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(54) Title: LIT IMAGE PROJECTION LAMP AND METHOD

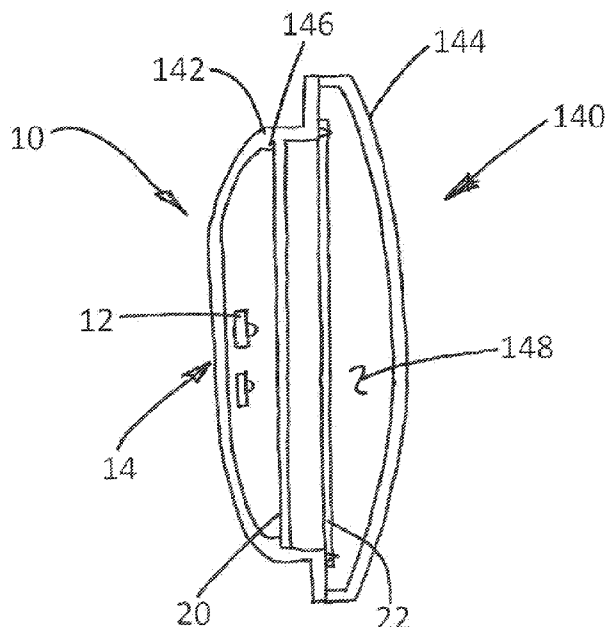


FIG. 2

(57) Abstract: Lit image projection lamp and method. In an exemplary embodiment of a projection device of the present disclosure, the projection device comprises a light source; a first lens positioned at a first distance from the light source; and a second lens at a second distance from the first lens; wherein the first lens and the second lens are lenticular lenses, each having an optical axis; and wherein the projection device is configured to generate a three-dimensional image from light emitted from the light source that passes through the first lens and the second lens.



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LIT IMAGE PROJECTION LAMP AND METHOD

PRIORITY

5 The present international (PCT) patent application is related to, and claims the priority benefit of, U.S. Provisional Patent Application Serial No. 62/165,785 filed May 22, 2015, and U.S. Provisional Patent Application Serial No. 62/181,545, filed June 18, 2015, the contents of which are incorporated by reference in their entirety into this disclosure.

BACKGROUND

10 The design of the exterior lighting components of automobiles plays an important role in the styling and marketing of vehicles in the automotive market. Vehicle designers are interested in technologies that can both provide the required regulatory functions of automotive exterior lighting and enable a unique and aesthetically pleasing lit and unlit appearance of the lighting components on the vehicle. There is also a desire to create uniformity and continuity in the lit appearance of functionally separate lamps that may be in close proximity to one another, for
15 instance, a corner tail lamp relative to an applique or lift gate lamps. Therefore, there remains a significant need for the apparatuses, methods, and systems disclosed herein

BRIEF SUMMARY

According to one aspect of the present disclosure, a projection device includes one, two, three, four, or more lenticular lenses positioned in front of a light source to generate a three-
20 dimensional image of the light source between the two lenses when lit. The size, shape, and appearance of the image may be altered by the distances between and orientation of the lenses, characteristics of the lenticular lenses, and characteristics of the light source. The appearance of the lit image is further affected by the angle of observation to the projection device. Various projection devices of the present disclosure may be incorporated into a lamp assembly to
25 provide a unique and shifting lit appearance.

This summary is not intended to identify key or essential features of the claimed subject matter, nor is it intended to be used as an aid in limiting the scope of the claimed subject matter. Further embodiments, forms, objects, features, advantages, aspects, and benefits shall become apparent from the following description and drawings.

30 In an exemplary embodiment of a projection device of the present disclosure, the projection device comprises a light source; a first lens positioned at a first distance from the light source; and a second lens at a second distance from the first lens; wherein the first lens and the second lens are lenticular lenses, each having an optical axis; and wherein the projection device is configured to generate a three-dimensional image from light emitted from the light source that

passes through the first lens and the second lens. In at least one embodiment, the light source comprises one or more light-emitting diodes. In at least one embodiment, the light source is a light pipe. In at least one embodiment, the first lens is orthogonal or parallel to an axis of the light source. In at least one embodiment, the first lens and the second lens have an optical density of between 20 and 150 flutes per inch. In at least one embodiment, the optical axis of the first lens is rotated relative to the optical axis of the second lens. In at least one embodiment, the optical axis of the first lens is tilted relative to the optical axis of the second lens. In at least one embodiment, the optical axis of the first lens is tilted relative to the light source. In at least one embodiment, the three-dimensional image is projected as an image selected from the group consisting of an image of a ribbon, an image of a series of twisting lines, an image of fire, an image of shark teeth, an image of diamonds, an image of curved lines, an image of stars, an image of squares, an image of a waterfall, and an image of arcs and a waterfall. In at least one embodiment, the three-dimensional image is projected as an image having a shape selected from the group consisting of a twisted shape, a curved and pointed shape, a fringed leaf shape, a curved triangle shape, a square shape, an amorphous shape, a cube shape, and a diamond shape. In at least one embodiment, the three-dimensional image is projected as an image having a first color and a second color different from the first color. In at least one embodiment, three-dimensional image is projected as an image having a first color, a second color, and a third color, where each of the first color, the second color, and the third color are different from one another. In at least one embodiment, device is further configured to generate a second three-dimensional image from light emitted from the light source that passes through the first lens and the second lens, wherein the three-dimensional image is different from the second three-dimensional image. In at least one embodiment, the device forms part of a lamp assembly, the lamp assembly further comprising a housing and an outer lens, wherein the device is positioned within the housing. In at least one embodiment, the three-dimensional image is present or perceived within the housing between the second lens and the outer lens. In at least one embodiment, the lamp assembly is configured as a vehicle lamp assembly. In at least one embodiment, the lamp assembly further comprises a third lens positioned a third distance from the second lens, wherein the projection device is configured to generate the three-dimensional image from light emitted from the light source that passes through the first lens, the second lens, and the third lens.

In an exemplary embodiment of a lamp assembly of the present disclosure, the lamp assembly comprises a projection device of the present disclosure, such as a projection device comprising a light source, a first lens positioned at a first distance from the light source, and a second lens at a second distance from the first lens, wherein the first lens and the second lens are

lenticular lenses, each having an optical axis; a housing; and an outer lens coupled to the housing to define a volume, wherein the projection device is positioned within the volume; wherein the projection device is configured to generate a three-dimensional image within the volume from light emitted from the light source that passes through the first lens and the second lens.

In an exemplary embodiment of a projection device of the present disclosure, the projection device comprises a light source; a first lens positioned at a first distance from the light source; and a blocker plate positioned a second distance from the first lens, the blocker plate defining an aperture therethrough; wherein the first lens is a lenticular lens having an optical axis; and wherein the projection device is configured to generate a three-dimensional image from light emitted from the light source that passes through the first lens and through the aperture of the blocker plate. In at least one embodiment, the light source comprises one or more light-emitting diodes. In at least one embodiment, the light source is a light pipe. In at least one embodiment, the first lens has an optical density of between 20 and 150 flutes per inch. In at least one embodiment, the three-dimensional image is projected as an image having a first color and a second color different from the first color. In at least one embodiment, device is further configured to generate a second three-dimensional image from light emitted from the light source that passes through the first lens and the second lens, wherein the three-dimensional image is different from the second three-dimensional image. In at least one embodiment, the device forms part of a lamp assembly, the lamp assembly further comprising a housing and an outer lens, wherein the device is positioned within the housing, and wherein the three-dimensional image is present or perceived within the housing between the second lens and the outer lens.

In an exemplary embodiment of a lamp assembly of the present disclosure, the lamp assembly comprises a projection device of the present disclosure, such as a projection device comprising a light source, a first lens positioned at a first distance from the light source, and a blocker plate positioned a second distance from the first lens, the blocker plate defining an aperture therethrough; wherein the first lens is a lenticular lens having an optical axis; a housing; and an outer lens coupled to the housing to define a volume, wherein the projection device is positioned within the volume; and wherein the projection device is configured to generate a three-dimensional image from light emitted from the light source that passes through the first lens and through the aperture of the blocker plate.

BRIEF DESCRIPTION OF THE DRAWINGS

The disclosed embodiments and other features, advantages, and disclosures contained herein, and the matter of attaining them, will become apparent and the present disclosure will be better understood by reference to the following description of various exemplary embodiments of the present disclosure taken in conjunction with the accompanying drawings, wherein:

FIGS. 1A-1F show isometric views of embodiments of projection devices according to the present disclosure;

FIG. 2 shows a cross-sectional isometric view of an embodiment of a lamp assembly according to the present disclosure;

FIG. 3 shows an isometric view of a lit embodiment of a lamp assembly according to the present disclosure;

FIG. 4 shows a cross-sectional view of a lenticular lens according to an embodiment of the present disclosure;

FIG. 5 shows a plan view of an embodiment of a projection device according to the present disclosure;

FIG. 6 shows a cross-sectional isometric view of an embodiment of a lamp assembly according to the present disclosure;

FIG. 7 shows a plan view of an embodiment of a projection device according to the present disclosure;

FIG. 8 shows various embodiments of a lens subassembly according to the present disclosure;

FIGS. 9A-16B show exemplary three-dimensional images generated by exemplary devices of the present disclosure; and

FIGS. 17A-19 show exemplary lamp assemblies having exemplary three-dimensional images generated therein.

An overview of the features, functions and/or configurations of the components depicted in the various figures will now be presented. It should be appreciated that not all of the features of the components of the figures are necessarily described. Some of these non-discussed features, such as various couplers, etc., as well as discussed features are inherent from the figures themselves. Other non-discussed features may be inherent in component geometry and/or configuration.

DETAILED DESCRIPTION

The present application discloses various embodiments of a projection device and methods for using and constructing the same. According to one aspect of the present disclosure, a lamp assembly having a projection device. For the purposes of promoting an understanding of the principles of the present disclosure, reference will now be made to the embodiments illustrated in the drawings, and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of this disclosure is thereby intended.

FIGS. 1A and 1B show projection devices 10 according to at least two embodiments of the present disclosure. As shown in FIG. 1A, the projection device 10 may include one or more light sources 12, a first lens 20, and a second lens 22, each positioned a distance or distances from one another, such that light emitted from the light source 12 is transmitted through the first lens 20 and the second lens 22. The first lens 20 and the second lens 22 may be structured and disposed relative to one another to generate a virtual, three-dimensional (3D) image 30 of the light source 12. The image 30 may be generated such that it appears to be located in space between the first lens 20 and the second lens 22 when viewed by an observer looking toward the light source 12 through the first lens 20 and second lens 22 in the general direction of arrow A. The image 30 may alternatively be generated such that it appears to be located after second lens 22, such as between second lens 22 and an outer lens 148 shown in FIG. 2, when viewed by an observer looking toward the light source 12 in the general direction of arrow A. The image 30 may have a length 32, a width 34, and a depth 36 from the perspective of the observer. The width 34 and the length 32 can be changed by changing the distance between first lens 20 and second lens 22, for example, or changing one or more of the distances between light source 12, first lens 20, and/or second lens 22. A third lens 50, such as shown in FIG. 1B, can be positioned relative to second lens 22 as shown in FIG. 1B, so that first lens 20, second lens 22, and third lens 50 generate a variable depth 36 to the lit image, thus generating a three-dimensional cube-lit image 30, for example. The embodiment depicted in FIGS. 1A and 1B include six, point light sources 12 arranged in an array 14, which generate six images 30 in cooperation with the first lens 20 and second lens 22. In certain embodiments, the projection device 10 may include fewer or more light sources 12. As shown in FIG. 1A, the image 30 of a point light source 12 may be projected as a hexahedron and/or an illuminated four-sided plane, or in the case of a device 10 using a first lens 20, a second lens 22, and a third lens 50, such as shown in FIG. 1B, an illuminated three-dimensional cube.

In at least one embodiment according to the present disclosure, the first lens 20 and the second lens 22 may be lenticular lenses. Generally, a lenticular lens has a plurality of convex flute optics or flutes 26 (not shown in FIG. 1A) arranged side by side such that the flutes 26

extend in the same direction, defining a longitudinal axis of the lens such that each flute 26 has an optical axis generally orthogonal to the longitudinal axis. The plurality of flutes 26 may enable a horizontal parallax as described further herein.

FIGS. 1C, 1D, 1E, and 1F show additional projection device 10 embodiments according to the present disclosure. Referring back to FIG. 1A, a viewer can perceive image 30 as being present beyond the first lens 20 and the second lens 22, such as between the second lens 22 and an outer lens 144 as referenced herein. Image 30 can be perceived as being present beyond the first lens 20, the second lens 22, and the third lens 50, as shown in FIG. 1B. Image 30, in various device embodiments, can be perceived by a viewer as being present behind light source 12 (such as shown in FIG. 1C), between light source 12 and first lens 20 (as shown in FIG. 1D), between the first lens 20 and the second lens 22 (as shown in FIG. 1E), or between the second lens 22 and the third lens 50 (such as shown in FIG. 1F), for example. Depending on the embodiment of device 10 prepared for a particular purpose, images 30 generated by said devices 10 can be perceived as being present at various locations within device 10, as referenced and shown herein.

