element 150 can be placed in the angle between zones 110 and 112 in various ways, e.g. closely adjacent to the zones 110 and 112, as shown in figure 1, but it could also be placed in front of zones 110 and 112 and slightly overlap the edges of the front- and side screen zones, or be aligned and in contact with zones 110 and 112, or any other way of preference. The dashed lines (only 201 and 202 indicated) suggest possible further extension of the different screens.

In figure 3 on the surface of the screen zones facing the viewer 155, the screen zones can be configured to provide a special optical property or properties, e.g. having a coating or a physical structure. As mentioned above, the front screen zone can have a higher degree of specular reflection while the side screen zones have a higher degree of diffuse reflection. In figure 3, the amount of diffuse reflection is indicated to be increasing with

the density of the bars 204 (only two bars are numbered, for clarity. The front screen zone 110 has no bars 204 since it has the highest degree of specular reflection, and the side screen zone 112 has the highest density of bars 204 since it has the highest degree of diffuse reflection. The inventors have found that if the extension zone, e.g. extension element 150 can be curved and has a smooth transition in an optical property or optical properties between the front screen zone 110 and the side screen zone 112, whereby the content of the projected images can move smoothly between the front- and side screen zones. Thus, the viewer can perceive such projection screen system as one big immersive screen. For example, an optical property or the optical properties of the edge 206 of extension zone, e.g. extension element 150 can be matched with that or those of the edge 205 of the front screen zone 110. The same is valid, *mutatis mutandis*, on the other side where the optical property or optical properties of edges 207 and 208 can be matched. Note that the edges 205-208 can be the outmost parts of the screen zones, and the screen zones may extend further along the dashed lines in figure 3 (such as 201 or 202).

Thus, it is advantageous if the optical property or optical properties of the extension zone, e.g. extension element comprise a gradient in the optical property or optical properties to create a transition between the optical properties of the front- and side screen zones. One embodiment comprises the gradual transition between mainly specular to mainly diffuse reflection. Figure 4 shows polar plots of reflection where that of a) is the most diffuse of the two and that of b) is the most specular of the two. The length of the vectors 300-303 represents the reflectance value. The reflectance at angle $\alpha=0$ (coinciding with the y-axis and referred to as the normal incidence) is represented by the vectors 300 and 302 for the diffuse and specular reflectance respectively. Thus, the specular reflectance 302 is much larger at normal incidence than the diffuse reflectance 300. The angle α depicted in figure 4 is approximately the same (about 45 degrees), for which the vectors 301 and 303 represent the diffuse and

specular reflectance respectively. It can be seen that in the vicinity of 45 degrees, the reflectance 301 of the diffuse profile is much larger than the reflectance 303 at the same angle on the specular profile. It can also be advantageous to make sure that the above mentioned transition in reflectance has a gradual change in angular dependent profile, e.g. when starting from figure 4a) and arriving at figure 4b).

Figure 5 shows an exemplary example of the present invention comprising reflectance measurements of an extension zone, e.g. extension element having a reflectance gradient as discussed in the previous section. White light from a conventional cinema projector is illuminating the sample. The reflected luminance was measured with a luminance meter from Lichtmesstechnik Berlin. Measurements were done at 0, 25 and 45 degrees angle of inclination with respect to the normal to the substrate, at seven measurement points. The measurements started from the sample edge having a white color and ending at the sample edge having a grey color. There were 13 cm between each measurement point. The measured values were normalized with those of the 45 degrees inclination. The result is shown in figure 5, where the curve for 0 (relative to 45) degrees inclination having triangular markings and the curve for 25 (relative to 45) degrees inclination having square markings. The curve for 0 degree inclination exhibits high reflectance (relative to the reflectance at 45 degrees) in close vicinity to the white sample's edge. The relative reflectance at this angle drops significantly at points closer to the grey sample edge. The reflectance curve for 25 (relative to reflectance at 45 degree inclination exhibits significantly lower reflection near the white sample edge, compared to the curve at 0 degrees. The large decrease in relative reflection when comparing the curve of 0 to the curve of 25 degrees close to the white sample edge indicates that the relative degree of specular reflection is high towards this edge. And the smaller drop in relative reflection close to the grey sample edge indicates that the relative degree of diffuse reflection is higher at this edge. This is also illustrated in figure 4 where the decrease from 302 to 303 for the

specular reflectance profile is much larger than the decrease 300 to 301 for the diffuse reflectance profile.

