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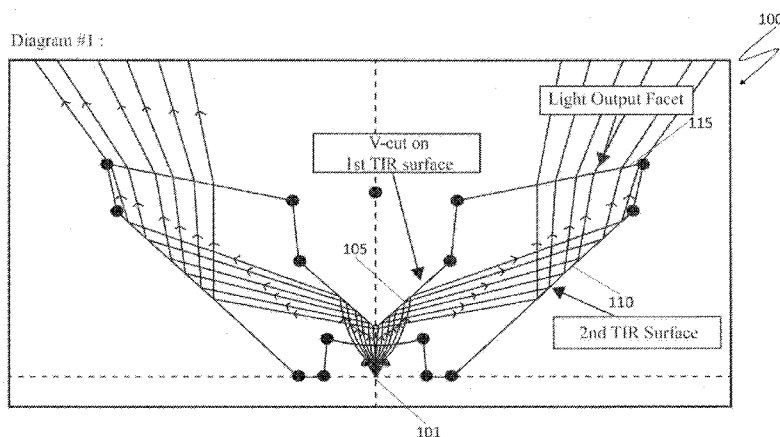


FIG. 1

(57) Abstract: A lighting device for reducing glare from light emitting diodes (LED) includes at least one LED light source including an optical axis, a housing encompassing the LED light source for capturing light emitted from the LED light source during operation of the lighting device, a first surface positioned within said housing in front of the LED light source for receiving light from the LED based lighting device, and a second surface positioned within the housing lateral to the first surface for receiving light from the first surface, and an output surface for receiving light from said second surface. Particularly, the LED light source operates without any reflective coating.

Lighting Devices to Reduce Glare From Light Emitting Diodes (LEDs)

BACKGROUND OF THE INVENTION

5 Field of the Invention

Embodiments of the present invention relate to optical device technologies, and more particularly, to lighting devices which reduce glare from light emitting diodes (LEDs).

10 Description of the Related Art

Traditionally, incandescent bulbs have been considered as a high quality light source generating a light with a spectrum close to the spectrum of black body radiator. Although, the incandescent bulbs have good colour rendering properties they use a considerable amount of energy when compared to the generated visible light. This results in a corresponding large outlet of carbon dioxide.

To overcome the disadvantages of incandescent bulbs compact fluorescent light bulbs have been proposed as an alternative in recent past. However, the spectrum of the light generated by compact fluorescent light bulbs differs significantly from that of black body radiators and incandescent bulbs. Consequently the colour rendering properties of the light is low. Therefore, light-

emitting diode technology has been developed to replace the common light bulbs and the compact fluorescent light bulbs.

Moreover, light based devices using the technology of light emitting diodes (LED) have the potential to generate high quality light having a spectrum
5 close to that of black body radiators, while using only a small amount of energy as compared to the generated visible light. LED-based devices and systems can be designed with a view to produce light with one or more desired spectral properties, depending on the proposed application of the technology. Another advantage of LED based devices are that they produce a very limited amount of
10 heat radiation. Consequently, LED based devices can be utilized in places where the subject to be illuminated is heat sensitive, such as special grocery based products or any kind of specimen which is to be preserved.

Therefore, LED based devices and apparatuses are environmentally friendly and have a big potential in energy saving and long operation life in
15 comparison with traditional lighting devices available in the past. One of the performance criteria for LED illumination apparatuses is light output uniformity. For example, it is desired that the light output for an LED illumination apparatus maintain relatively uniform colour and brightness throughout different areas of the LED illumination apparatus. However, most of the existing LED light based
20 devices and apparatuses suffer from one or more shortcomings of poor light output uniformity.

Generally, in a conventional LED illumination apparatus a number of discrete LED devices are used which may lead to relatively small Lambertian source which is commonly known as light output hot spots with high intensity at the centre. This means that available LED illumination apparatuses may produce a light output that is not uniform but includes a plurality of intensely lit regions surrounded by dimmer regions, which may cause discomfort for e.g., glare for a human eye. Moreover, the LED hot spot or direct glare could cause visual discomfort or more severe case of temporary blindness if the person is exposed to high brightness lumination. Furthermore, presently available methods of addressing these issues may lead to expensive fabrication costs. In many cases the fabrication time period to manufacture these types of LEDs based devices and apparatuses are time consuming to the manufacturer.

Therefore, while conventional LED illumination apparatuses and devices have been generally adequate for their intended purposes, they have not been entirely satisfactory in every aspect.

Accordingly, there exists a need in the art for devices and apparatuses for providing an LED illumination apparatus that is free of hot spots and that distributes light in more uniform fashion across all directions and addresses the limitations of the prior art.

SUMMARY OF THE INVENTION

Embodiments of the present disclosure, generally, disclose a lighting device for reducing glare from light emitting diodes (LED). Particularly, the lighting device includes at least one LED light source, which includes an optical axis, a housing encompassing the LED light source for capturing light emitted from the LED light source during operation of the lighting device, a first total internal reflection (TIR) surface is positioned within the housing in front of the LED light source for receiving light from the LED lighting source, and a second TIR surface is positioned within the housing lateral to the first TIR surface for receiving light from the TIR first surface. Specifically, in the present invention the LED light source operates without any reflective coating.

In accordance with an embodiment of the present invention, the present invention provides an optical device which is designed to reflect, redirect and expand light beam in the same embodiment without any reflective coating. Particularly, the present invention utilizes a total internal reflection (TIR) structure to control light direction.

In accordance with an embodiment of the present invention, the lighting device is designed to control a single LED which can be multiplied in any number and joined together into a cluster.

In accordance with an embodiment of the present invention, the present invention provides a lighting device with indirect illumination. Specifically, this embodiment provides a larger emission area and subsequently reduce glare. Further, the first total internal reflection (TIR) surface shields the direct glare.

5 In accordance with another embodiment of the present invention, the first total internal reflection (TIR) surface and the second total internal reflection (TIR) surface creates longer travelled path. Consequently, this creates beam expansion or larger emission area therefore reduces luminance (Intensity/emission area) which further reduces the glare.

10 In accordance with another embodiment of the present invention, the Non-air gap embodiment eliminates Fresnel loss and hence provides better light output. Moreover, the first total internal reflection (TIR) surface and the second total internal reflection (TIR) surface create high light output efficiency.

In accordance with one embodiment of the present invention, at least
15 one contour or a plurality of combination of contours of the first surface is selected based on a total internal reflection (TIR) condition where a critical angle exceeds a plurality of incoming rays on an interface of higher refractive index material to low refractive index material.

In accordance with one embodiment of the present invention, at least
20 one contour or a plurality of combination of contours of the first surface is selected from a group comprising a spherical profile or a non-spherical profile

and wherein said non-spherical profile is selected from a group comprising a parabolic, a hyperbolic, and an ellipsoid contour.

In accordance with one embodiment of the present invention, at least one contour or a plurality of combination of contours of said second surface is
5 selected from a spherical profile and a non-spherical profile and wherein said at least one contour or said plurality of combination of contours are selected based on a total internal reflection (TIR) condition.

BRIEF DESCRIPTION OF THE DRAWINGS

10 So that the manner in which the above recited features of the present invention can be understood in detail, a more particular description of the invention, briefly summarized above, may be had by reference to embodiments, some of which are illustrated in the appended drawings. It is to be noted, however, that the appended drawings illustrate only typical embodiments of this
15 invention and are therefore not to be considered limiting of its scope, for the invention may admit to other equally effective embodiments.