FIG. 4 shows a cross-sectional view of portions of three flutes 26, one full flute and two partial flutes to either side. As shown in FIG. 4, the first lens 20 and the second lens 22 may have a thickness 28. The first lens 20 and the second lens 22 may have any suitable thickness 28 including, for example, 0.1-10 millimeters (mm). In certain embodiments, the thickness 28 of the first lens 20 and/or the second lens 22 may be between 1-3 mm. In at least one embodiment, the thickness 28 of the first lens 20 and/or the second lens 22 may be 1 mm. In various embodiments, lenticular flutes 26 may be on opposite sides of the same lens 20, 22, 50.

The first lens 20 and the second lens 22 may be further characterized by other dimensions defining the flutes 26 as shown in FIG. 4. The dimensional characteristics of the flutes 26 affect the images 30 projected by the projection device 10. For example, the density or spacing of the flutes 26 may be characterized in lines per inch (LPI). In at least one embodiment, the first lens 20 and the second lens 22 may be formed with 20-150 LPI. In certain embodiments, the first lens 20 and the second lens 22 may have more LPI, while in other embodiments the first lens 20 and the second lens 22 may include fewer LPI. Other dimensional characteristics of flutes 26 may also affect the images 30 projected by the projection device 10. For example, the viewing angle of the flutes 26 is determined by the radius of the flutes 26. The higher the viewing angle, for example, the more curvature the projected image 30 will have. The viewing angle is described as the angle at which the viewer can move off axis and still see the projected image 30, as referenced herein.

FIG. 5 illustrates the principle of operation of the first lens 20 in cooperation with the second lens 22 to generate the projected lit image 30. Images 30, as referenced herein, may also be referred to as projected images 30, three-dimensional images 30, lit images 30, etc. In FIG. 5, the image 30 is depicted as a human face to make clear that the interaction of the first lens 20 with the second lens 22 generates at least two separate perspectives of the light source 12, where each eye of an observer 40 views a different perspective. However, it will be understood that in embodiments of the present disclosure the image 30 may not resemble a human face. Instead, the image 30 is a stereoscopic composite image of the light source 12 formed by the observer 40 from the different perspective views of the light source 12 as perceived by each eye of the observer 40. Without being bound to a particular theory, the projection device 10 uses compound horizontal parallax enabled by the use of multiple lenticular lenses to generate a virtual 3D image 30 of the light source 12.

The image 30 is a projection of the light source 12. The first lens 20 projects a first line, such as the length 32, as light emitted by the light source 12 is bent at different angles by the individual flutes 26 of the first lens 20. The second lens 22 projects a second line at an angle to the first line, such as the width 34, as light transmitted through the first lens 20 is bent at different angles by the individual flutes 26 of the second lens 22. The combination of the two projected lines generates the image 30 in which the width 34 is determined by the distance between the first lens 20 and second lens 22.

The size, shape, and appearance of the image 30 are affected by the type of light source 12 and the characteristics of the first lens 20 and second lens 22. Further, the relative distances and orientations between the light source 12, the first lens 20, and the second lens 22 further affect the size, shape, and appearance of the images 30. In at least one embodiment, the first lens 20 may be oriented parallel to the light source 12. The second lens 22 (and third lens 50 in embodiments having a third lens 50) may be oriented parallel to the first lens 20. In such an embodiment, the image 30 of a point light source 12 is projected as a hexahedron, such as a regular hexahedron (i.e., a cube) or a rectangular cuboid. Alternatively, the second lens 22 may be oriented at an angle relative to the first lens 20 (i.e., tilt). In such an embodiment, the image 30 of a point light source 12 is projected as a non-regular hexahedron, such as a trapezohedron. The distances between the first lens 20, the second lens 22, and/or the third lens 50, affects the length 32, width, 34, and/or depth 36 of the image 30, causing the projected hexahedron to appear either wider, longer, or narrower. Rotation of the first lens 20 relative to the second lens 22 or the third lens 50, or tilting lenses 20, 22, and/or 50 relative to one another affects the aspect ratio of the image 30, causing the projected hexahedron to appear either wider or

narrower in the width dimension 34 and/or potentially the length 32 dimension and/or the depth 36 dimension.

The appearance of the image 30 may be affected further by the angle of observation of the observer. The direction A depicted in FIGS. 1A and 1B is generally in line with an axis of the light source 12 and the optical axis of the first lens 20 and second lens 22. From such a vantage point, the observer may see the projected images 30 as shown in FIGS. 1A and 1B. As the observer moves horizontally from side to side, changing the direction A and the observer's angle to the light source 12 accordingly, the image 30 appears to flip as if the observer is then seeing the opposite side of the projected cube, for example going from observing the left to the right side of the cube. Likewise, when the vantage point of the observer moves vertically up and down relative to the light source 12, the image 30 appears to flip vertically as if the observer is then seeing the opposite vertical side of the projected cube, for example going from observing the top to the bottom side of the cube. In embodiments such as depicted in FIGS. 1A and 1B, having multiple lights source 12 spaced at a distance from one another both horizontally and vertically, the individual images 30 of each light source 12 will appear to flip at different angles of observation, creating an interesting and appealing visual effect.

In at least one embodiment according to the present disclosure, the first lens 20 and the second lens 22 may be lenticular lenses having a plurality of spherical lenslets 128 as shown in FIG. 8. The spherical lenslets 128 may include parameters such as a radius of an individual lenslet 128 and a thickness of a plate or film upon which the lenslets 128 are disposed. The spherical lenslets 128 may enable an omnidirectional parallax, providing view information in a generally conically shaped field of view as shown in FIG. 8.

The first lens 20 and the second lens 22 may be substantially flat sheets, as depicted in FIGS. 1 and 5, upon which flutes 26 or lenslets 128 are disposed. In certain embodiments, the first lens 20 and/or the second lens 22 may have non-planar surfaces with curvature in two or three dimensions. For example, the first lens 20 and/or the second lens 22 may at least partial wrap around the light source 12 or follow a contour of an outer lens that defines the exterior styling of a lamp assembly including the projection device 10. In one form, individual flutes 26 or lenslets 128 of the first lens 20 and/or second lens 22 may be rotated with respect to its other flutes 26 or lenslets 128 such that the optical axes of some flutes 26 or lenslets 128 are normal position to the X-axis to compensate for diffused appearance and performance that may be observed at wide viewing angles from the perspective of the observer. Such an arrangement of flutes 26 and/or lenslets 128 may be applied particularly to the most inboard portions of the first lens 20 and/or second lens 22 relative to certain applications.

In certain embodiments, the first lens 20 and/or the second lens 22 may include laser etching or some other surface treatment that may further affect and/or visually interact with the appearance of the image 30 to enhance the 3D visual effect. In yet further embodiments, first lens 20 and/or the second lens 22 may include a decorative treatment to further enhance and/or visually interact with the appearance of the image 30. By way of non-limiting example, the decorative treatment may include a pad print logo that may be given an appearance of depth in cooperation with the image 30.

The first lens 20 and the second lens 22 may be formed by any suitable process including, without limitation, injection molding, compression molding/forming, vacuum forming, extruding, thermoset, and rolling. In at least one embodiment, the first lens 20 and/or the second lens 22 may be a relatively thin film. The first lens 20 and second lens 22 may be a transparent polymer including, without limitation, poly(methyl methacrylate), polycarbonate, and polyetherimide. In certain embodiments, the first lens 20 and second lens 22 may be glass.

The projection device 10 may be incorporated into a lamp assembly 140 as shown in FIG. 2. The lamp assembly 140 may include an outer lens 144 attached to a housing 142 to form a volume 148 therebetween. The housing 142 and/or outer lens 144 may be structured to secure and position the projection device 10 within the volume 148. The housing 142 and/or outer lens 144 may be structured to establish and maintain the relative distance between the light source 12 (or array 14 of more than one light source 12), the first lens 20, and the second lens 22. In at least one embodiment, the housing 142 may include one or more bosses 146 structured to positively locate the first lens 20 and/or the second lens 22. In certain embodiments, the first lens 20 and/or the second lens 22 may be attached to the housing 142 by any suitable means. For example, the first lens 20 and/or the second lens 22 may be welded to the housing 142 using, without limitation, a sonic weld process, a vibration weld process, or thermal tack process. Alternatively or additionally, the first lens 20 and/or the second lens 22 may be attached to the housing 142 using an adhesive. In at least one embodiment, the housing 142, outer lens 144, first lens 20, and/or second lens 22 may be configured to trap the first lens 20 and/or the second lens 22 in the desired position without an additional means of attachment.

FIG. 3 shows a photograph of a lamp assembly 140 lit using a projection device 100 within a housing 142 and behind an outer lens 144. As shown in FIG. 3, the projection device 100 generates a three-dimensional image 130 for each light source of the lamp assembly 140. The outer lens 144 may have a substantially uniform thickness without optics formed therein. Alternatively, the outer lens 144 may include optics formed therein. In such embodiments, the optics of the outer lens 144 may affect the appearance of the image 130. For example, the outer lens 144 may include pillow optics or flutes that may enhance the appearance of the image 130.

Further, as described herein with respect to the first lens 20 and second lens 22, the outer lens 144 may include decorative treatments configured to visually interact with the image 130.

In certain embodiments, the lamp assembly 140 may be an automotive exterior lamp configured to provide signaling and/or illuminating functions in accordance with applicable governmental regulations. In at least one embodiment, the lamp assembly 140 may be a tail lamp and may include tail and/or stop functions. In an embodiment, the lamp assembly 140 may be a park and signal lamp and may include park and/or turn functions. In yet another embodiment, the lamp assembly 140 may be sidemarker providing sidemarker functions. In certain embodiments, the lamp assembly 140 may include various different functions.

In at least one embodiment according to the present disclosure, the projection device 10 may include more than one pair of lenses, where the first lens 20 and second lens 22 define one pair. In such an embodiment, the additional pairs of lenses may enable varying the appearance of the image 30 within the same viewing angle. Further, the additional pairs of lenses may be applied to a portion of the field of view of the light source 12, for example at larger angles from the axis of the light source 12 and/or at the edges of the lamp assembly 140.

In an alternative embodiment according to the present disclosure, a blocker plate 122 may be substituted for at least one of the lenticular lenses as shown in FIG. 6. In such an embodiment, a lamp assembly 150 may include a projection device 101 between the housing 142 and outer lens 144 within the volume 148. As shown in FIG. 6, the projection device 101 may include one or more light sources 12 arranged in the array 14 and oriented to emit light through a first lens 120 and subsequently toward the blocker plate 122. The blocker plate 122 includes at least one aperture 124 through a substantially opaque body portion 126. The aperture 124 may be proportioned to block all light from the light source 12 except a desired shape of light to generate the desired image 30. Accordingly, the aperture 124 may be proportioned to a specific size and/or shape including, for example, logo patterns, emblems, letters, cylinders, triangles, or any desired shape. In one form, the aperture 124 may have a width of about 2 mm (in the dimension as shown in the cross-sectional view of FIG. 6). The aperture 124 may further have a length selected to generate the desired image 30. The length of the aperture 124 may be defined orthogonal to the width or at a desired angle off from orthogonal. In at least one embodiment, the length may be about 50 mm in a dimension orthogonal to the width.

The proportions and/or shape of the aperture 124 may be selected with respect to the size and shape of the lamp assembly 150, the number of light sources 12, the desired functions of the lamp assembly 150, and/or the desired projected image 30. FIG. 7 illustrates the principle of operation of the first lens 120 in cooperation with the blocker plate 122 to generate the image

30. As shown in FIG. 7, the image 30 is generated by the interaction of the first lens 120 with the blocker plate 122 to create two separate perspectives of the light source 12, where each eye of the observer 40 views a different perspective. Accordingly, the image 30 is a stereoscopic composite image formed by the observer 40 from the different perspective views of the light source 12 as perceived by each eye of the observer 40 through the blocker plate 122.

The blocker plate 122 may be separated from the first lens 120 by a suitable distance. The closer the blocker plate 122 is to the first lens 120, the wider the angle of separation between the left and right images. Further, the relative position and orientation of the blocker plate 122 to the first lens 120 affects the shape, proportion, and viewing angle of the image 30. The relative position and orientation of the blocker plate 122 to the first lens 120 may be selected to generate the desired image 30. In certain forms, the blocker plate 122 may be a parallax barrier.