In one embodiment there is one large screen (curved or flat) having an optical property or optical properties on the area at the borders of the screen that are different than those on the interior area of the screen.

Barco Escape™ V2 has side screen zones with no discontinuity / no gap between the side zones and the front zone. The screen material being Lambertian (or close to it), some of the light reflected on the side screen zone will impinge on the front screen zone. Different gains for the screen surface on the side zone can be used less gain results in less reflection with the result of less reflected light in the direction of the front screen zone. Therefore a gain gradient going from e.g. 0,7 on the side zone and at the start of the extension zone close to the side zone to 1.0 or slightly more for the front screen zone and on the extension zone close to the front zone can be used.

Embodiments of the present invention provide enhancements to improve the continuity of a perceived projected image, for example to ensure that the images are nicely blended and an observer can perceive one continuous image without sudden transition areas. Embodiments of the present invention provide projection display system with two or three different screen zones, including a synergistic or matching effect between the physical screen zones as such, e.g. a gradient of an optical property of the zones as well as a matching between the image content projected onto the screen zones. Hence the extension zone can have a synergistic or matching effect between the side screen zone and the front screen zone on either side of the extension zone, e.g. a gradient of an optical property in the extension zone to match with the side and front zones as well as a matching between the image content projected onto the front side and extension screen zones. Optionally the extension zone can be shaped to provide a transition between a side zone and a front zone.

The perceived optical subjective human perception of the transition between two screen zones should preferably be continuous. In figure 6, two screen zones 310 and 311 with identical optical reflection properties and identical incident light beams are put in close proximity and under an angle to each other, e.g. with an included obtuse angle. An observer 312 will perceive the same screen property from different angles, and hence will see a sudden difference in brightness in the interface between the two screen zones. At his current location, the observer will see the reflection of the front screen zone perpendicularly, and that of the side screen zone from a steep angle. Since the screen zones have the same reflection profile, the perceived reflection reaching the observer from the screen zone under an angle is lower, resulting in a discontinuity in perceived light.

Hence, it is advantageous to have a continuous geometrical shape for the extension zone without a sudden step or angular step transition between the screen zones. For example a bent structure for the extension zone is preferred with the same tangential directions at both of its edges as the adjacent screen zones, e.g. see extension zone 313 in figure 7. The tangential directions at both of the edges of the extension zone are parallel to the front screen zone 310 and the side screen zone 311 respectively.

Additionally there can be a smooth transition between the angular-dependent reflection profile of the front and side screen zones, to reduce discontinuities in the perceived light.

Side screen zones can have a different angular dependent reflection profile than main or front screen zone. The side screen zone can be made more diffuse to make sure that observers perceive a more uniform light distribution over the screen zones. The side screen zone’s reflection can also be reduced to reduce cross-reflections 316 from the front screen zone to the side screen zone. The projector 314 projects an image onto the front screen

zone 310, and the light at the edges can be partially reflected onto the (edge of the) side screen zone 311. Thus, the light reflected at the edge of the side screen zone 311 can comprise light originating from the first projector 314, which is reflected onto the side screen zone 311 from the front zone 311. So by making the side screen zone 311 less reflective, the cross reflection 316 can be reduced. Therefore it is beneficial if there is a gradient between the two reflection profiles of front and side zones. For example, there can be a continuous transition from mainly specular reflection of the front screen zone to more diffuse reflection of the side screen zones.

By combining both effects of extension zone shape and gradient of an optical property of the screen in the extension zone, a uniform input image can be provided.

It is advantageous if the image projected on the screen zones is smooth without sudden transition artifacts between the adjacent images that are projected by different projectors 314, 315 for the front screen zone and the side screen zone respectively – see Figure 8. For instance, when using soft edge blending, the projected images overlap and the content projected by both projectors can be tuned in the overlapping zone to make it uniform, see figure 9.