Fig. 1 illustrates a diagram of principle of operation of the lighting device, in accordance with one embodiment of the present invention;

Fig. 2A illustrates a pictorial representation of the spherical profile, and
20 non-spherical profile contour of a first surface of a total internal reflection (TIR), in accordance with one embodiment of the present invention;

Fig. 2B illustrates a pictorial representation of the spherical, and non-spherical profile of a second surface of the total internal reflection (TIR), in accordance with one embodiment of the present invention;

Fig. 3 illustrates a pictorial representation of the second surface of different surface curvature of the total internal reflection (TIR), in accordance with one embodiment of the present invention;

Fig. 4 illustrates a pictorial representation of a light control governed by the total internal reflection (TIR), in accordance with one embodiment of the present invention;

Fig. 5 illustrates a pictorial representation of a light diffusing structure including organized micro structure elements, in accordance with one embodiment of the present invention;

Fig. 6A illustrates an exploded view of a square output facet of the light output surface, in accordance with one embodiment of the present invention;

Fig. 6B illustrates a perspective view of a light output surface, in accordance with one embodiment of the present invention;

Fig. 7 illustrates a pictorial representation of the lighting device with a design to control over an array of LEDs, in accordance with one embodiment of the present invention;

Fig. 8 illustrates a top view pictorial representation of the lighting device joined into a cluster, in accordance with one embodiment of the present invention;

Fig. 9 illustrates a pictorial representation of the lighting device wherein there is no air gap between LED and lens, in accordance with another embodiment of the present invention;

Fig. 10 A illustrates a pictorial representation of the side view of common
5 lens for multiple LEDs in array or cluster formation in an air gap solution, in accordance with yet another embodiment of the present invention;

Fig. 10 B illustrates a pictorial representation of the perspective view of common lens for multiple LEDs in array or cluster formation in an air gap solution, in accordance with yet another embodiment of the present invention;

10 Fig. 11 A illustrates a pictorial representation of the front view of the multiple TIR lens blend into common lens for multiple LEDs in array or cluster formation, in accordance with yet another embodiment of the present invention;

Fig. 11 B illustrates a pictorial representation of the prospective view of the multiple TIR lens blend into common lens for multiple LEDs in array or
15 cluster formation, in accordance with yet another embodiment of the present invention; and

Fig. 12 illustrates a pictorial representation of the side view of common lens for multiple LEDs in array or cluster formation in a non-air gap solution, in accordance with yet another embodiment of the present invention;

20 While the present lighting devices have been described herein by way of example for several embodiments and illustrative drawings, those skilled in the art will recognize that the present lighting device is not limited to the

embodiments or drawings described. It should be understood, that the drawings and detailed description thereto are not intended to limit embodiments to the particular form disclosed. Rather, the intention is to cover all modifications, equivalents and alternatives falling within the spirit and scope of the invention as defined by the appended claims. Any headings used herein are for organizational purposes only and are not meant to limit the scope of the description or the claims. As used herein, the word "can" and "may" is used in a permissive sense (i.e., meaning having the potential to), rather than the mandatory sense (i.e., meaning must). Similarly, the words "include", "including", and "includes" mean including, but not limited to.

DETAILED DESCRIPTION

Various embodiments of the present invention relates to lighting devices for reducing glare from the light emitting diodes (LEDs). Moreover, the present invention provides the lighting device that has been designed to reflect, to redirect and to expand light beam in the same embodiment without any reflective coating. Particularly, to control light direction the present lighting devices are utilizing total internal reflection (TIR) structure to control the light direction from the light emitting diode (LED). Furthermore, the present lighting device provides the advantage of shaping the light source and thereby controlling the glare in the same embodiment.

In the following detailed description, numerous specific details are set forth to provide a thorough understanding of claimed subject matter. However, it will be understood by those skilled in the art that claimed subject matter may be practiced without these specific details. In other instances, methods, apparatuses or systems that would be known by one of ordinary skill have not been described in detail so as not to obscure claimed subject matter.

Fig.1 illustrates a diagram of principle of operation of the lighting device, in accordance with one embodiment of the present invention. The present optical device 100 utilizes a Total Internal Reflection (TIR) structure to shield away LED hotspot or direct glare generated by the optical device 100. Specifically, the Total internal reflection (TIR) is a phenomenon that happens when a propagating light strikes a medium boundary at an angle larger than a particular critical angle with respect to the normal to the surface. Moreover, the Total internal reflection (TIR) can only occur when light in a medium with a higher refractive index hits the surface that is in contact with a medium of lower refractive index. For example, the critical angle for polycarbonate with refractive index of 1.585 to air is 39 degree.

Particularly, the Total Internal Reflection (TIR) structure is positioned on top of the LED 101, to redirect the light beam which eventually expands the light beam. Consequently, the light beam then radiates as a larger emission area by means of diffuse or specular surface through the process of reflection or transmission mode. In use, the expansion of emission area lowers the

luminance value as stated in formula 1 below which will directly reduce the glare as stated in formula 2 to the human eyes.

Formula 1: Luminance (nits) = Intensity of light source (cd) / Emission area (m²)

5 Formula #2:
$$\text{Glare} = \sum_{k=1}^n \frac{L_s^{\text{exp}} * w}{L_b^{\text{exp}} p^{\text{exp}}}$$

Where,

Ls = Luminance of light source

Lb = Luminance of background

10 p = position index, p = 1 when glare source is perfectly centered in your vision.

exp = weighting exponent applied to each variable

w = solid angle perceived from glare source

Particularly, as illustrated in FIG. 1 the light is coming out from the center of LED is blocked by the Total Internal Reflection (TIR) structure. In one embodiment, the contour of the Total Internal Reflection (TIR) structure is a radially V-cut which is mounted on top of the LED. Particularly, in FIG. 1 the V-cut is on the first Total Internal Reflection (TIR) surface 105. Further, as the light reflected from a first Total Internal Reflection (TIR) surface 105 is subsequently reflected again on a second Total Internal Reflection (TIR) surface 110 towards the light output facet 115 as illustrated in FIG. 1, in accordance with an embodiment of the present invention. Moreover, the beam expansion takes

place when light hits on the second Total Internal Reflection (TIR) surface 110. This phenomena takes place because the path of the light travelled is longer.

In one embodiment, the contour of the optical piece of the present invention can be of a different shape other than "V" contour of the optical piece
5 and is not limited to "V" contour. Specifically, any other contour of the optical piece can be utilized for the present invention as long as the particular contour of the optical piece is able to meet the Total Internal Reflection (TIR) condition. Moreover, the condition implies that the critical angle exceeds for the incoming rays on the interface of higher refractive index material to low refractive index
10 material for e.g. Polycarbonate to air.

Fig. 2A illustrates a pictorial representation 200 of the spherical profile, and non-spherical profile contour of the first surface 105 of the total internal reflection, in accordance with another embodiment of the present invention. Particularly, one or more contours of the optical lighting device 100 that meet
15 the Total Internal Reflection (TIR) condition includes spherical profile and non-spherical profile such as parabolic, hyperbolic, and ellipsoid provided that it meets the Total Internal Reflection (TIR) condition which relates to lens material and in-coming angle rays.

In another embodiment, the Total Internal Reflection (TIR) within the
20 same optical embodiment eliminates the light loss from one media to another which is also known as Fresnel loss.

In yet another embodiment, the light diffusing or light manipulating structure can be built upon the Total Internal Reflection (TIR) surfaces or light emission surfaces to enhance the control of beam shaping and visual impression. Moreover, the surface of the Total Internal Reflection (TIR) can be
5 divided into segmented profile with each of the profile directing and controlling the light rays in certain direction to achieve desired light pattern and beam angle.

In yet another embodiment, the light diffusing structure can be built upon the Total Internal Reflection (TIR) surfaces. Specifically, the light diffusing is
10 more of averaging or scattering light into random direction so that smearing effect is there to provide uniform appearance. Moreover, the light diffusing structure can consist of organized micro structure elements or randomized surface texturing, which provides light smearing effects.

In yet another embodiment, the surface finish of the light diffusing
15 structure can be of a glossy finish or a non-glossy finish.

Fig. 2B illustrates a pictorial representation250 of the spherical, and non-spherical profile of a second surface 110 of the total internal reflection (TIR), in accordance with one embodiment of the present invention. The second surface 110 of the total internal reflection (TIR) is able to reflect and manipulate light
20 into a desired direction and pattern. Particularly, the second surface 110 of the total internal reflection (TIR) in the same embodiment is used to collect the side light from the LED to the output facets 115. Consequently, the second surface

110 enhances the light output by directing light in a same medium in a controlled manner instead of side light being bounced around and lost.

Fig.3 illustrates a pictorial representation 300 of the second surface 110 of different surface curvature of the total internal reflection (TIR), in accordance with one embodiment of the present invention. Particularly, the structure of different surface curvature or gradient alters the light output direction. Specifically, the beam shaping or the light control is governed by the total internal reflection (TIR) surface and it's curvature as illustrated in the Fig.3.

Fig. 4 illustrates a pictorial representation 400 of a light control governed by the total internal reflection (TIR), and Fig. 5 illustrates a pictorial representation of a light diffusing structure 500 including organized micro structure elements, in accordance with one embodiment of the present invention. Particularly, several of the pattern light diffusing or light manipulating structure in macro or micro level can be mounted upon the total internal reflection (TIR) surfaces or light output surfaces to enhance the control of the beam shape and the brightness appearance.