The blocker plate 122 may be formed of an opaque material such as, without limitation, a polymer, including poly(methyl methacrylate), polycarbonate, and polyetherimide, or a metal. In certain embodiments, the blocker plate 122 may be coated or painted to form the opaque body portion 126. For example, the blocker plate 122 may include a metalized finish of aluminum, nickel, or any suitable material to enable the desired appearance. In such an embodiment, the metalize finish may be applied by painting, chemical vapor deposition, physical vapor deposition, or any suitable process.

Referring to FIG. 6, the housing 142 of the lamp assembly 150 may be configured to secure and position the projection device 101 within the volume 148. The housing 142 and/or outer lens 144 may be structured to establish and maintain the relative distance between the light source 12 (or array 14 of more than one light sources 12), the first lens 120, and the blocker plate 122. In at least one embodiment, the housing 142 may include one or more bosses 146 structured to positively locate the first lens 20 and/or the blocker plate 122. In certain embodiments, the first lens 20 and/or the blocker plate 122 may be attached to the housing 142 by any suitable means. For example, the first lens 20 and/or the blocker plate 122 may be welded to the housing 142 using, without limitation, a sonic weld process, a vibration weld process, or thermal tack process. Alternatively or additionally, the first lens 20 and/or the blocker plate 122 may be attached to the housing 142 using an adhesive. In at least one embodiment, the housing 142, outer lens 144, first lens 20, and/or blocker plate 122 may be configured to trap the first lens 20 and/or blocker plate 122 in the desire position without an additional means of attachment. As shown in FIG. 6, the blocker plate 122 may be disposed between the first lens 120 and the outer lens 144. Alternatively, the blocker plate 122 may be disposed between the first lens 120 and the light source 12 as shown in FIG. 7.

In another embodiment, the light source 12 need not be disposed directly behind the first lens 20, 120, the second lens 22, and/or the blocker plate 122 as shown in FIGS. 2 and 6. In such an embodiment, the light source 12 may be disposed relative to an intermediary optical device such that the image 30 is generated from a virtual image of the light source 12 as indirectly enabled by the intermediary optical device. For example, the light source 12 may be disposed relative to a reflector such that the image 30 is generated from a virtual image of the light source 12 as indirectly reflected via the reflector. In one form, the light source 12 could be disposed at a proximal end of a light pipe or guide such that the image 30 is generated from a virtual image of the light source 12 as indirectly refracted and reflected through the light pipe or guide.

Alternatively, other embodiments of the present disclosure may not include the light source 12. In such an embodiment, the image 30 may be generated by the reflection of ambient light entering the projection device 10 or projection device 101 through the first lens 20, 120, second lens 22, and/or blocker plate 122 from a source external to the device 10, 101. For example, the ambient light source may be sunlight, street lighting, area lighting, or any suitable source.

The light source 12 may be a point source, for example a light-emitting diode (LED) or a laser diode. In embodiments including more than one light source 12, the light sources 12 may be spaced from one another by 10 mm or more. In at least one such embodiment, the light sources 12 are spaced apart by about 60 mm.

In certain embodiments, the light source 12 may be a line source, such as a gas discharge (e.g., neon) tube, an edge-lit micro-optic sheet, or a light pipe. In yet other embodiments, the light source 12 may have other form factors, for example high intensity discharge arcs, halogen bulbs, or incandescent bulbs. The form factor of the light source 12 may affect the shape, size, and appearance of the generated image 30. The form factor of the light source 12 may be affected by an intermediary optical device such as an indirect reflector, Fresnel lens, light pipe, or edge-lit micro-optic sheet, as described herein.

FIGS. 9A-18 show additional embodiments of three-dimensional images 30, 130 generated using various device 10, 100, 101 embodiments of the present disclosure, such as those including a first lens 20, a second lens 22, and at least one additional lenticular lens (such as a third lens 50). FIG. 9A shows a three-dimensional image 30 projected to appear as a ribbon image (a series of ribbons), FIG. 9B shows a three-dimensional image 30 projected to appear as a series of twisting lines, and FIG. 9B shows a three-dimensional image 30 of the present disclosure projected to appear as fire. FIG. 9D shows a three-dimensional image 30 of the present disclosure projected to appear as shark teeth (having a shark tooth configuration), and

FIG. 9E shows a three-dimensional image 30 of the present disclosure projected to appear as one or more cubes.

FIGS. 10A-10C show various embodiments of three-dimensional images 30, projected to appear as a series of planes (diamond-shapes), whereby any number of planes can be generated using devices 10, 100, 101. FIG. 10D shows a three-dimensional image 30 of the present disclosure projected to appear as webs (interconnected shapes). FIGS. 11A-12E show various other embodiments of three-dimensional images 30 of the present disclosure, having various twisted shapes (FIG. 11A), curved and pointed shapes (FIGS. 11B, 11C, and 11D), a series of curved lines (FIG. 11E), fringed leaf shapes (FIG. 12A), ribbons (FIG. 12B), amorphous shapes (FIGS. 12C and 12D), and/or curved triangle shapes (FIG. 12E).

Three-dimensional images 30 of the present disclosure may also be generated as shown in FIGS. 13A-18. FIG. 13A shows a three-dimensional image 30 of the present disclosure projected as having an amorphous shape, while FIGS. 13B and 13C shows three-dimensional images 30 of the present disclosure projected to appear as a series of cubes. As shown in FIG. 13B, for example, various three-dimensional images 30 of the present disclosure can include and/or project one or more colors, such as a first color 200, a second color 202, and a third color 204, for example. Said colors 200, 202, 204 can be/include any number of colors, such as red, blue, white, yellow, etc. In at least one embodiment, color 200 comprises red, color 202 comprises blue, and color 204 comprises yellow. In at least another embodiment, first color 2020 comprises blue, second color 202 comprises red, and third color 204 comprises yellow. Various devices 10, 100, 101 of the present disclosure, therefore, can be configured to project one or more colors 200, 202, and/or 204, for example.

FIG. 13D shows a three-dimensional image 30 of the present disclosure projected to appear as a series of stars, and FIG. 13E shows a three-dimensional image 30 of the present disclosure projected to appear as a series of squares. FIGS. 14A, 14B, 14C, and 14D shows three-dimensional images 30 of the present disclosure projected as having various amorphous shapes. FIG. 15A shows a three-dimensional image 30 of the present disclosure projected to appear as having a cubism pattern, while FIG. 15B shows a three-dimensional image 30 of the present disclosure projected to appear as a series of curved lines. FIG. 15C shows a three-dimensional image 30 of the present disclosure projected to appear as a pattern of adjacent curved lines, such as a ultra-high frequency ("UHF"), and FIG. 15D shows a three-dimensional image 30 of the present disclosure projected to appear as a series of ribbons. FIG. 16A shows a three-dimensional image 30 of the present disclosure projected to appear as a waterfall, while FIG. 16B shows a three-dimensional image 30 of the present disclosure projected to appear as a waterfall and arcs.

FIGS. 17A and 17B show exemplary lamp assemblies 140 of the present disclosure (which could also be lamp assemblies 150, as referenced herein), each shown as projecting three-dimensional images 30 as generally referenced herein. FIG. 17A shows an embodiment of a lamp assembly 140 projecting a three-dimensional image 30 that differs from the three-dimensional image 30 projected in FIG. 17B, noting that the same lamp assembly 140, 150 of the present disclosure can project different images 30 as may be desired. For example, one image 30 could be projected when a vehicle using lamp assembly 140 is stopped and/or is turning, and another image 30 could be projected when the vehicle is not stopped, such as a daytime light while driving. In embodiments when one lamp assembly 140 can project two or more images 30, one image 30 may be in a first orientation, and another image 30 may be in a second and different orientation, such as a flipped orientation or another different orientation from the first orientation, such as shown in FIG. 18.

FIG. 19 shows an additional lamp assembly 140 embodiment of the present disclosure, configured to project a three-dimensional image 30 having at least two colors (such as a first color 200 and a second color 202). Image 30, as shown therein, may appear as a series of horizontal bars, for example, and is referred to as a homogenous image.

While various embodiments of a projection device and methods for using and constructing the same have been described in considerable detail herein, the embodiments are merely offered by way of non-limiting examples of the disclosure described herein. It will therefore be understood that various changes and modifications may be made, and equivalents may be substituted for elements thereof, without departing from the scope of the disclosure. Indeed, this disclosure is not intended to be exhaustive or to limit the scope of the disclosure.

Further, in describing representative embodiments, the disclosure may have presented a method and/or process as a particular sequence of steps. However, to the extent that the method or process does not rely on the particular order of steps set forth herein, the method or process should not be limited to the particular sequence of steps described. Other sequences of steps may be possible. Therefore, the particular order of the steps disclosed herein should not be construed as limitations of the present disclosure. In addition, disclosure directed to a method and/or process should not be limited to the performance of their steps in the order written. Such sequences may be varied and still remain within the scope of the present disclosure.

CLAIMS

1. A projection device comprising:

a light source;

a first lens positioned at a first distance from the light source; and

5 a second lens at a second distance from the first lens;

wherein the first lens and the second lens are lenticular lenses, each having an optical axis; and

wherein the projection device is configured to generate a three-dimensional image from light emitted from the light source that passes through the first lens and the second
10 lens.

2. The device of claim 1, wherein the light source comprises one or more light-emitting diodes.

3. The device of claim 1, wherein the light source is a light pipe.

4. The device of claim 1, wherein the first lens is orthogonal or parallel to an axis of
15 the light source.

5. The device of claim 1, wherein the first lens and the second lens have an optical density of between 20 and 150 flutes per inch.

6. The device of claim 1, wherein the optical axis of the first lens is rotated relative to the optical axis of the second lens.

7. The device of claim 1, wherein the optical axis of the first lens is tilted relative to the optical axis of the second lens.
20

8. The device of claim 1, wherein the optical axis of the first lens is tilted relative to the light source.

9. The device of claim 1, wherein the three-dimensional image is projected as an
25 image selected from the group consisting of an image of a ribbon, an image of a series of twisting lines, an image of fire, an image of shark teeth, an image of diamonds, an image of curved lines, an image of stars, an image of squares, an image of a waterfall, and an image of arcs and a waterfall.

10. The device of claim 1, wherein the three-dimensional image is projected as an
30 image having a shape selected from the group consisting of a twisted shape, a curved and pointed shape, a fringed leaf shape, a curved triangle shape, a square shape, an amorphous shape, a cube shape, and a diamond shape.

11. The device of claim 1, wherein the three-dimensional image is projected as an image having a first color and a second color different from the first color.

12. The device of claim 1, wherein the three-dimensional image is projected as an image having a first color, a second color, and a third color, where each of the first color, the second color, and the third color are different from one another.

5 13. The device of claim 1, wherein the device is further configured to generate a second three-dimensional image from light emitted from the light source that passes through the first lens and the second lens, wherein the three-dimensional image is different from the second three-dimensional image.

10 14. The device of claim 1, forming part of a lamp assembly, the lamp assembly further comprising a housing and an outer lens, wherein the device is positioned within the housing.

15 15. The device of claim 14, wherein the three-dimensional image is present or perceived within the housing between the second lens and the outer lens.

16. The device of claim 14, wherein the lamp assembly is configured as a vehicle lamp assembly.

15 17. The device of claim 1, further comprising:
a third lens positioned a third distance from the second lens;
wherein the projection device is configured to generate the three-dimensional image from light emitted from the light source that passes through the first lens, the second lens, and the third lens.

20 18. A lamp assembly, comprising:
a projection device comprising:
a light source,
a first lens positioned at a first distance from the light source, and
a second lens at a second distance from the first lens,
25 wherein the first lens and the second lens are lenticular lenses, each having an optical axis; and
a housing; and
an outer lens coupled to the housing to define a volume, wherein the projection device is positioned within the volume;
30 wherein the projection device is configured to generate a three-dimensional image within the volume from light emitted from the light source that passes through the first lens and the second lens.

19. A projection device comprising:
a light source;
a first lens positioned at a first distance from the light source; and
a blocker plate positioned a second distance from the first lens, the blocker plate
5 defining an aperture therethrough;

wherein the first lens is a lenticular lens having an optical axis; and
wherein the projection device is configured to generate a three-dimensional
image from light emitted from the light source that passes through the first lens and through the
aperture of the blocker plate.

10 20. The device of claim 19, wherein the light source comprises one or more light-emitting diodes.

21. The device of claim 19, wherein the light source is a light pipe.

22. The device of claim 19, wherein the first lens has an optical density of between
20 and 150 flutes per inch.

15 23. The device of claim 19, wherein the three-dimensional image is projected as an
image having a first color and a second color different from the first color.

24. The device of claim 19, wherein the device is further configured to generate a
second three-dimensional image from light emitted from the light source that passes through the
first lens and the second lens, wherein the three-dimensional image is different from the second
20 three-dimensional image.