Alternatively, a hard edge blending method can be used, where there is no overlapping zone, and the projected images are completely non-overlapping, projected adjacently.

Figure 10 shows an embodiment of the present invention where projector 320 can project an image onto a front screen zone 322, and projector 231 can project an image onto screen zone 323. The screens zones 322 and 323 can have different optical properties, e.g. the darker colour of 323 can indicate that it has a higher part of diffuse reflection, while the lighter color of 322 can indicate that it has a higher part of specular reflection. There is an extension zone 324 that can comprise a gradient between the

different optical properties so that it bridges between 322 and 323. There is no overlap between the projected images.

Figure 11 shows an embodiment of the present invention similar to that in figure 10. However a difference is that part of the projected images overlap. In the present figure the overlap is located near the extension zone 324, but it could be located e.g. entirely on screen or zone 322 or 323. To avoid that there will be too high brightness in the overlap area there can be filters 325 and 326 added to the projectors. These filters can e.g. be of neutral density type, providing a transmission gradient.

While specific examples of the invention are described in detail above to facilitate explanation of various aspects of the invention, it should be understood that the intention is not to limit the invention to the specifics of the examples. Rather, the intention is to cover all modifications, embodiments, and alternatives falling within the spirit and scope of the invention as defined by the appended claims.

CLAIMS

1. A projection screen system comprising a first zone, a side zone and an extension zone, the first zone having a first proximal boundary being the boundary between the first zone and the extension zone, the extension zone having two mutually facing edges, the side zone having a distal edge and a second proximal boundary being the boundary between the side zone and the extension zone, the first and side zones being located adjacent to each other with the first proximal boundary of the first zone and the second proximal boundary of the side zone facing each other and at a distance to each other, the extension zone being located to bridge said distance, wherein the first proximal boundary of the first zone and a first edge of the extension zone which are being closest to each other have a matching first optical property, and the second proximal boundary of the side zone and a second edge of the extension zone being closest to each other, have a matching second optical property, and the extension zone has a gradient of the first and second optical properties between its two edges.

2. A projection screen system according to claim 1 wherein the extension zone is curved in the direction of the gradient.

3. A projection screen system according to any of the above claims wherein the first and side zones have coatings with different optical properties.

4. A projection screen system according to any of the above claims wherein the first and side zones have coatings with different optical reflectance.

5. A projection screen system according to any of the above claims wherein the first and side zones have coatings with different angular dependent reflection profile.

6. A projection screen system according to any of the above claims wherein the optical gradient on the extension zone comprises a change in the ratio of diffuse to specular reflectance.

7. A projection screen system according to any of the above claims wherein the optical gradient of the extension zone comprises a continuous transition in the angular dependent reflection profile.

8. A projection screen system according to any of the above claims wherein the extension zone has a surface dot pattern.

9. A projection screen system according to any of the above claims wherein the extension zone has diffusing and/or absorbing particles on a surface.

10. A projection screen system according to any of the above claims wherein the first and side zones have their planes of main extension at an angle to each other

11. A method for assembling a projection screen system comprising placing a first and a side zone with edges facing each other, the first zone having a first proximal boundary being the boundary between the first zone and an extension zone, the extension zone having two mutually facing edges, the side zone having a distal edge and a second proximal boundary being the boundary between the side zone and the extension zone, the first and second boundaries being at a distance to each other, placing the extension zone to bridge said distance, orienting the extension zone so that a first edge of the extension zone closest to the first proximal boundary with the first screen has a matching optical property to a first optical property of a first region of the front screen, and a second edge of the extension zone closest to the proximal boundary with the side screen has a matching optical property to a second optical property of a second region of

the side screen.

12. A method or assembling a projection screen system according to claim 11 comprising orienting the first and side zones with their planes of main extension at an angle to each other

13. A method for assembling a projection screen system according to claim 11 or 12 comprising orienting the extension zone with the gradient and/or a curvature extending from the first zone to the side zone.

14. A method for assembling a projection screen system according to any of claims 11 to 13 comprising orienting the extension zone with the gradient being the ratio of diffuse to specular reflectance.