In accordance with one embodiment of the present invention, the macro level of the light manipulating structure is selected from a group including a spherical surface, non-spherical surface, prismatic, wedge, triangular surfaces, fresnel, and segmented surface. Particularly, the non-spherical surface includes parabolic, hyperbolic, and ellipse surface.

In accordance with one embodiment of the present invention, the micro level of the light manipulating structure is selected from a group including etching texturing, sand-blasting texturing and diffractive surfaces.

Fig. 6A illustrates an exploded view of a square output facet of the light
5 output surface, and Fig. 6B illustrates a perspective view of the light output surface, in accordance with one embodiment of the present invention. The facet contour is selected from a group of round, square, rectangular or other polygon format.

Fig. 7 illustrates a pictorial representation 700 of the lighting device with
10 a design to control over an array of LEDs, and Fig. 8 illustrates a pictorial representation 850 of the lighting device joined into a cluster in accordance with one embodiment of the present invention. Particularly, the lighting device 100 has a design to control over a single LED and that can be multiplied in any number and joined into a cluster as illustrated in Fig. 8. Fig. 7 further illustrates
15 a sectional view A-A 700 of the lighting device 100.

Fig. 9 illustrates a pictorial representation of the lighting device 900, wherein there is no air gap between LED and lens, in accordance with another embodiment of the present invention. In accordance with an embodiment of the present invention, the present invention provides the lighting device 900 with
20 indirect illumination. Specifically, this embodiment provides a larger emission area and subsequently reduce glare. Further, the first total internal reflection (TIR) surface 105 shields the direct glare.

In accordance with another embodiment of the present invention, the first total internal reflection (TIR) surface 105 and the second total internal reflection (TIR) surface 110 creates longer travelled path. Consequently, this creates beam expansion or larger emission area therefore reduces luminance
5 (Intensity/emission area) which further reduces the glare.

The main purpose of the present device is that there is no glare and therefore no hot spot. The users utilizing the device will not be able to see the light source directly which provides the glare. The beam from the light source is reflected off the two surfaces which includes the first Total Internal Reflection
10 (TIR) surface 105 and the second Total Internal Reflection (TIR) surface 110 before going out. This process is called indirect illumination. Since, the first TIR surface 105 and the second TIR surface 110 are the Total Internal Reflection surfaces there is no light loss during reflection. Therefore the present design is very efficient.

15 In one embodiment, the beam gets reflected from the surface 105 to the surface 110, and subsequently the beam expands. Similarly when the beam gets reflected from the surface 110 and goes out, the beam further expands. Moreover, when the beam expands it reduces luminance that is intensity per emission area which further reduces the glare.

20 In accordance with another embodiment of the present invention, the Non-air gap embodiment eliminates Fresnel loss and hence provides better light output. Moreover, the first total internal reflection (TIR) surface 105 and the

second total internal reflection (TIR) surface 110 create high light output efficiency.

Fig. 10 A illustrates a pictorial representation of the side view of common lens for multiple LEDs in array or cluster formation in an air gap solution, and

5 Fig. 10 B illustrates a pictorial representation of the perspective view of common lens for multiple LEDs in array or cluster formation in an air gap solution, in accordance with yet another embodiment of the present invention.

Fig. 11 A illustrates a pictorial representation of the front view of the multiple TIR lens blend into common lens for multiple LEDs in array or cluster
10 formation, and Fig. 11B illustrates a pictorial representation of the perspective view of the multiple TIR lens blend into common lens for multiple LEDs in array or cluster formation, in accordance with yet another embodiment of the present invention. Fig. 12 illustrates a pictorial representation of the side view of the common lens for multiple LEDs in array or cluster formation in a non-air gap
15 solution, in accordance with yet another embodiment of the present invention.

Those of ordinary skill in the art will appreciate that one or more arrangements are possible in the present invention and not limited to the arrangement as described hereinabove.

Therefore, the present invention provides lighting devices in which the
20 contour of the light rays and glare is controlled simultaneously. The present invention provides the lighting device with a design to control over a single LED which can be multiplied in any number. Moreover, it can be joined into a cluster.

The lighting device can be utilized for many purposes for example the lighting device can be extended to cover an area for decorative illumination purpose.

Further, the present lighting device can act as a light emission window or an external cover. It is economical to manufacture because the design is simple
5 and subsequently it eliminates the cost of reflective coating. Particularly, the contouring of light rays and glare control is handled in the same embodiment. Moreover, in one or more embodiments light diffusing or light manipulating structures could be built upon the total internal reflection (TIR) surfaces or light emission surfaces to enhance the control of beam shaping and visual
10 impression.

Accordingly, while there has been shown and described the preferred embodiment of the invention is to be appreciated that the invention may be embodied otherwise than is herein specifically shown and described and, within said embodiment, certain changes may be made in the form and arrangement
15 of the parts without departing from the underlying ideas or principles of this invention within the scope of the claims appended herewith.

CLAIMS

1. A lighting device for reducing glare from light emitting diodes (LED), said lighting device comprising:
- 5 at least one LED light source comprising an optical axis;
- a housing encompassing said LED light source for capturing light emitted from said LED light source during operation of said lighting device;
- a first surface positioned within said housing in front of said LED light source for receiving a light beam from said LED lighting source; and
- 10 a second surface positioned within said housing for receiving said light beam from said first surface;
- an output surface for receiving light beam from said second surface;
- wherein said first surface redirects said light beam received from said at least one LED light source.
- 15
2. The LED based lighting device as claimed in claim 1, wherein said first surface is a total internal reflection (TIR) surface.
3. The LED based lighting device as claimed in claim 1, wherein said
- 20 second surface is a total internal reflection (TIR) surface.

4. The LED based lighting device as claimed in claim 1, wherein a contour of said first surface comprises a structure of radially V-cut shape.

5. The LED based lighting device as claimed in claim 1, wherein at least one
5 contour or a plurality of combination of contours of said first surface is selected based on a total internal reflection (TIR) condition where a critical angle exceeds a plurality of incoming rays on an interface of higher refractive index material to low refractive index material.

10 6. The LED based lighting device as claimed in claim 5, wherein at least one contour or a plurality of combination of contours of said first surface is selected from a group comprising a spherical profile or a non-spherical profile and wherein said non-spherical profile is selected from a group comprising a parabolic, a hyperbolic, and an ellipsoid contour.

15

7. The LED based lighting device as claimed in claim 1, wherein at least one contour or a plurality of combination of contours of said second surface is selected from a spherical profile and a non-spherical profile and wherein said at least one contour or said plurality of combination of contours are selected
20 based on a total internal reflection (TIR) condition.

8. The LED based lighting device as claimed in claim 1, wherein said LED light source operates without any reflective coating.

9. The LED based lighting device as claimed in claim 1, wherein a light
5 manipulating structure in macro level or micro level is mounted upon said total internal reflection (TIR) surfaces to enhance a control of a beam shape and brightness appearance.

10. The LED based lighting device as claimed in claim 9, wherein said macro
10 level of said light manipulating structure is selected from a group comprising a spherical surface, non-spherical surface, prismatic, wedge, triangular surfaces, fresnel, and segmented surface.

11. The LED based lighting device as claimed in claim 10, wherein said non-
15 spherical surface is selected from a group comprising a parabolic surface, a hyperbolic surface, and an ellipse surface.

12. The LED based lighting device as claimed in claim 10, wherein said
micro level of said light manipulating structure is selected from a group
20 comprising an etching texturing, a sand-blasting texturing and diffractive surfaces.

13. The LED based lighting device as claimed in claim 1, wherein a contour of an output facet of said light output surface is selected from a group of round, square, rectangular or other polygon format.

5 14. The LED based lighting device as claimed in claim 13, wherein a light manipulating structure in a macro level or a micro level is mounted upon said output surfaces to enhance a control of a beam shape and brightness appearance.

10 15. The LED based lighting device as claimed in claim 14, wherein said micro level of said light manipulating structure is selected from a group comprising an etching texturing, a sand-blasting texturing and diffractive surfaces.