25. The device of claim 24, forming part of a lamp assembly, the lamp assembly
further comprising a housing and an outer lens, wherein the device is positioned within the
housing, and wherein the three-dimensional image is present or perceived within the housing
between the second lens and the outer lens.

25 26. A lamp assembly, comprising:
a projection device, comprising: a light source, a first lens positioned at a
first distance from the light source, and a blocker plate positioned a second distance from the
first lens, the blocker plate defining an aperture therethrough;

wherein the first lens is a lenticular lens having an optical axis;

30 a housing; and

an outer lens coupled to the housing to define a volume, wherein the projection
device is positioned within the volume;

and wherein the projection device is configured to generate a three-dimensional
image from light emitted from the light source that passes through the first lens and through the
35 aperture of the blocker plate.

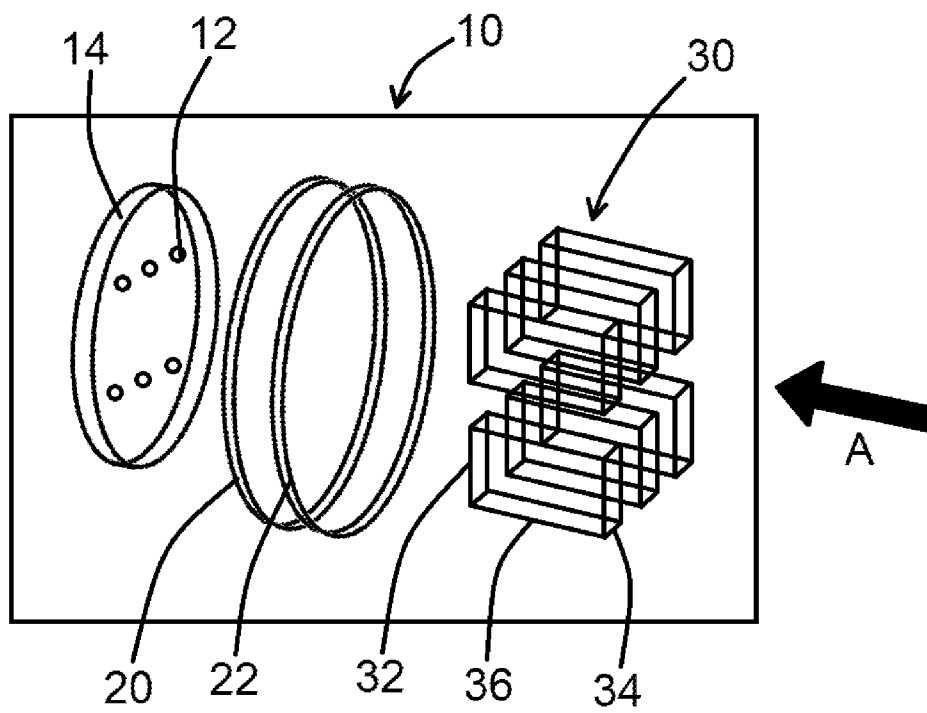


FIG. 1A

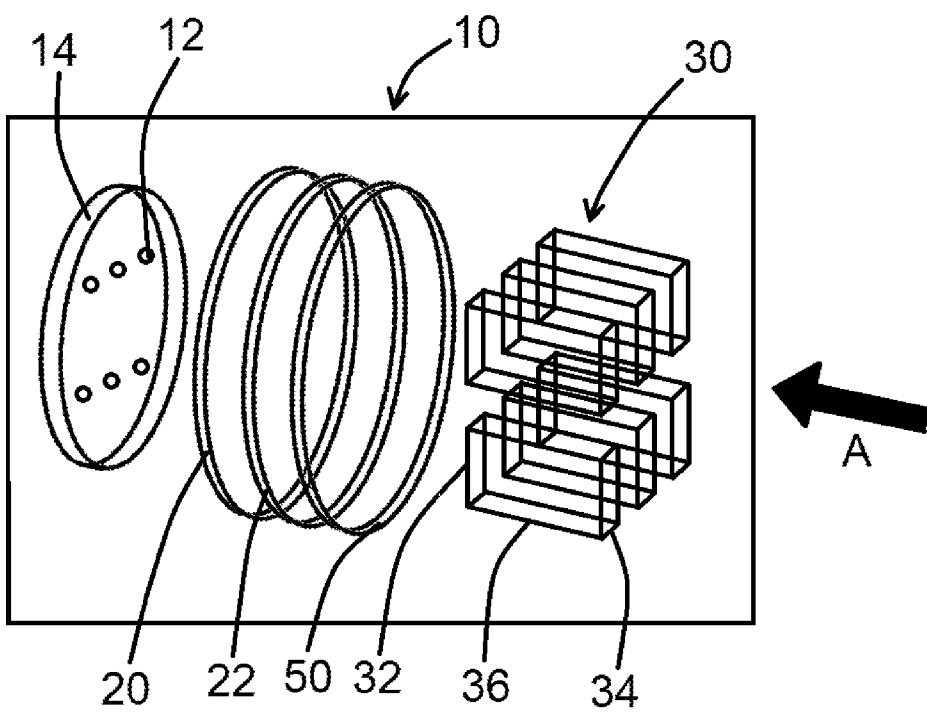


FIG. 1B

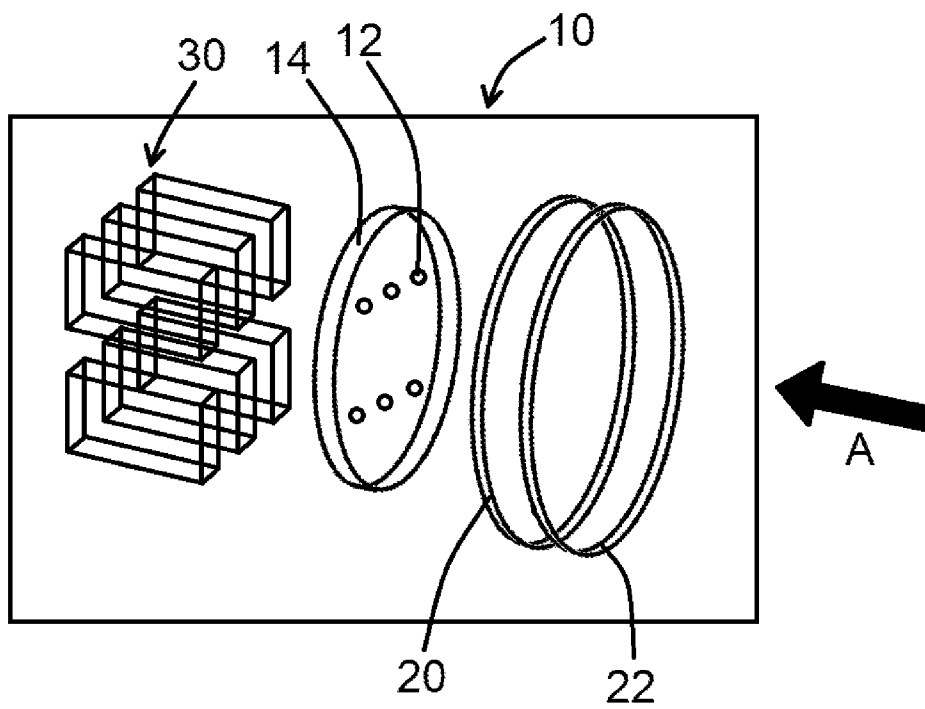


FIG. 1C

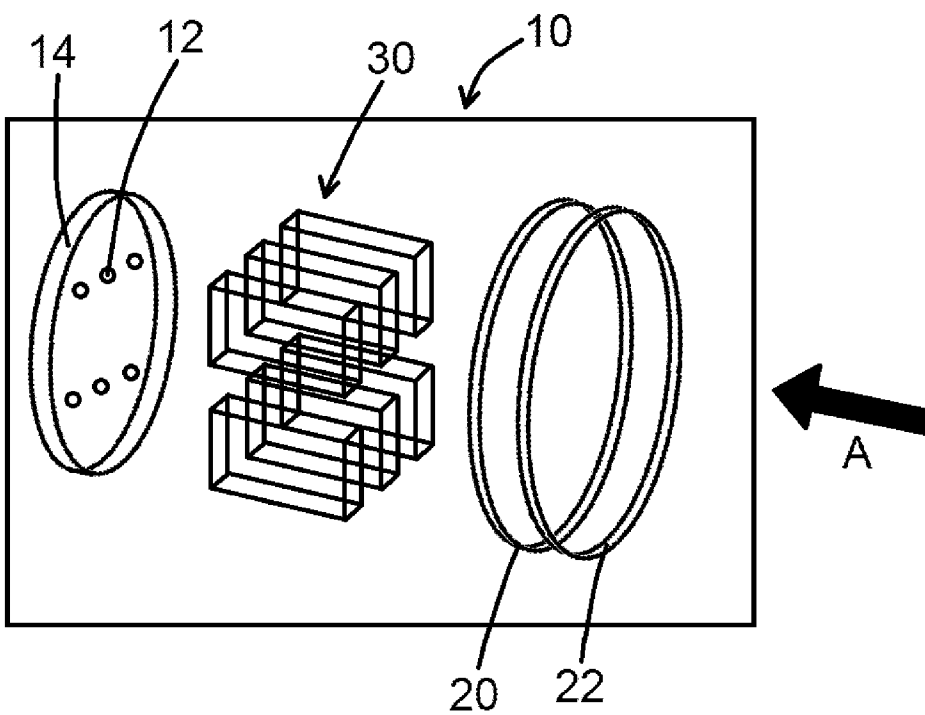


FIG. 1D

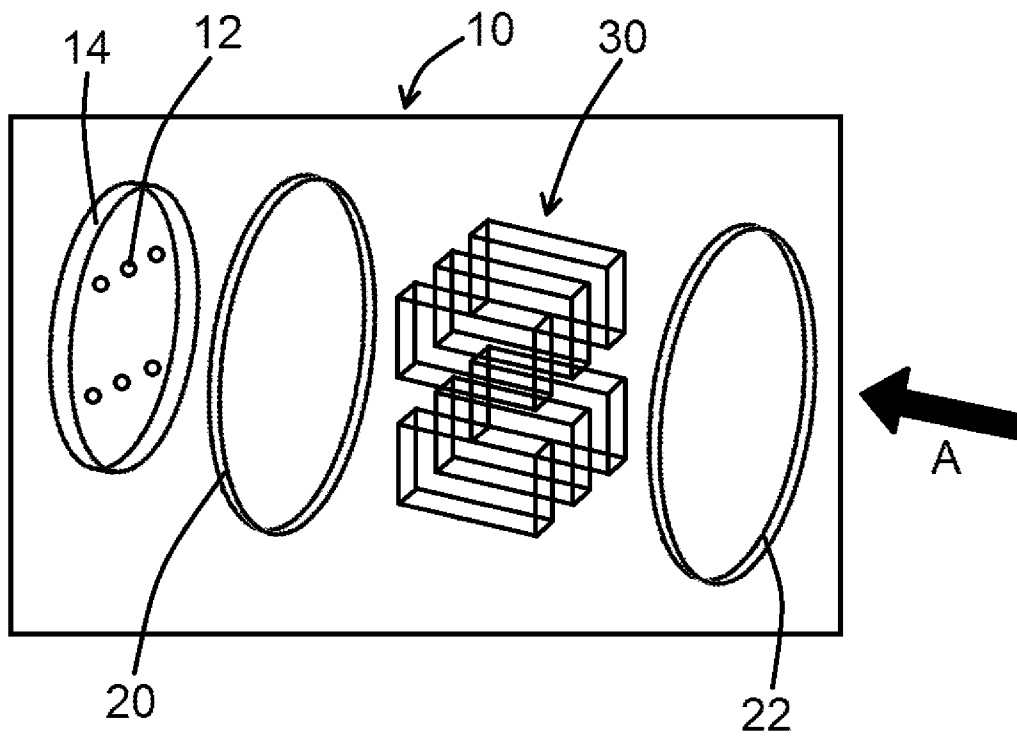


FIG. 1E

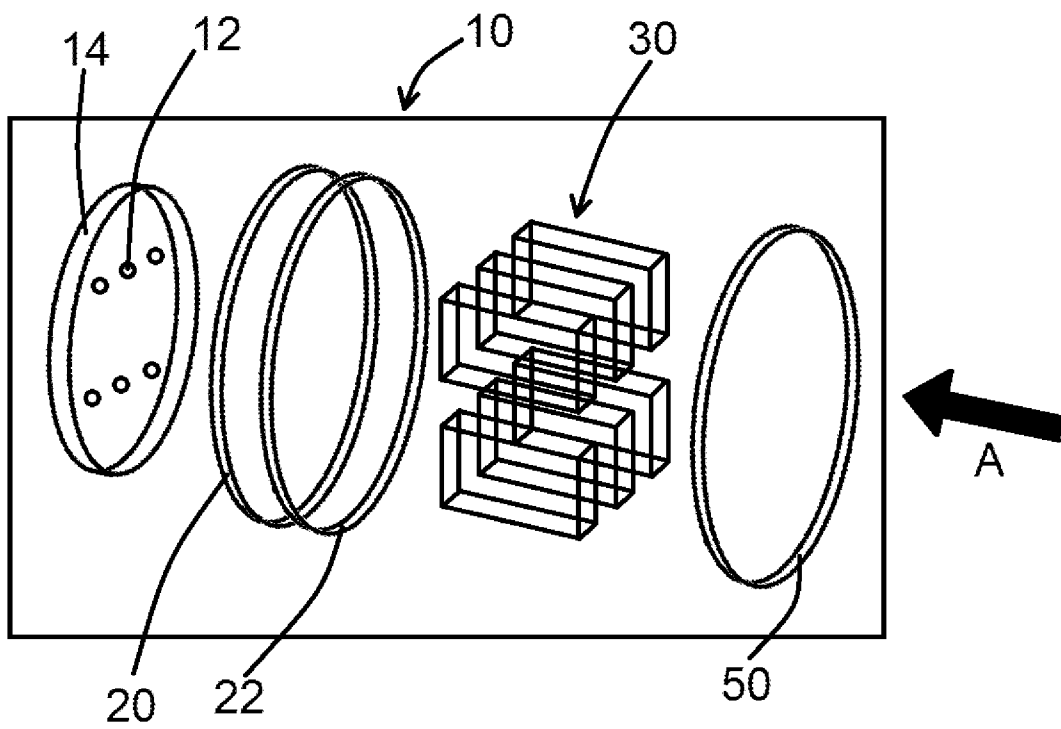


FIG. 1F

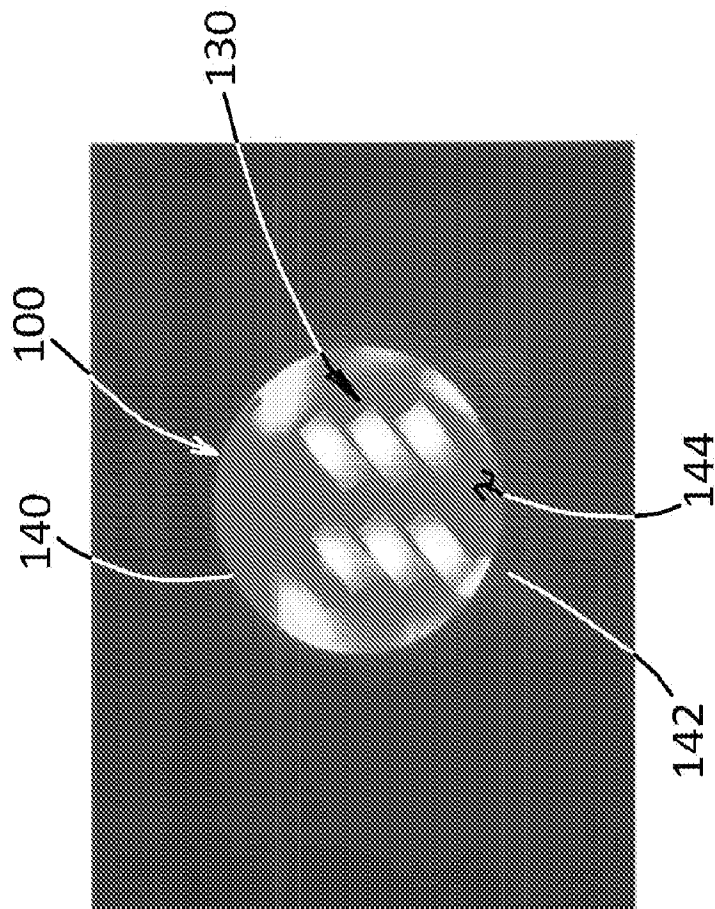


FIG. 3

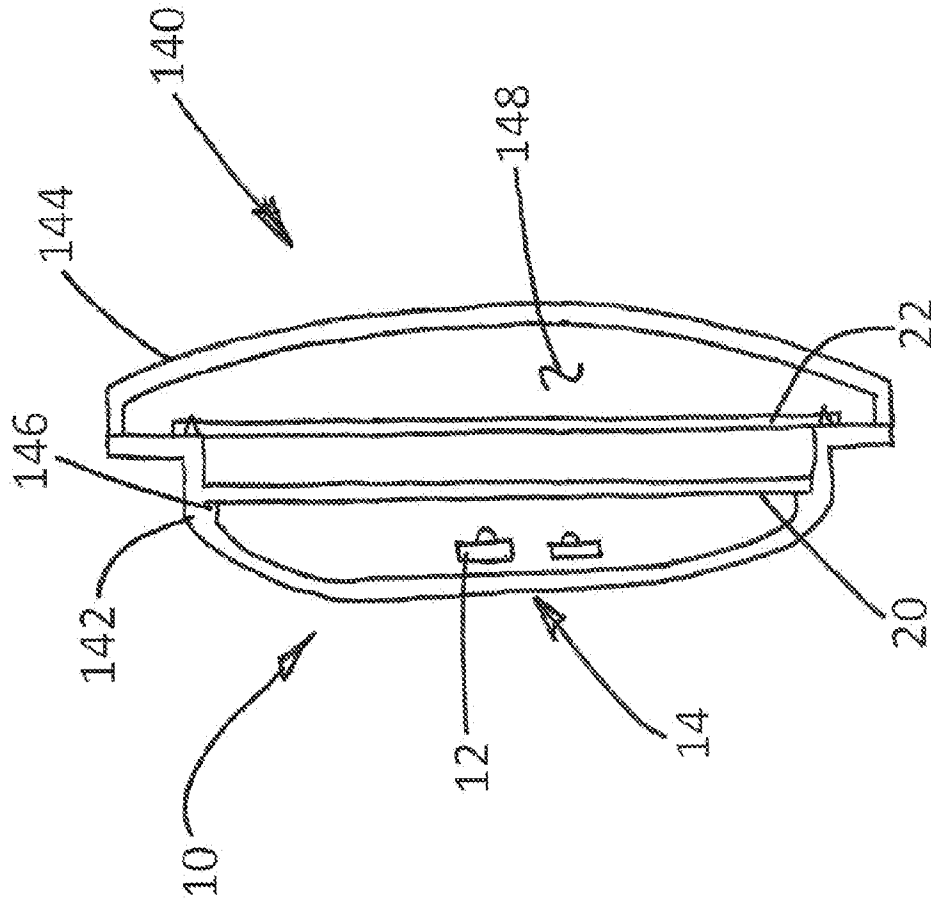