15. A projection screen system comprising at least one projection screen comprising a gradient in an optical property that is extending across a viewing area of the screen system with a screen, an area of the screen having a different optical property than the area of the rest of the screen.

16. A projection screen system according to claim 15 wherein the screen is curved in the direction of the gradient.

17. A projection screen system according to any of the claims 15 and 16 wherein the area of the screen having a different optical property than the area of the rest of the screen has a different angular dependent reflection profile.

18. A projection screen system according to any of the claims 15 to 17 wherein the area of the screen having a different optical property than the area of the rest of the screen has a change in the ratio of diffuse to specular reflectance.

19. A projection screen system according to any of the claims 15 to 18 wherein the area of the screen having a different

optical property than the area of the rest of the screen has a continuous transition in the angular dependent reflection profile.

20. A projection screen system according to any of the claims 15 to 19 wherein the area of the screen having a different optical property than the area of the rest of the screen has a surface dot pattern.

21. A projection screen system according to any of the claims 15 to 20 wherein the area of the screen having a different optical property than the area of the rest of the screen has diffusing and/or absorbing particles on a surface.

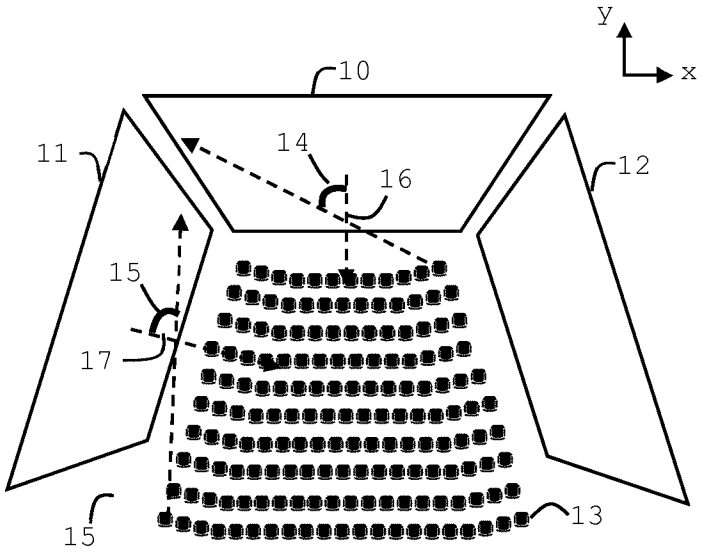

Figure 1 (prior-art)