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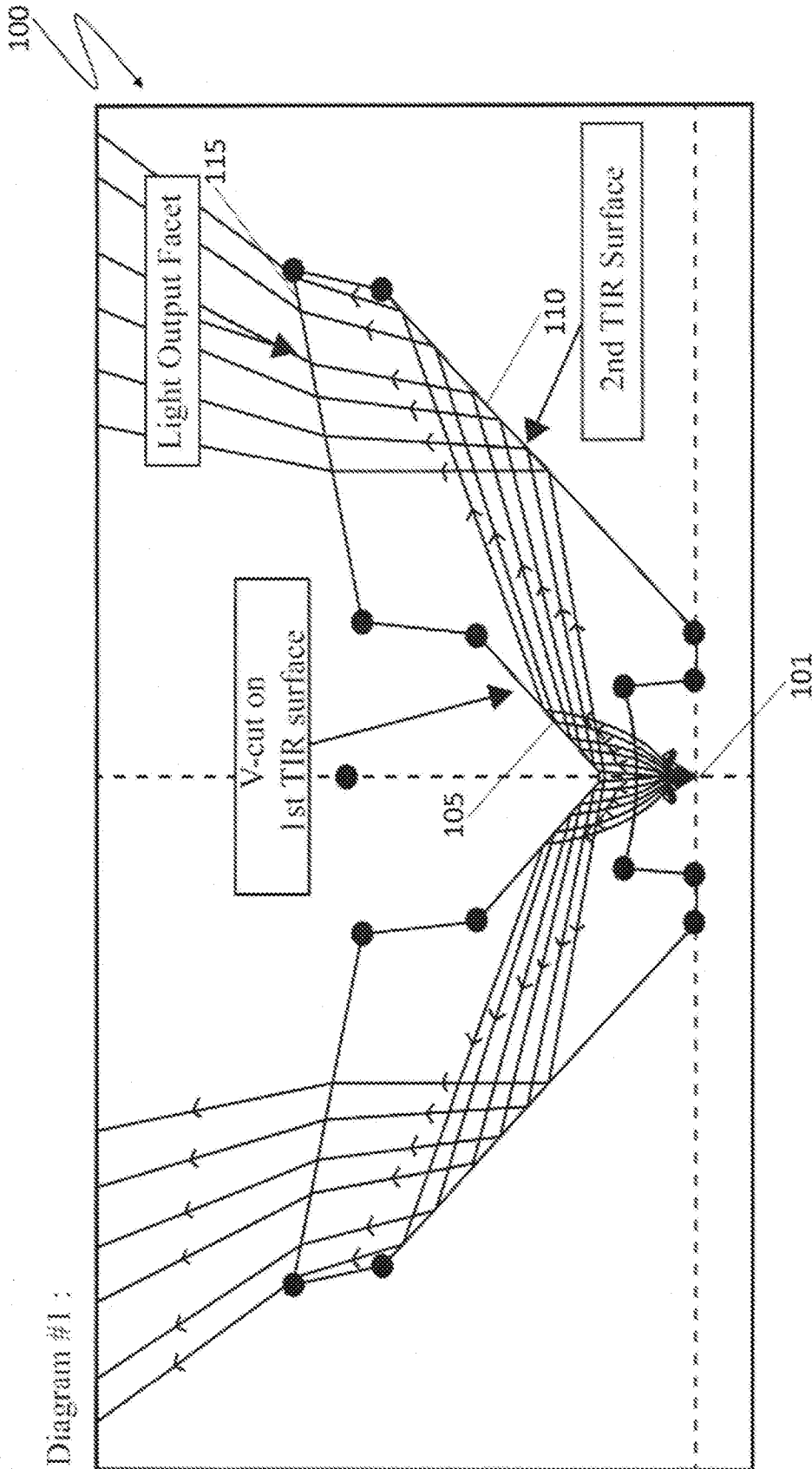