FIG. 2

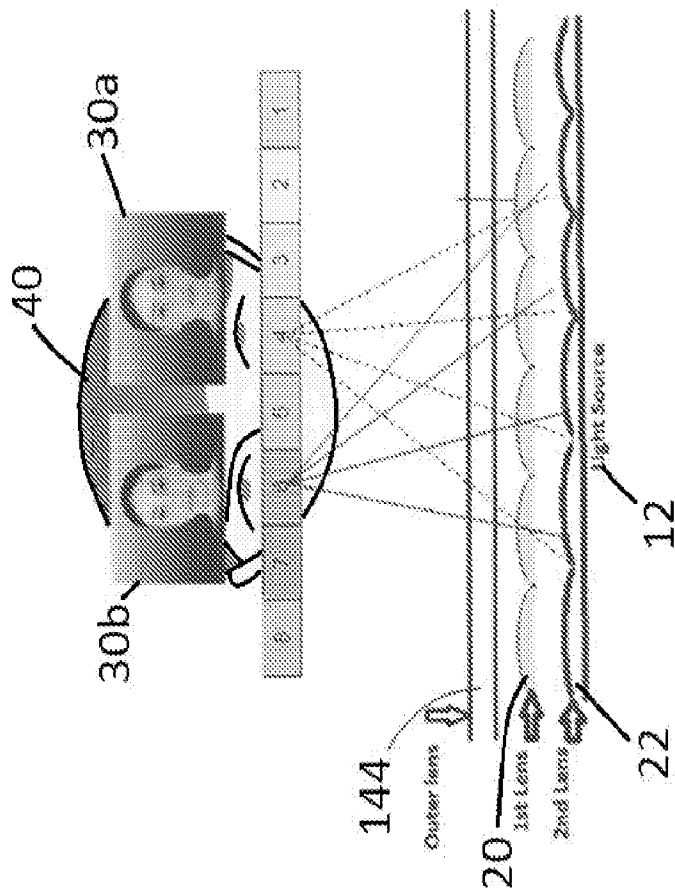


FIG. 5

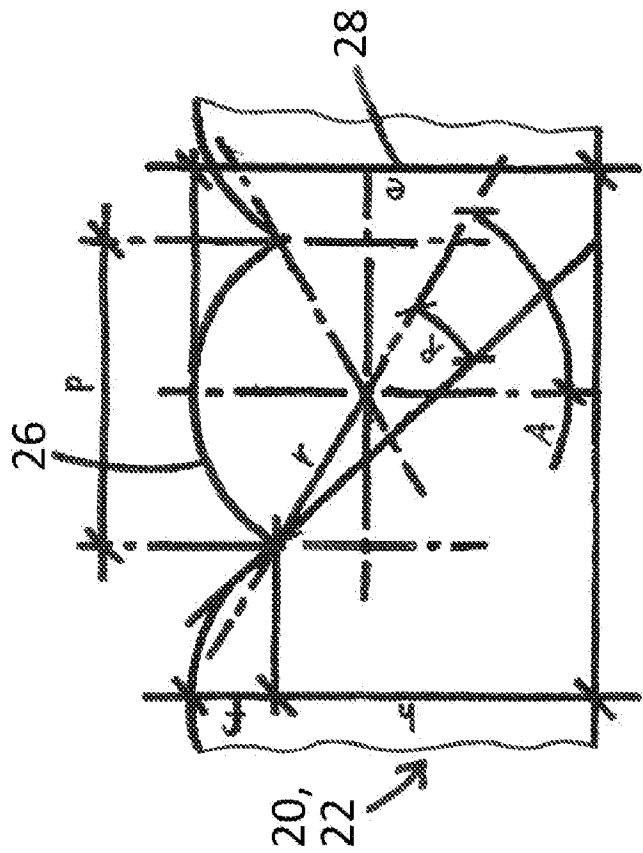


FIG. 4

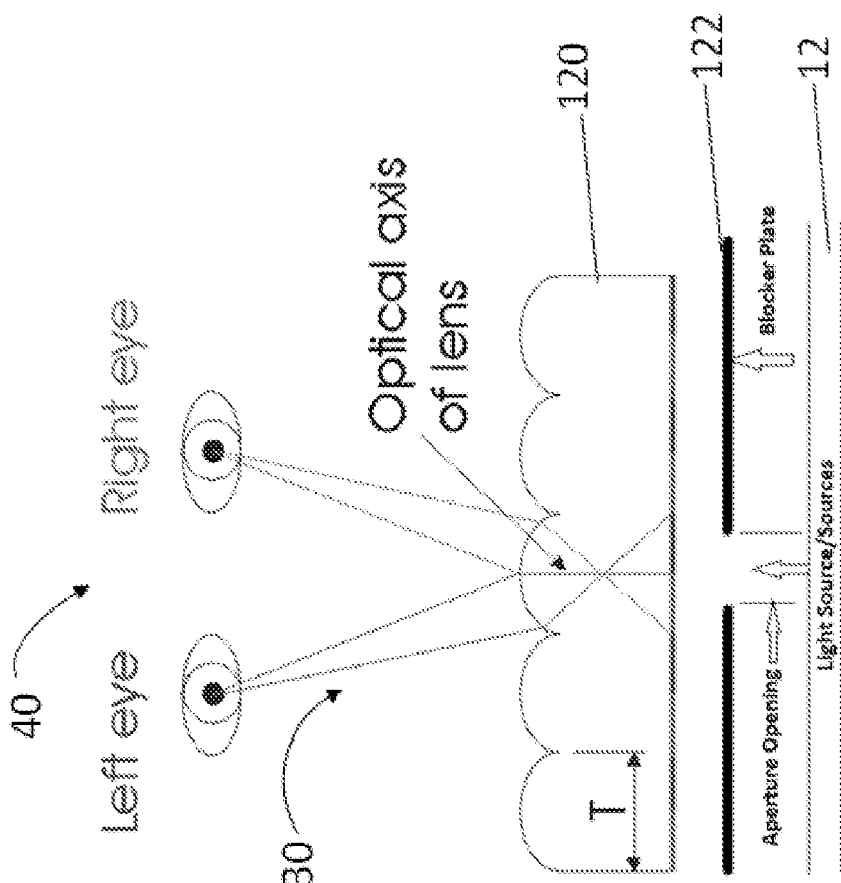


FIG. 7

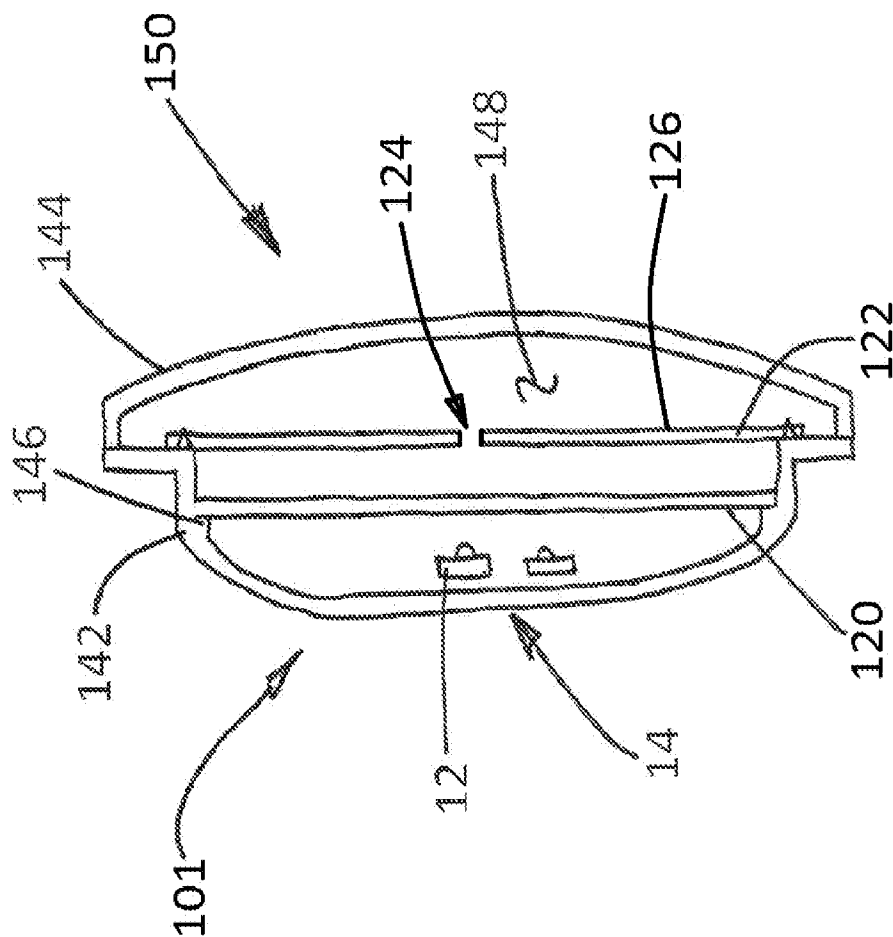


FIG. 6

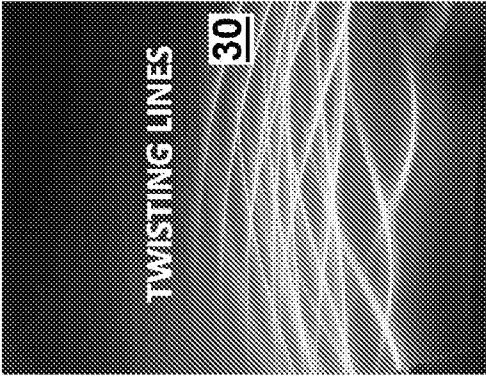


FIG. 9B



FIG. 9A

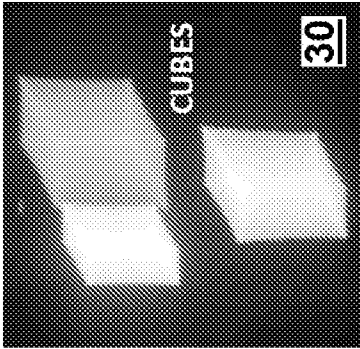


FIG. 9E

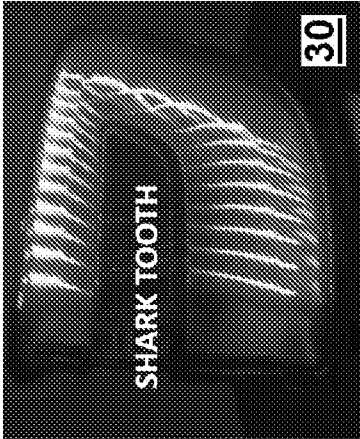


FIG. 9D

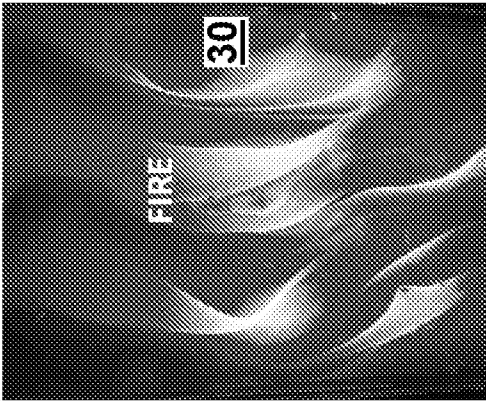


FIG. 9C

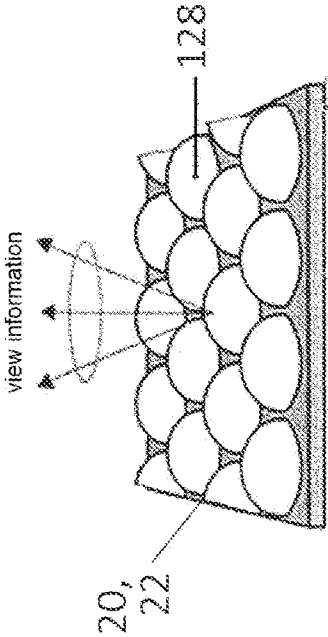


FIG. 8

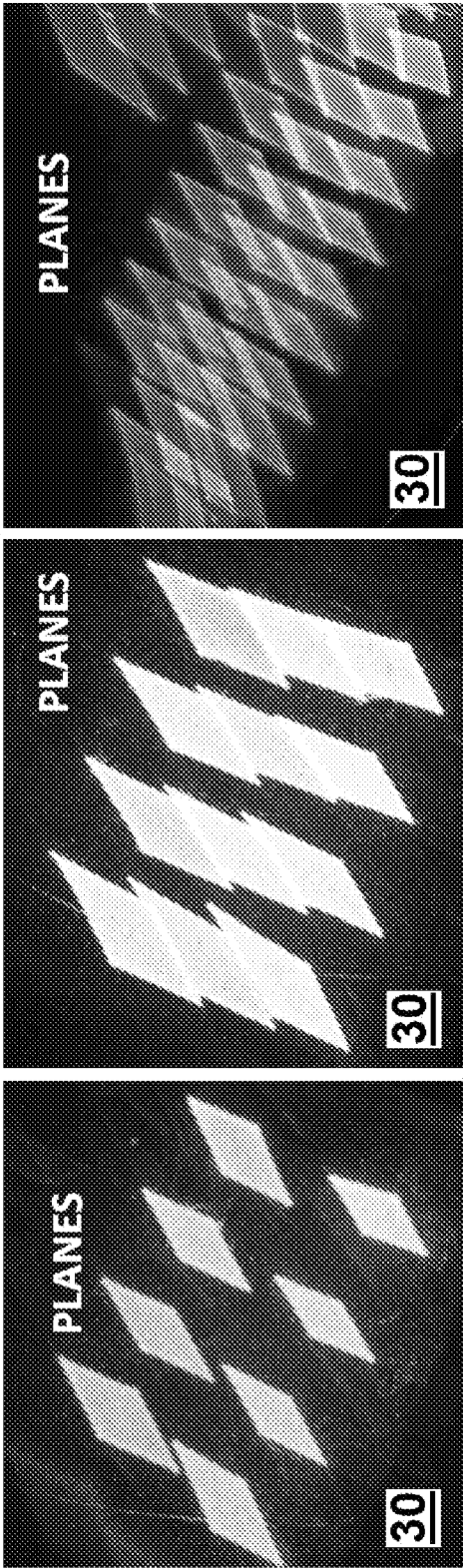


FIG. 10C

FIG. 10B

FIG. 10A

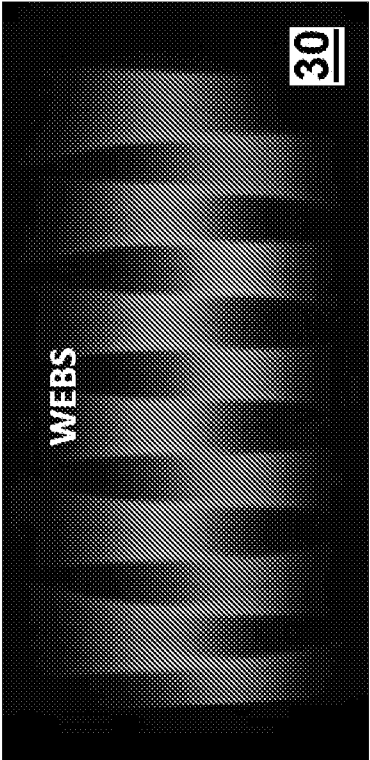


FIG. 10D

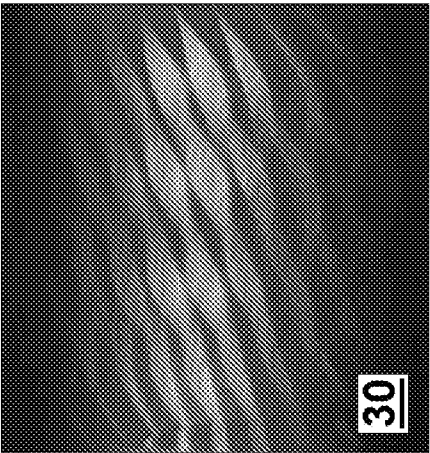


FIG. 11A



FIG. 11B