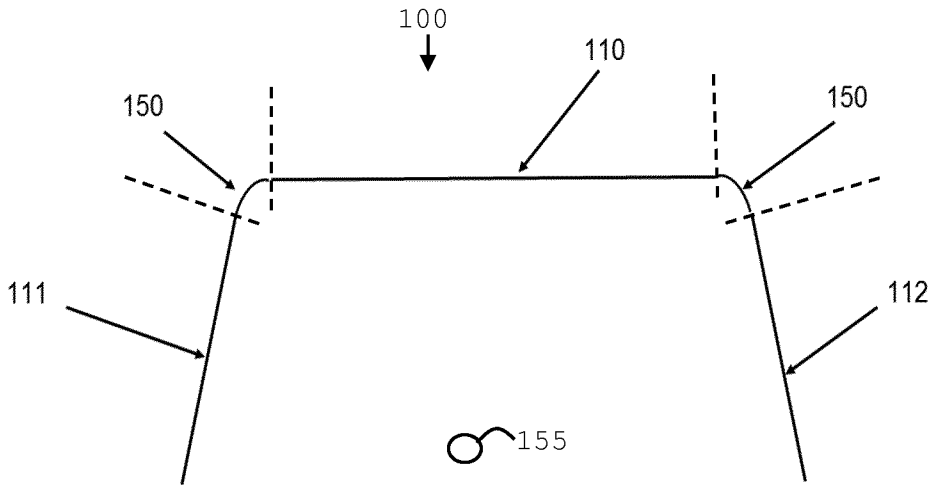

Figure 2

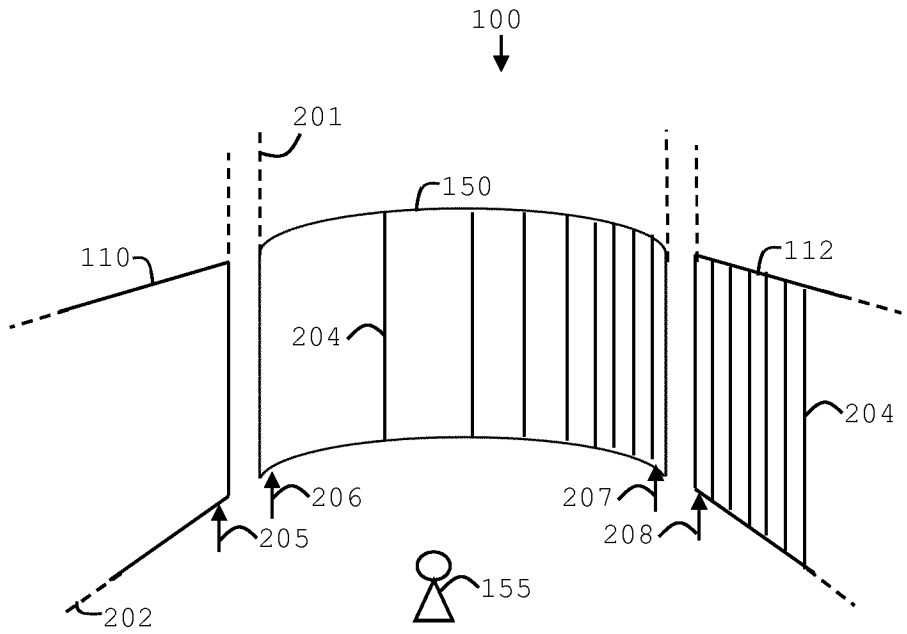

Figure 3

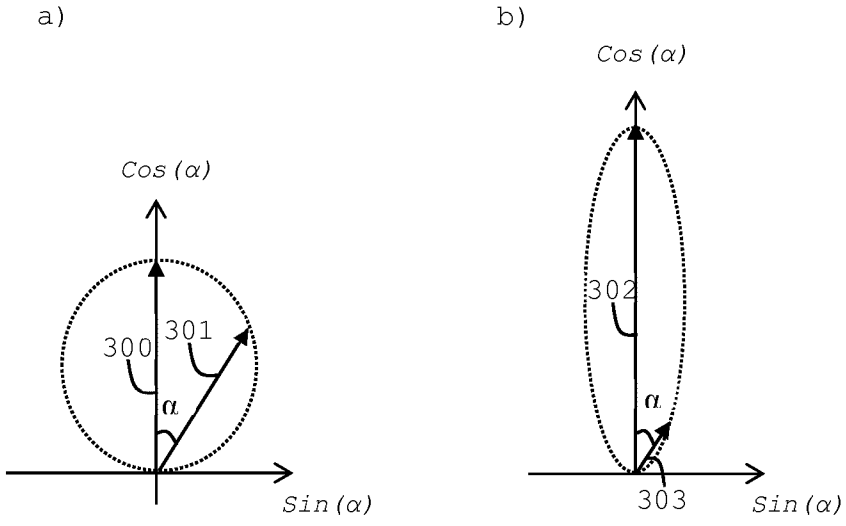

Figure 4

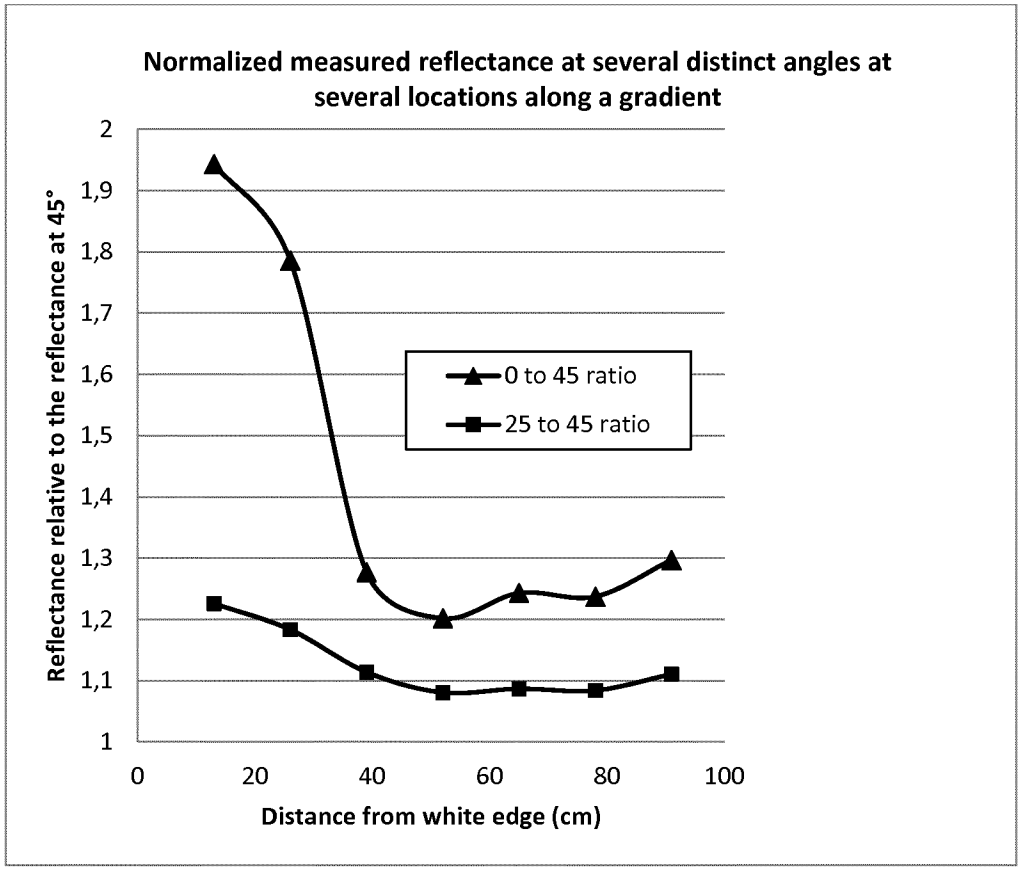

Figure 5

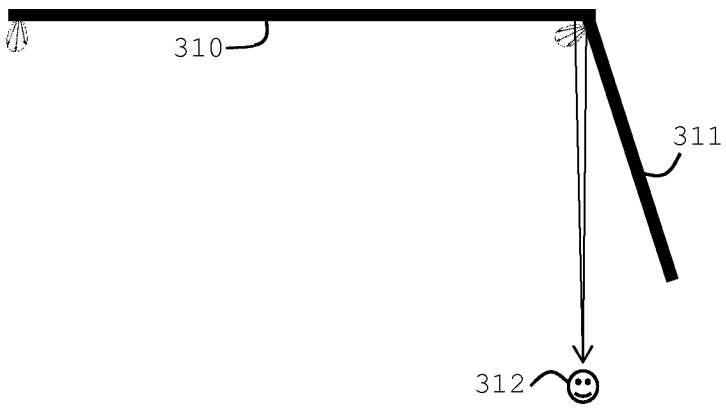

Figure 6: Observer perceives two adjacent screens with the same reflectance profile under a different angle.