FIG. 1

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200

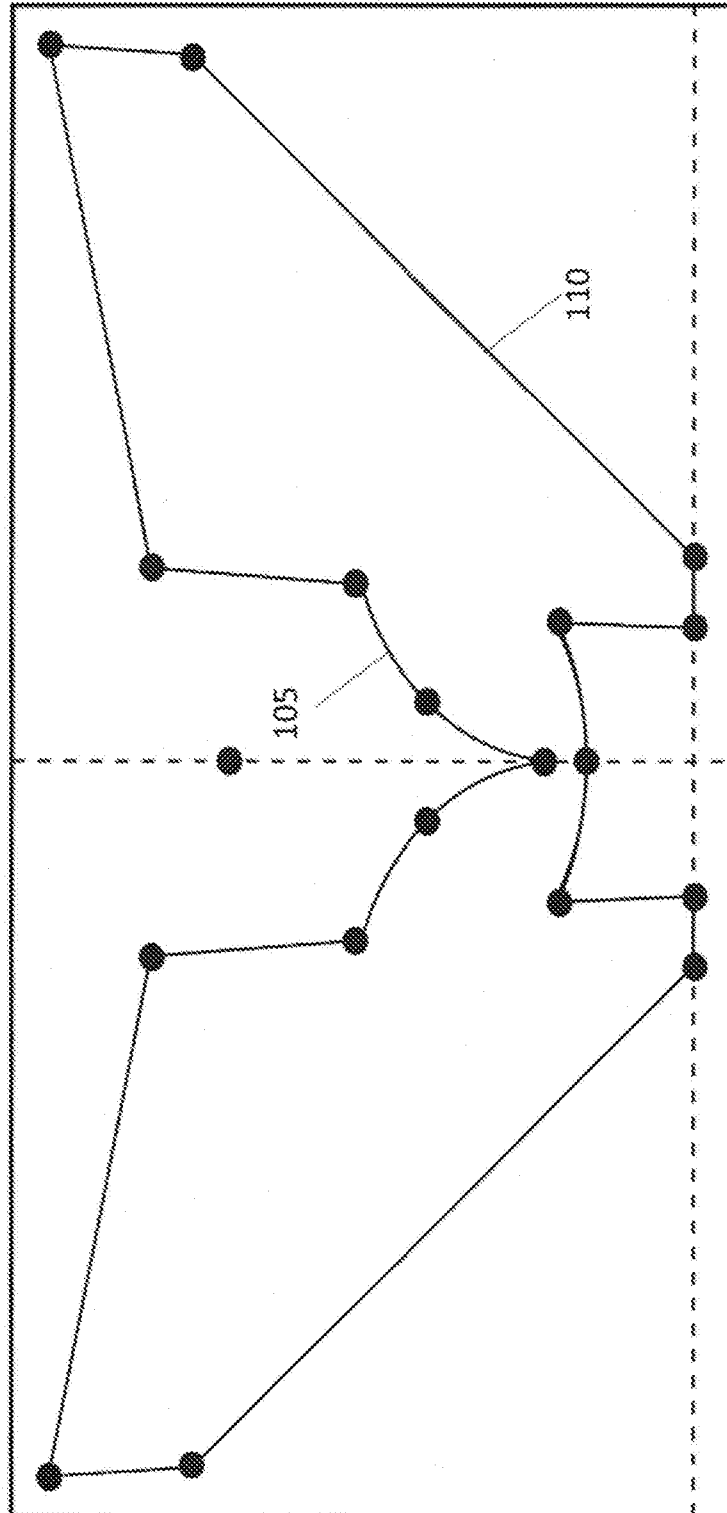


FIG. 2A

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250

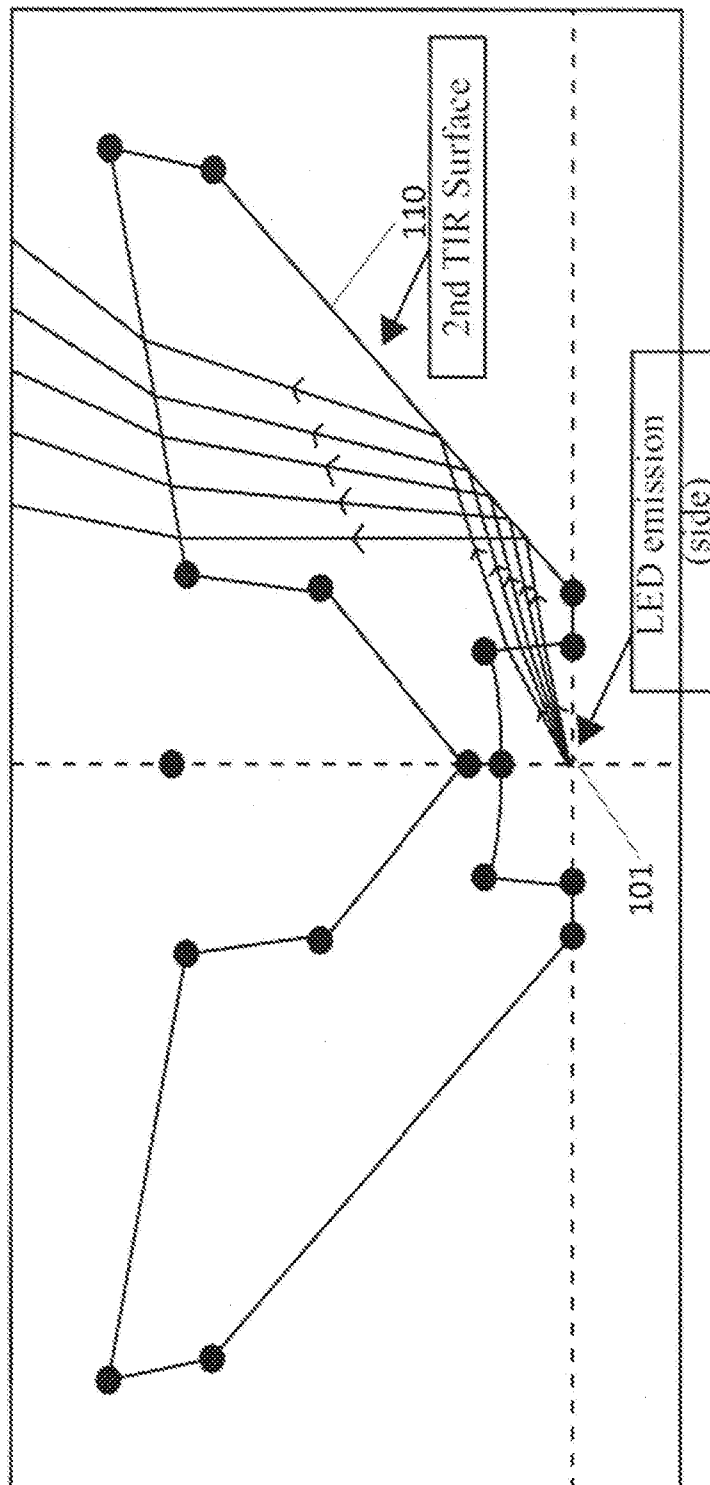
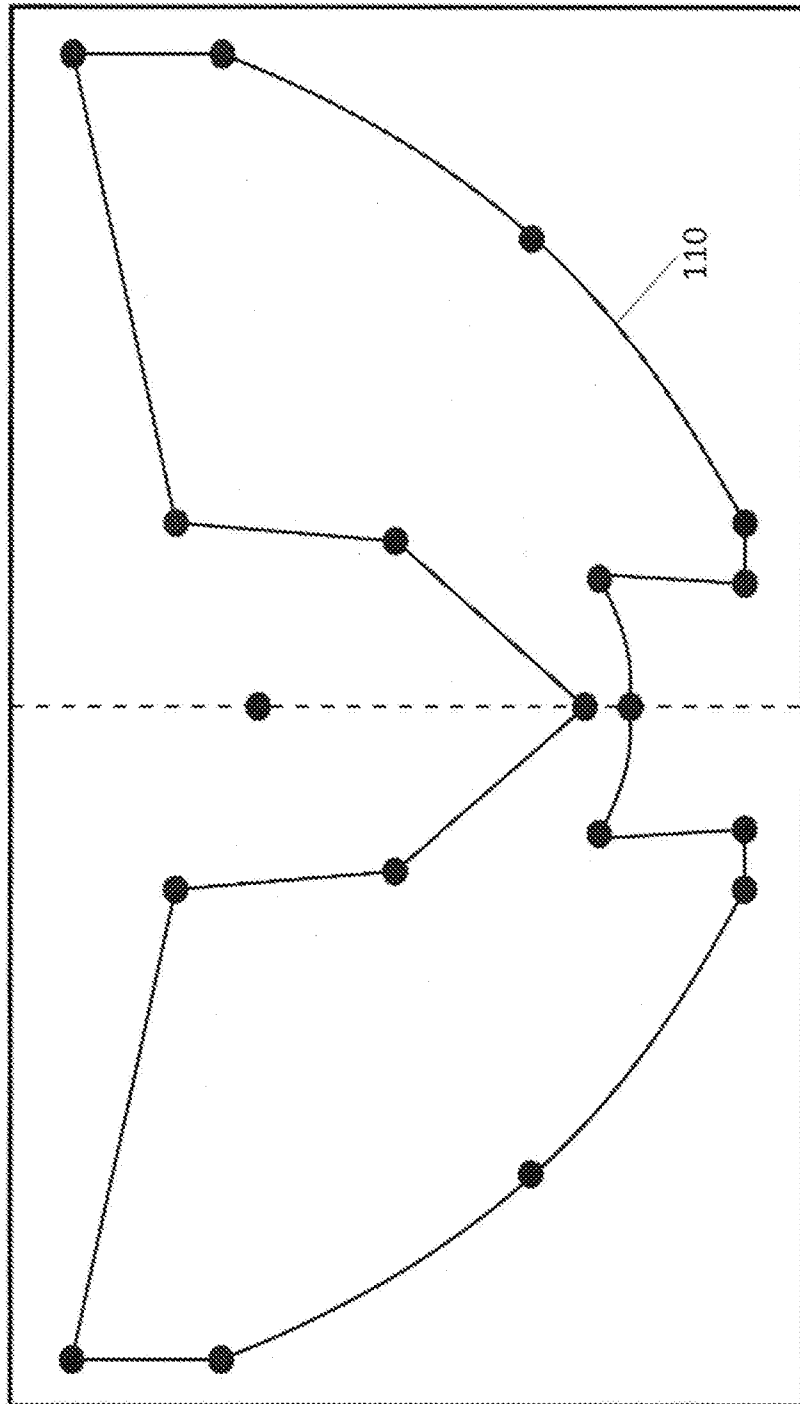