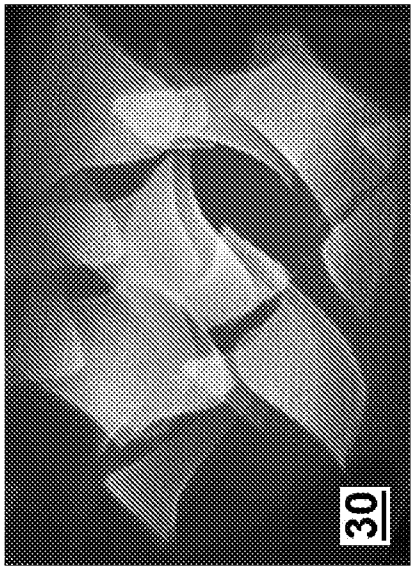


FIG. 11C

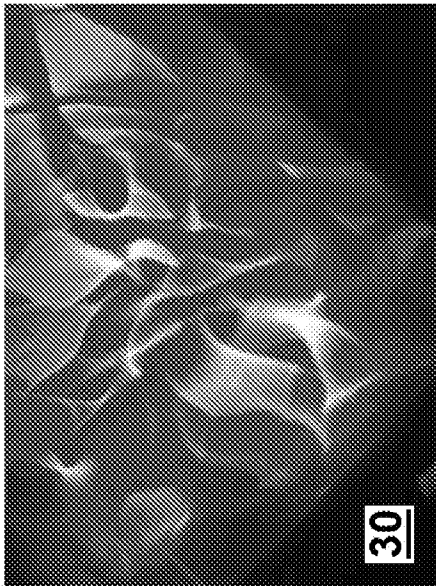


FIG. 11D

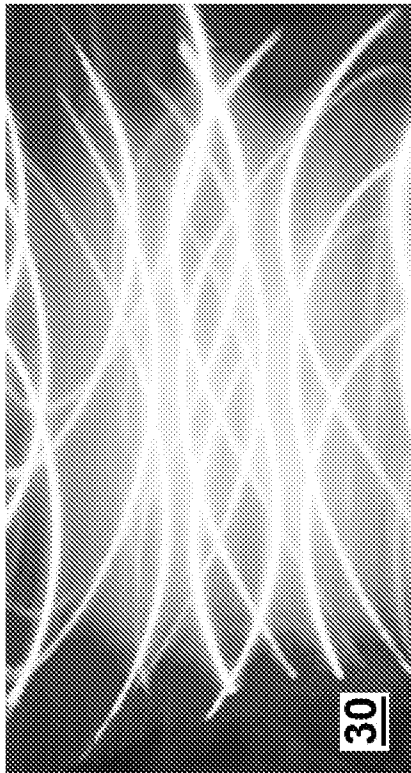


FIG. 11E

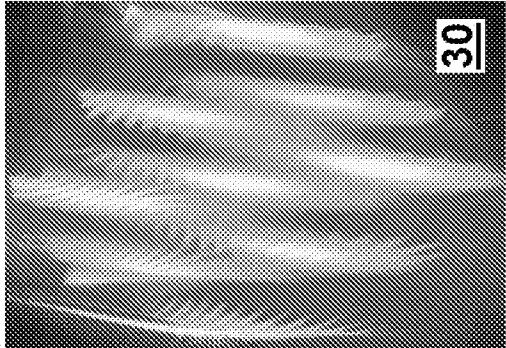


FIG. 12A

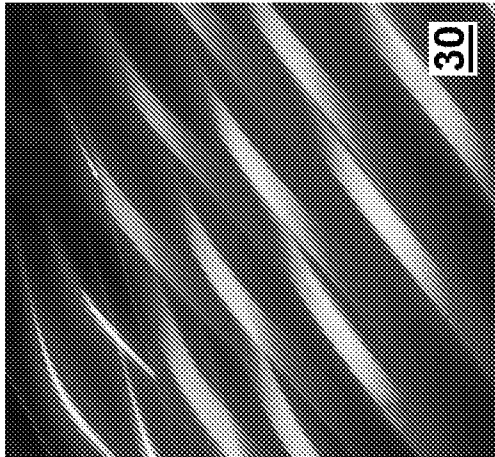


FIG. 12B

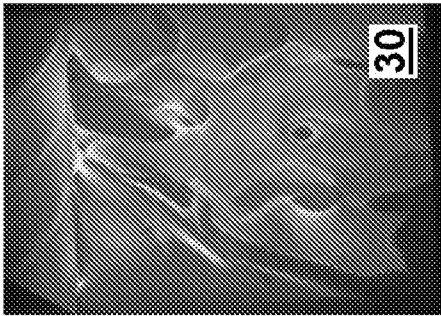


FIG. 12C

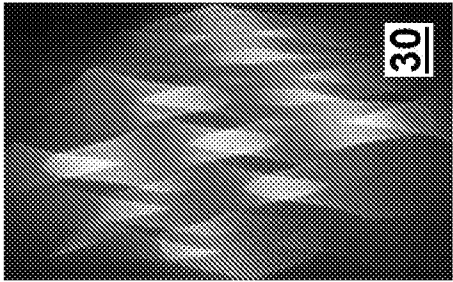


FIG. 12D

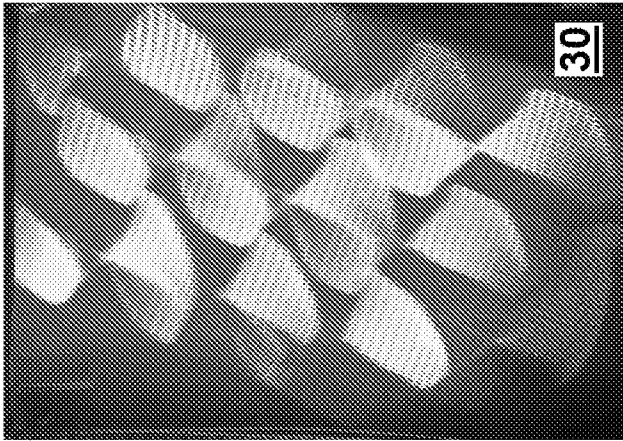
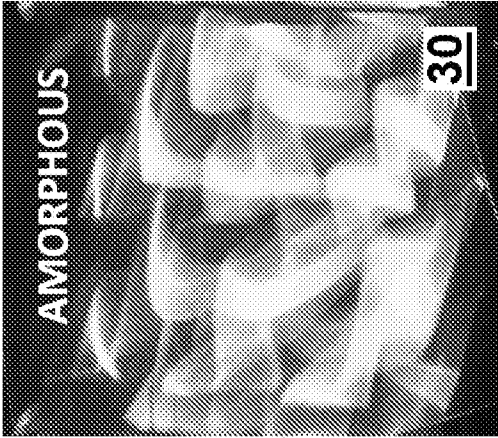
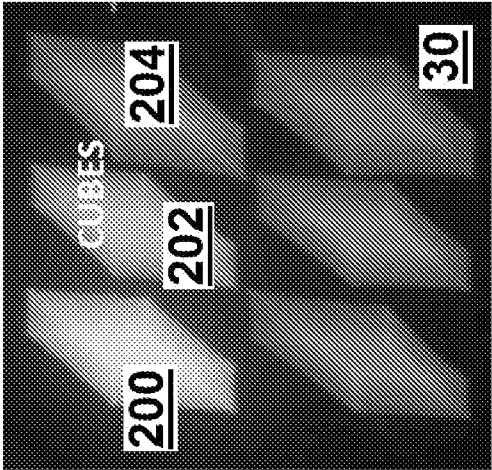


FIG. 12E



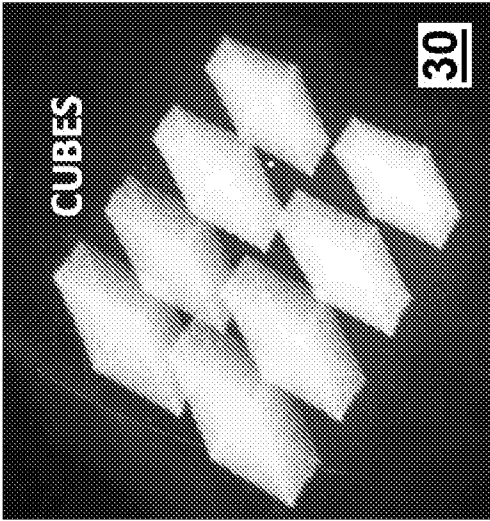
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FIG. 13A



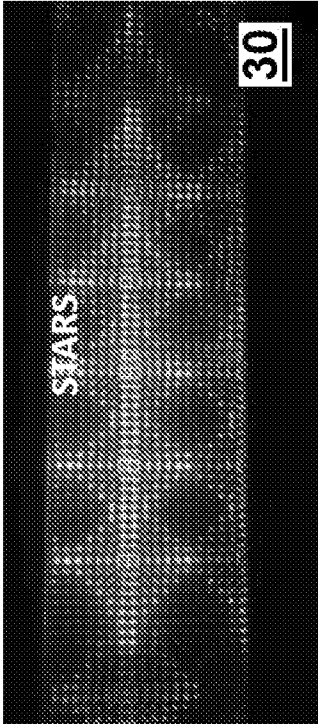
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FIG. 13B