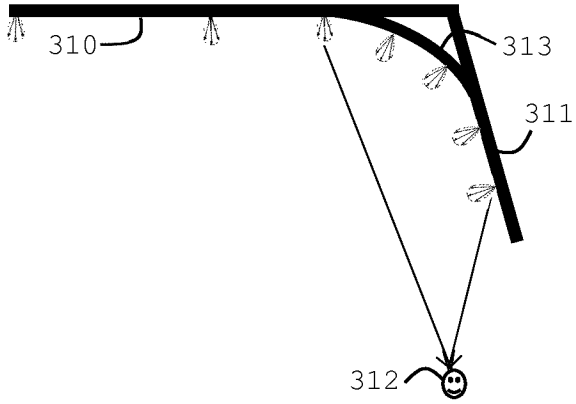

Figure 7

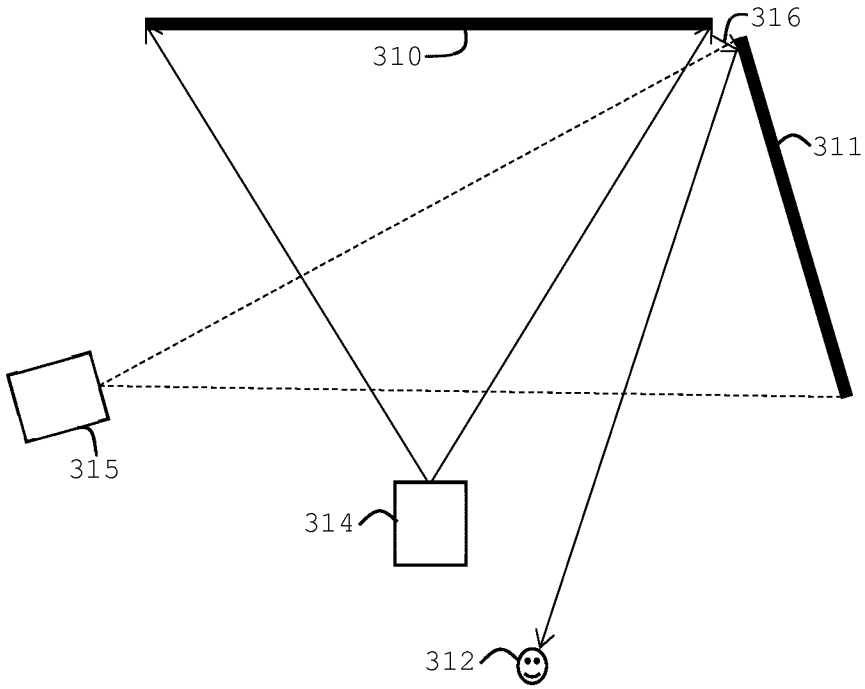

Figure 8

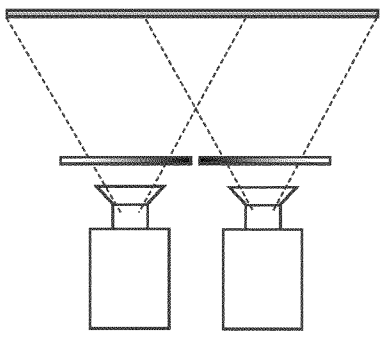

Figure 9

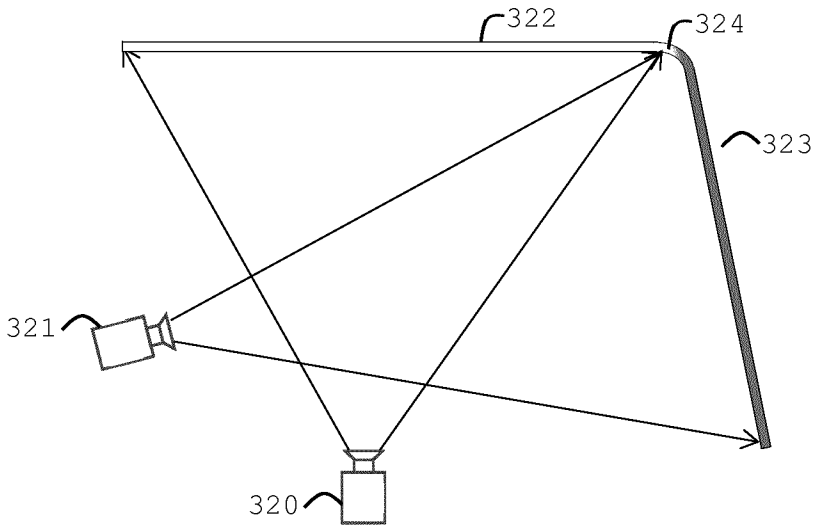

Figure 10

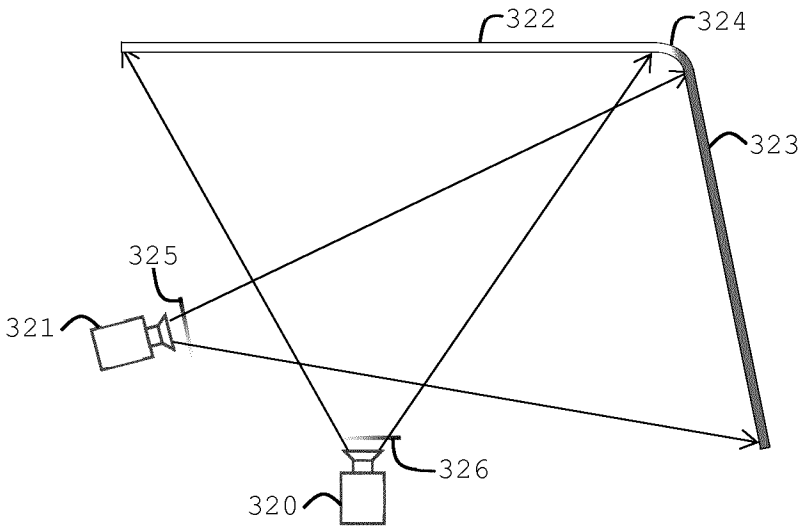

Figure 11

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/067885

A. CLASSIFICATION OF SUBJECT MATTER
INV. G03B21/56
ADD.

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
G03B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)
EPO-Internal, WPI Data

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2005/052623 A1 (HSIUNG CHAO-WANG [TW]) 10 March 2005 (2005-03-10) paragraph [0053] - paragraph [0054]; figures 3A-3B	1-14
A	WO 2014/193063 A1 (CJ CGV CO LTD [KR]) 4 December 2014 (2014-12-04) paragraph [0047] - paragraph [0110]; figures 1-11	1-14
A	WO 2016/014506 A2 (BARCO INC [US]) 28 January 2016 (2016-01-28) paragraph [0058] - paragraph [0081]; figures 1-7B	1-14
A	SU 118 138 A1 (GOLDOVSKIJ E M) 30 November 1958 (1958-11-30) the whole document	1-14

-/--

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents :

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
25 November 2016	03/02/2017

Name and mailing address of the ISA/	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL - 2280 HV Rijswijk Tel. (+31-70) 340-2040, Fax: (+31-70) 340-3016	Tomezzoli, Giancarlo

1

Form PCT/ISA/210 (second sheet) (April 2005)

INTERNATIONAL SEARCH REPORT

International application No
PCT/EP2016/067885