FIG. 2B

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300



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400

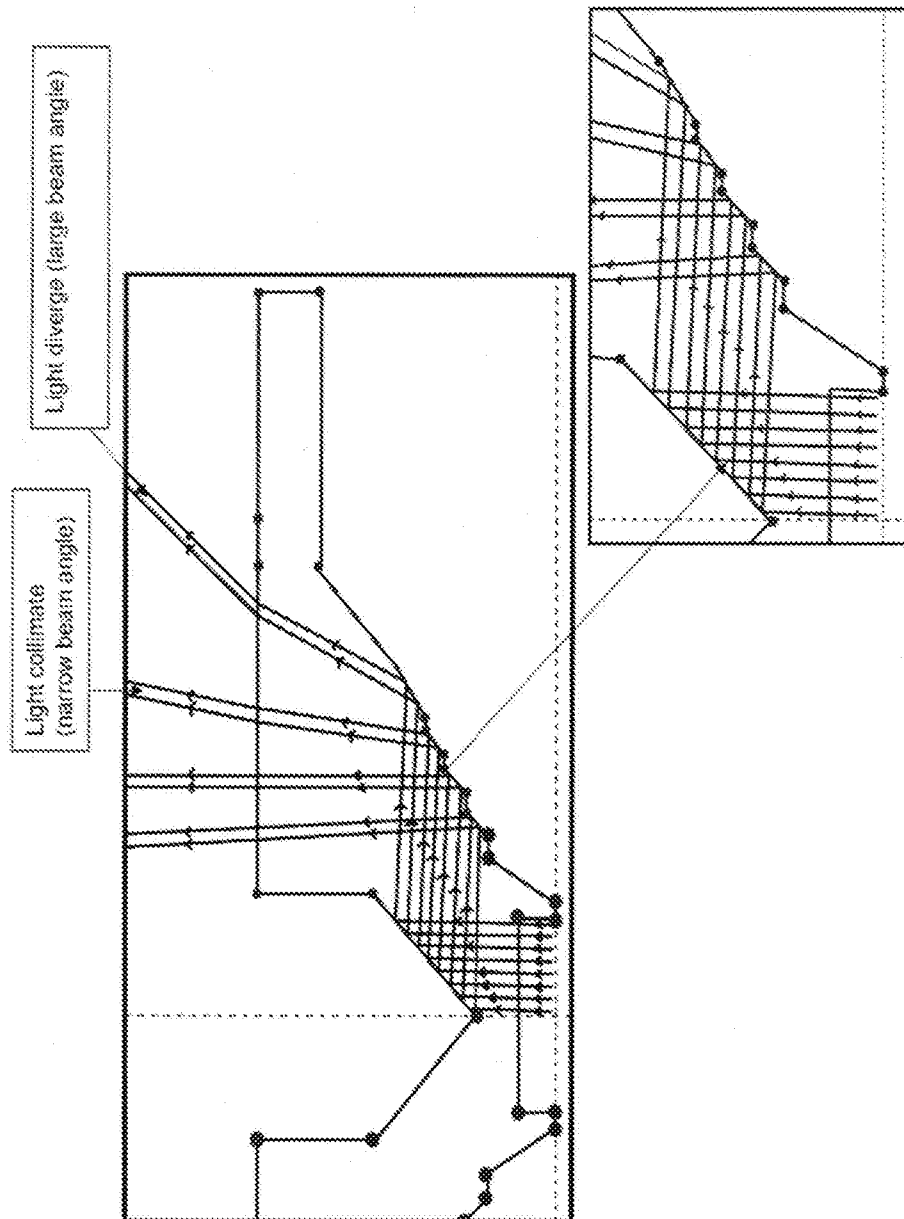



FIG. 4

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500

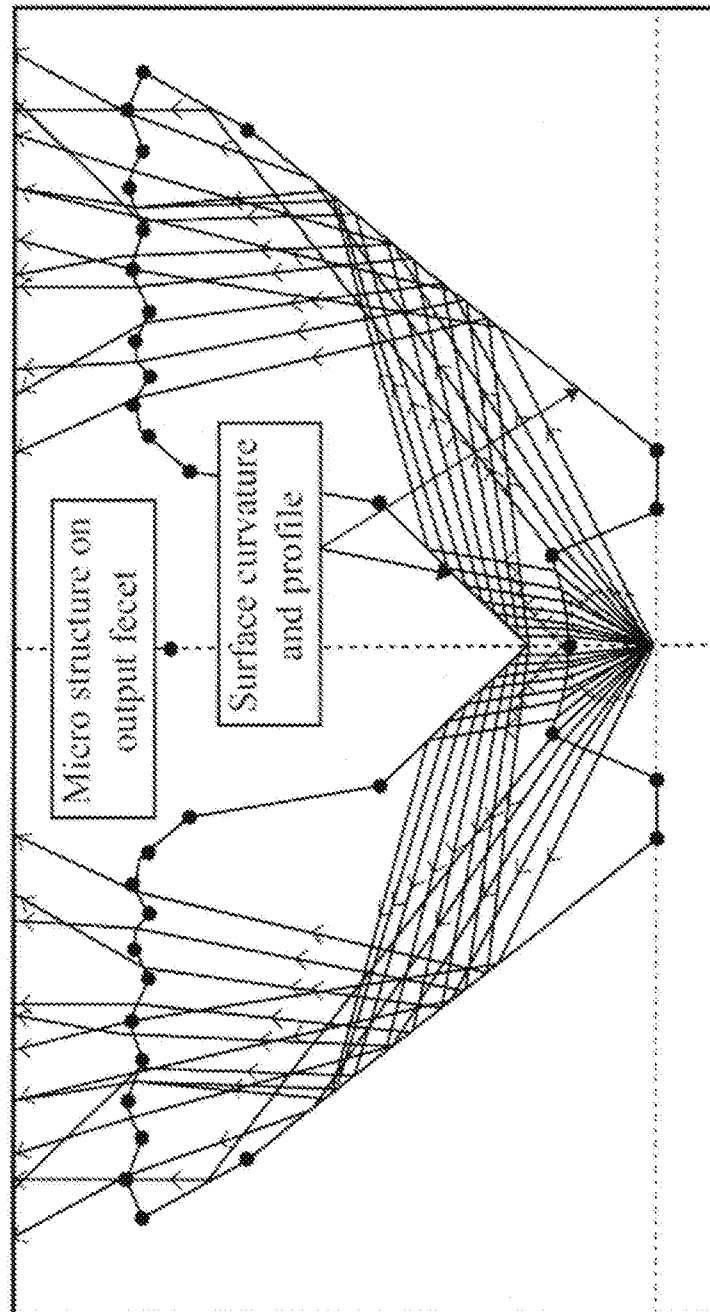


FIG. 5

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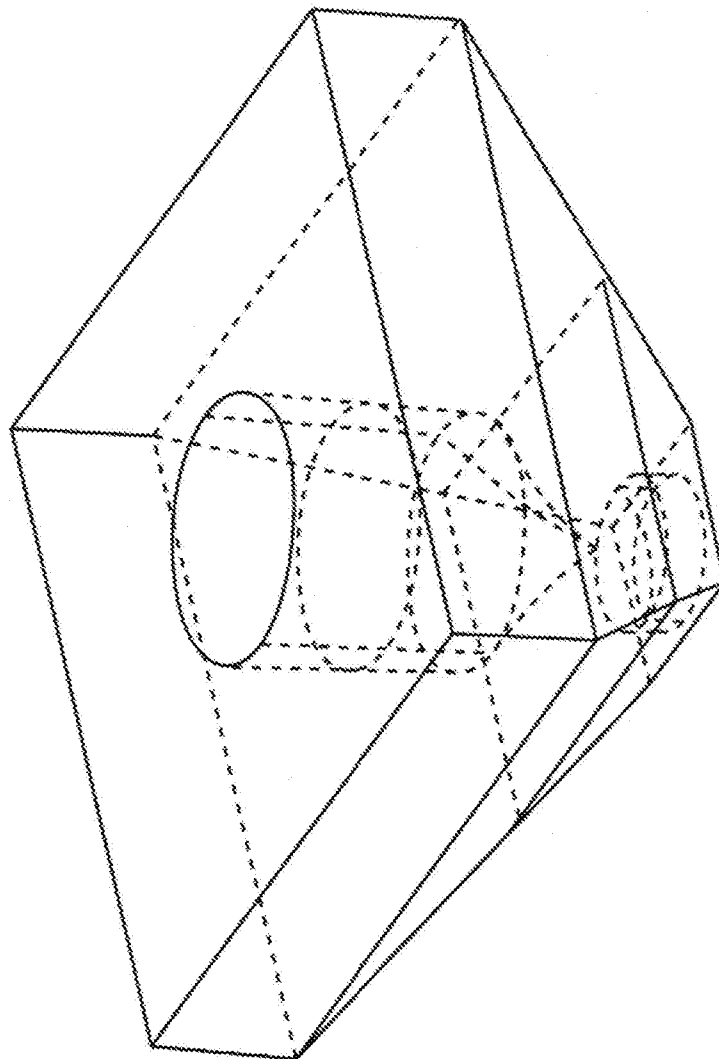