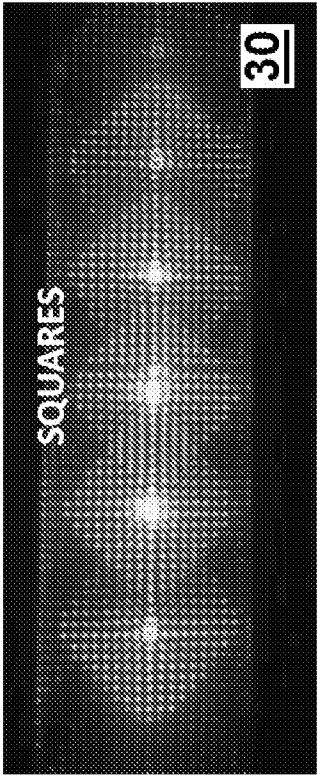
30

FIG. 13C



30

FIG. 13D



30

FIG. 13E

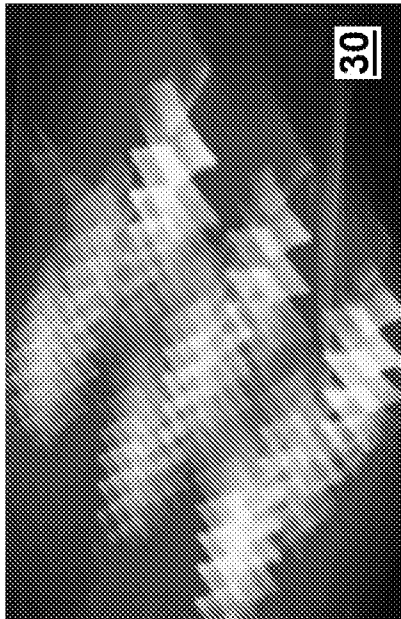


FIG. 14B

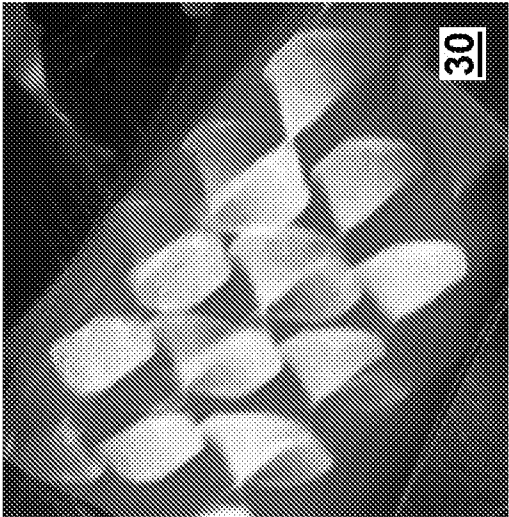


FIG. 14D

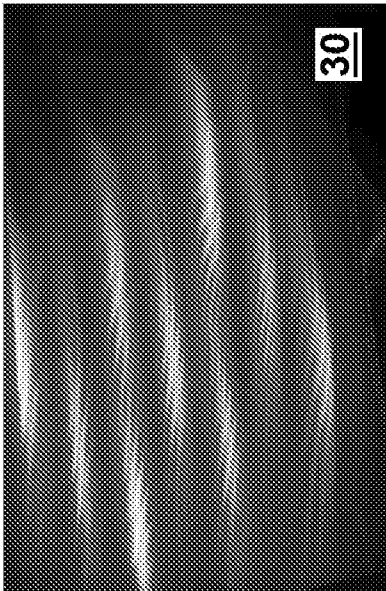


FIG. 14A

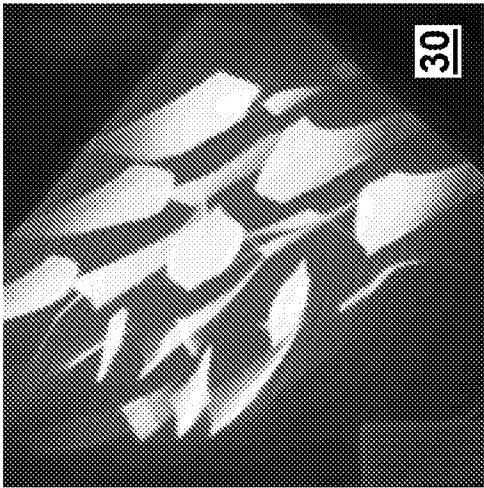


FIG. 14C

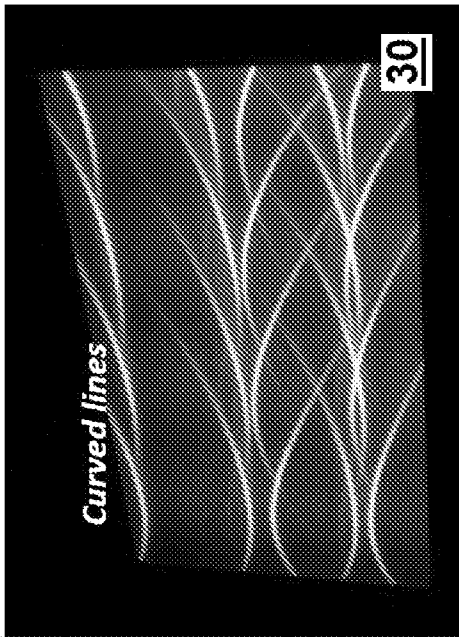


FIG. 15B

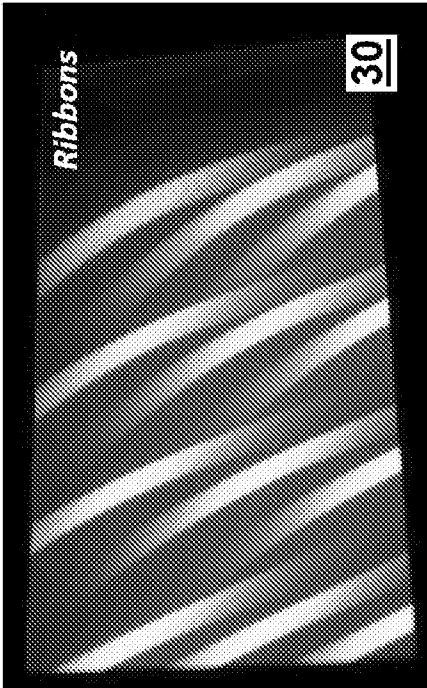


FIG. 15D

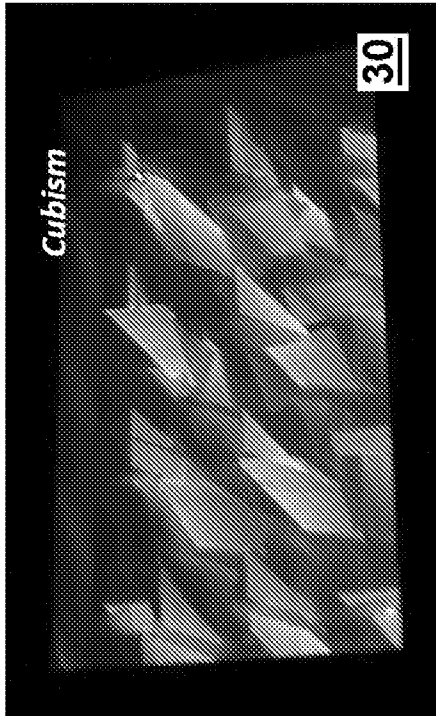


FIG. 15A

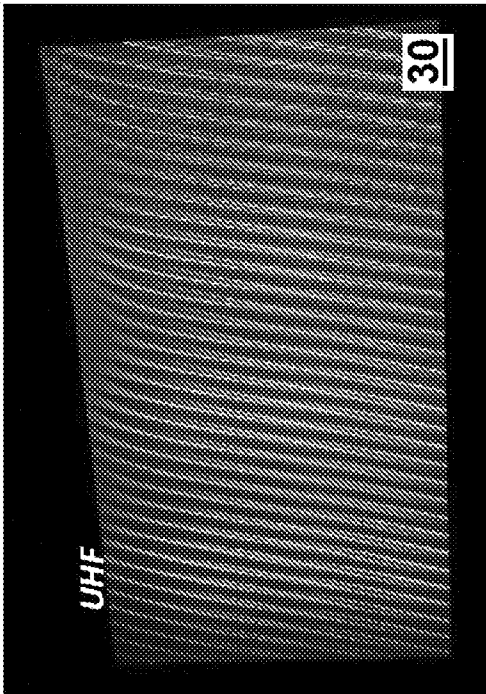


FIG. 15C

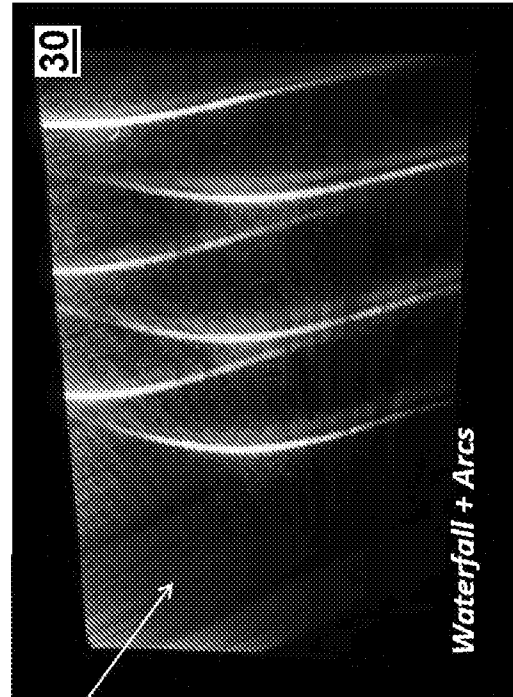


FIG. 16A

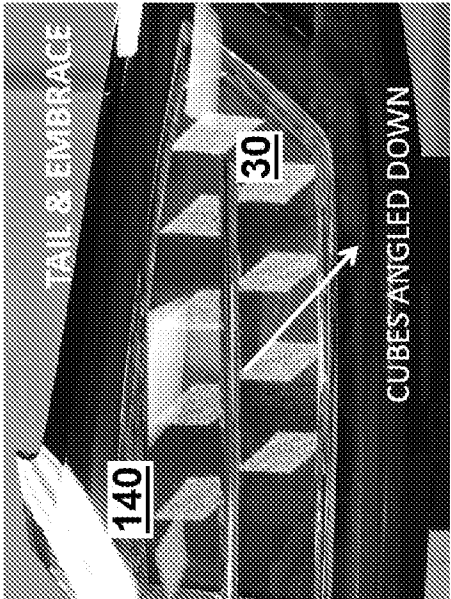


FIG. 17A

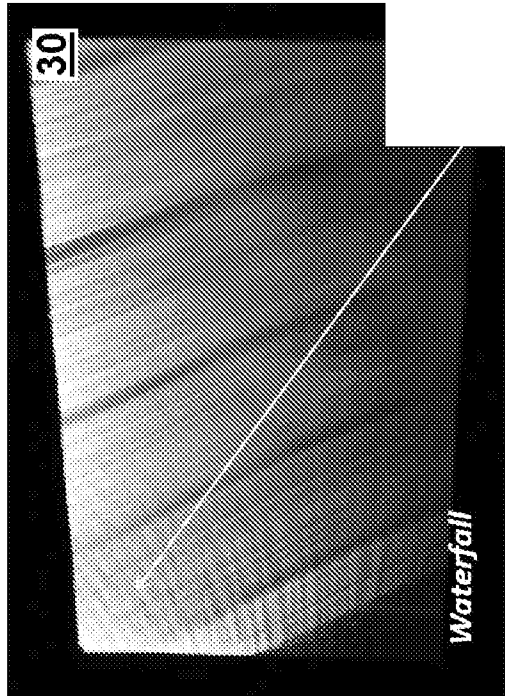


FIG. 16B

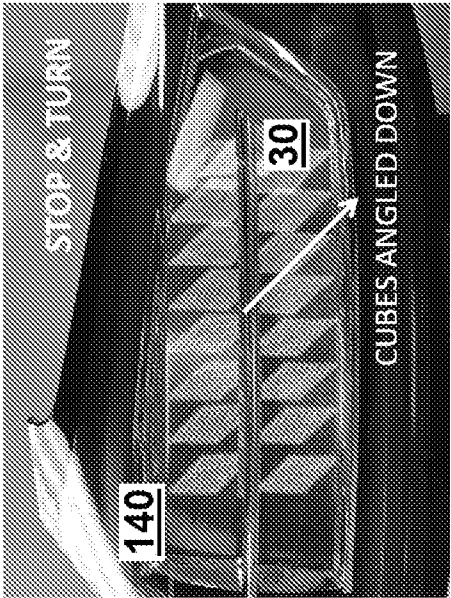


FIG. 17B

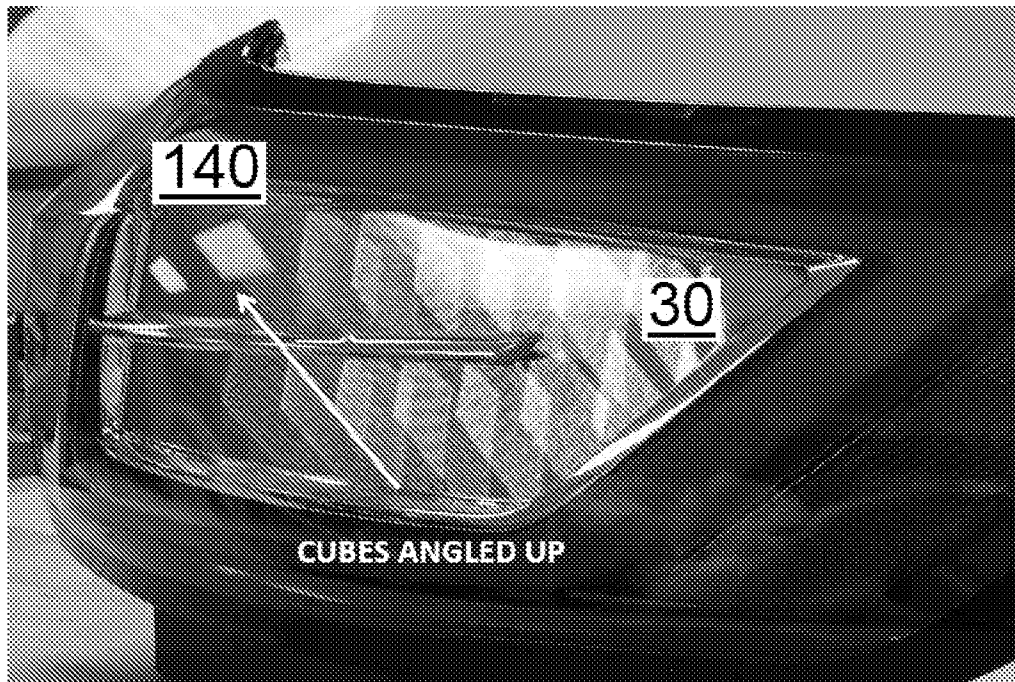


FIG. 18

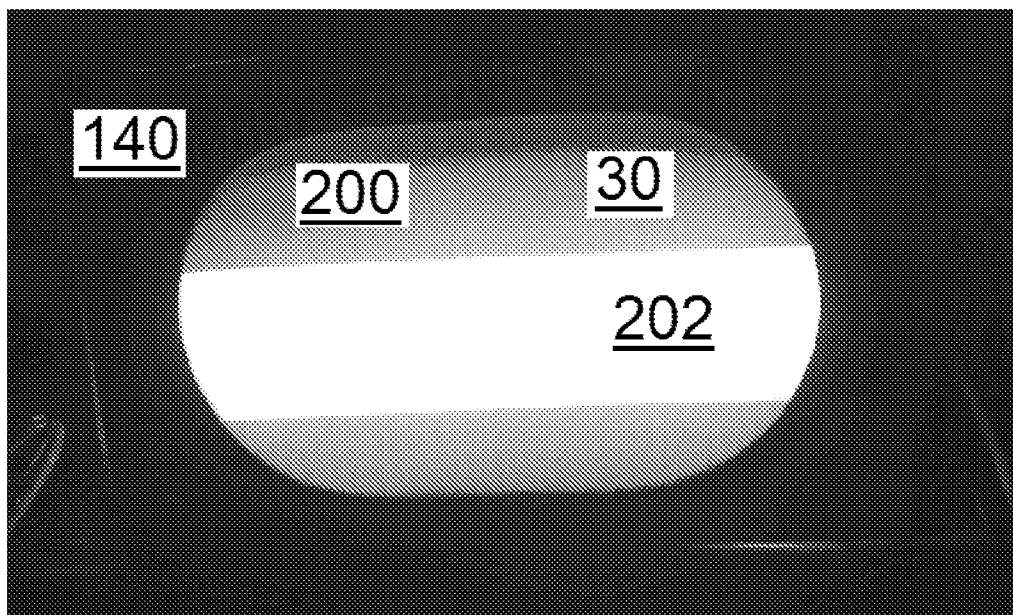


FIG. 19

INTERNATIONAL SEARCH REPORT

International application No.

PCT/US2016/033665

A. CLASSIFICATION OF SUBJECT MATTER

IPC(8) - G02B 27/22; G03B 21/00; G03B 21/14; G03B 21/20 (2016.01)

CPC - G02B 27/22; G03B 21/00; G03B 21/14; G03B 21/20 (2016.05)

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)

IPC - G02B 27/22; G03B 21/00; G03B 21/14; G03B 21/20

CPC - G02B 27/22; G03B 21/00; G03B 21/14; G03B 21/20

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

USPC - 353/7; 353/30; 353/31; 353/32 (keyword delimited)

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

Orbit, Google Patents, Google

Search terms used: lamp light pipe lenticular lens 3D three dimensional projection projector

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 8,870,380 B2 (HUANG) 28 October 2014 (28.10.2014) entire document	1, 2, 9, 10, 13
---		---
Y		3-8, 11, 12, 14-25
Y	US 2005/0007664 A1 (HARRIS et al) 13 January 2005 (13.01.2005) entire document	3, 4, 21
Y	Johnson et al. Advances in Lenticular Lens Arrays for Visual Display. SPIE. August 2005. [Retrieved 22 July 2016]. Retrieved from internet: <URL: https://www.researchgate.net/publication/237674438_Advances_in_lenticular_lens_arrays_for_visual_display_Invited_Paper > pages 1-12	5, 22
Y	US 2007/0081131 A1 (VAN DER PALEN et al) 12 April 2007 (12.04.2007) entire document	6, 7
Y	US 8,632,189 B2 (READ et al) 21 January 2014 (21.01.2014) entire document	8
Y	US 6,481,849 B2 (MARTIN et al) 19 November 2002 (19.11.2002) entire document	11, 12, 17, 19-26
Y	US 5,070,432 A (KITAZUMI et al) 03 December 1991 (03.12.1991) entire document	14-16, 18, 25, 26
A	US 2,550,350 A (WEST HENSON) 24 April 1951 (24.04.1951) entire document	5, 22

☐ Further documents are listed in the continuation of Box C.☐ 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

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