C(Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	WO 2007/149333 A2 (ALPHACURVE INC [US]; BOUD ANDREW C [AU]; STREIT ALEXANDER T [AU]) 27 December 2007 (2007-12-27) page 18, line 23 - page 19, line 1; figures 19A-19B -----	1-14

1

INTERNATIONAL SEARCH REPORT

International application No.
PCT/EP2016/067885

Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

see additional sheet

1. ☐ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☒ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

1-14

Remark on Protest

☐ The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.

☐ The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.

☐ No protest accompanied the payment of additional search fees.

FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-14

projection screen system comprising a gradient extension zone bridging the distance between said first zone and side zone.

---

2. claims: 15-21

projection screen system comprising a gradient in an optical property that is extending across a viewing area of the projection screen system

---

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No
PCT/EP2016/067885

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
US 2005052623 A1	10-03-2005	JP 2005039788 A	10-02-2005
		TW 200426487 A	01-12-2004
		US 2005052623 A1	10-03-2005
WO 2014193063 A1	04-12-2014	CN 105074567 A	18-11-2015
		EP 3004986 A1	13-04-2016
		JP 2016526951 A	08-09-2016
		WO 2014193063 A1	04-12-2014
WO 2016014506 A2	28-01-2016	US 2016088271 A1	24-03-2016
		WO 2016014506 A2	28-01-2016
SU 118138 A1	30-11-1958	NONE	
WO 2007149333 A2	27-12-2007	US 2008186415 A1	07-08-2008
		WO 2007149333 A2	27-12-2007