FIG. 6A

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650

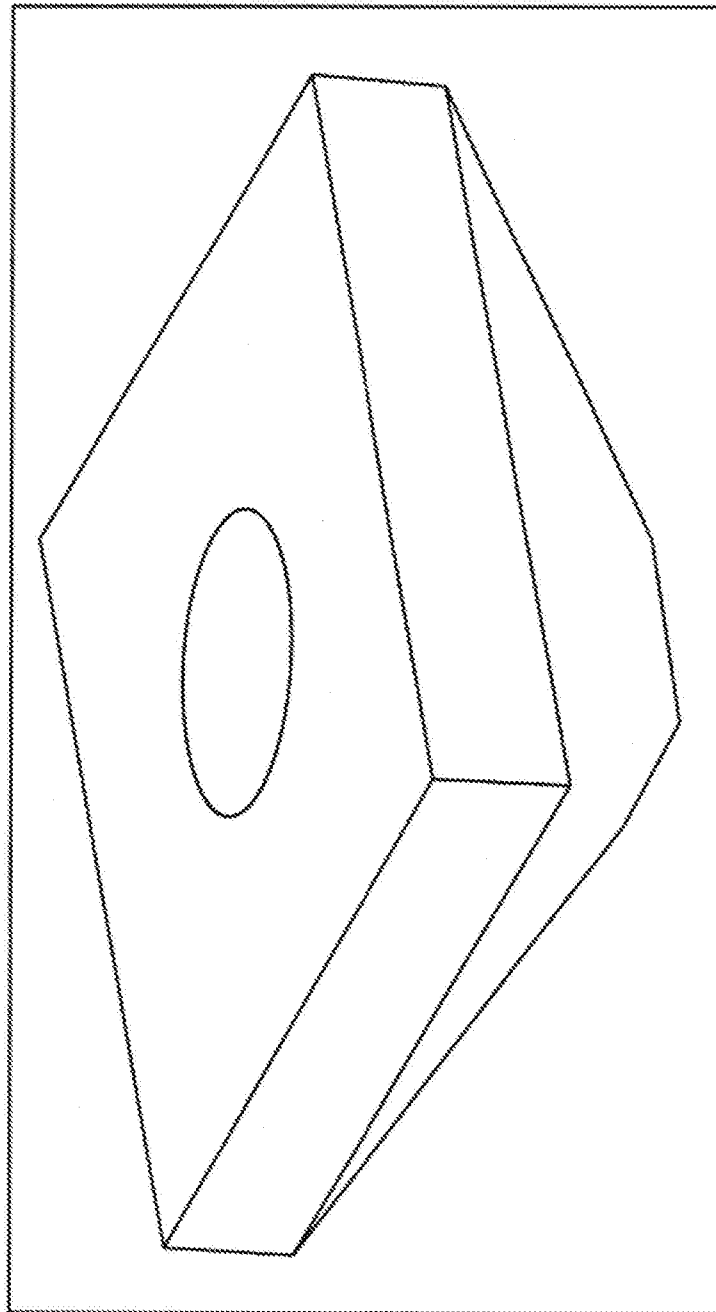


FIG. 6B

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700

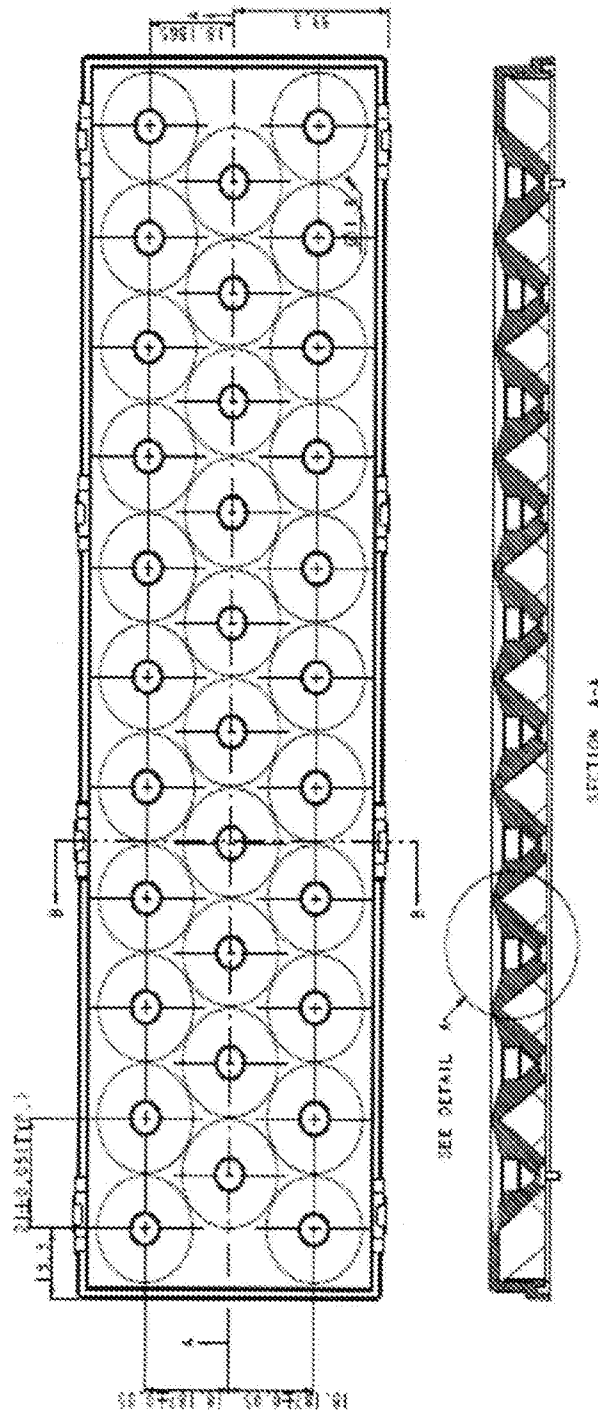


FIG. 7

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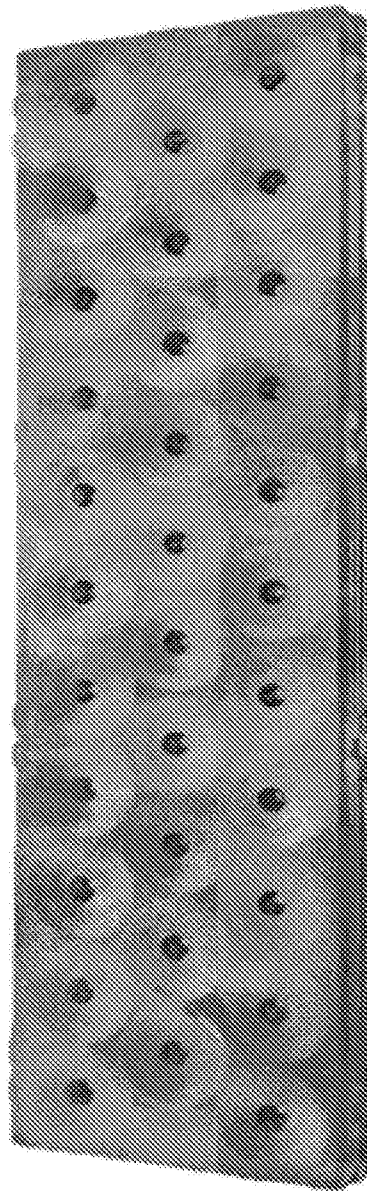


FIG. 8

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900

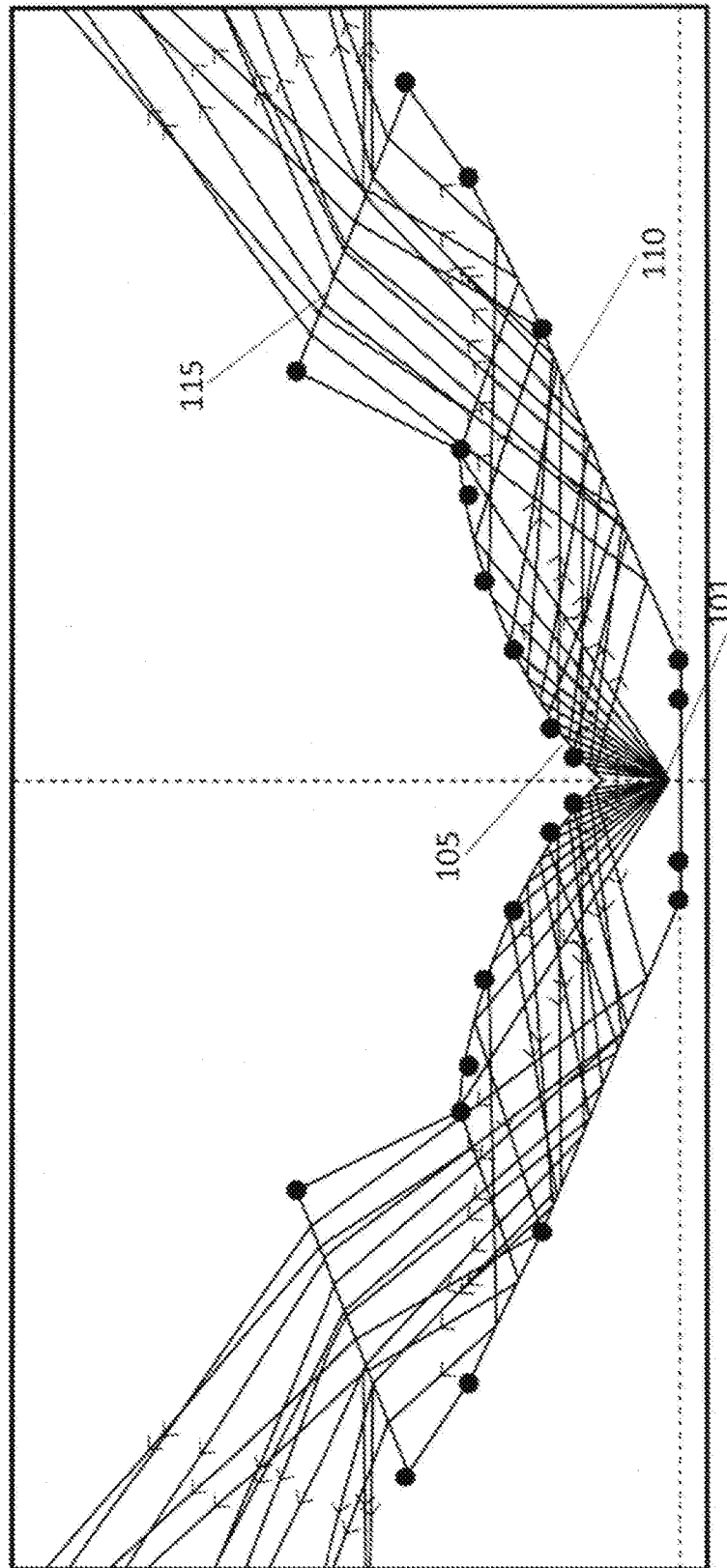


FIG. 9

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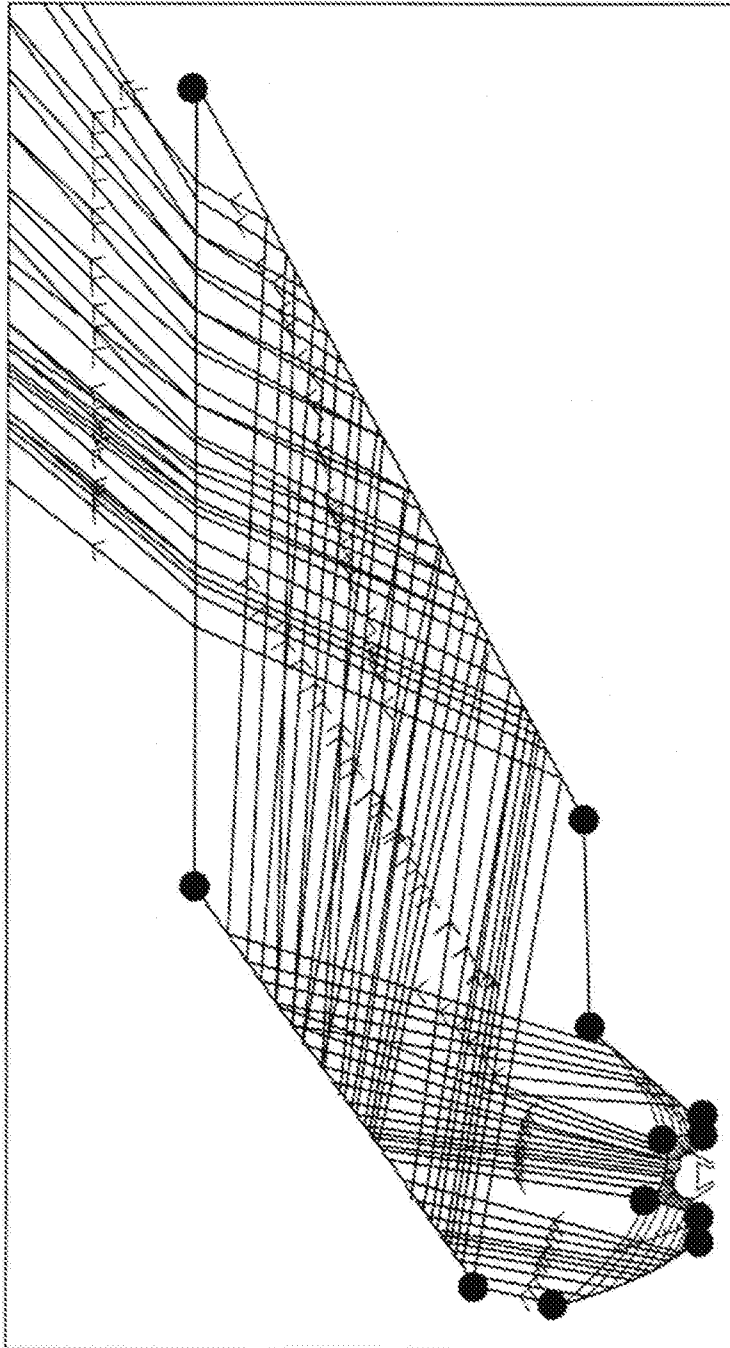


FIG. 10A

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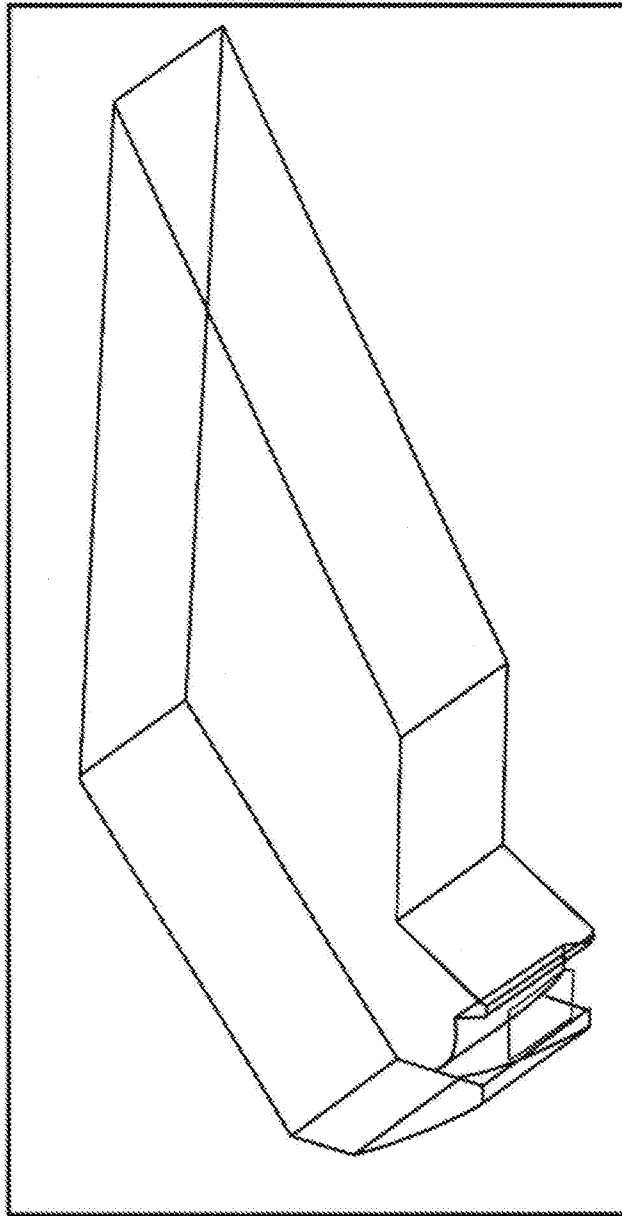


FIG. 10B

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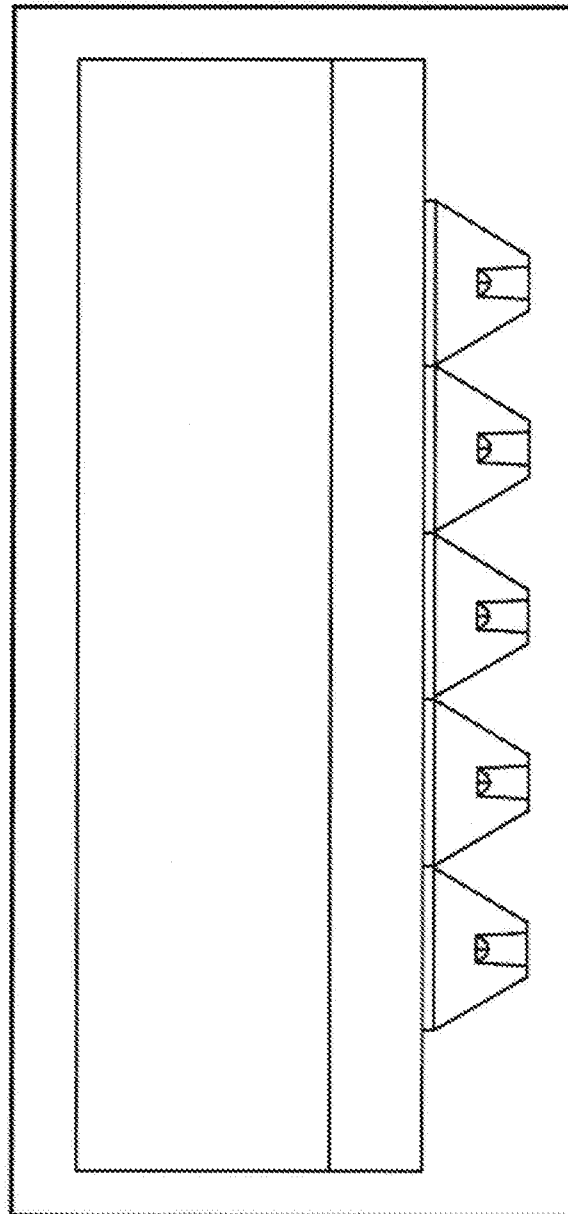


FIG. 11A

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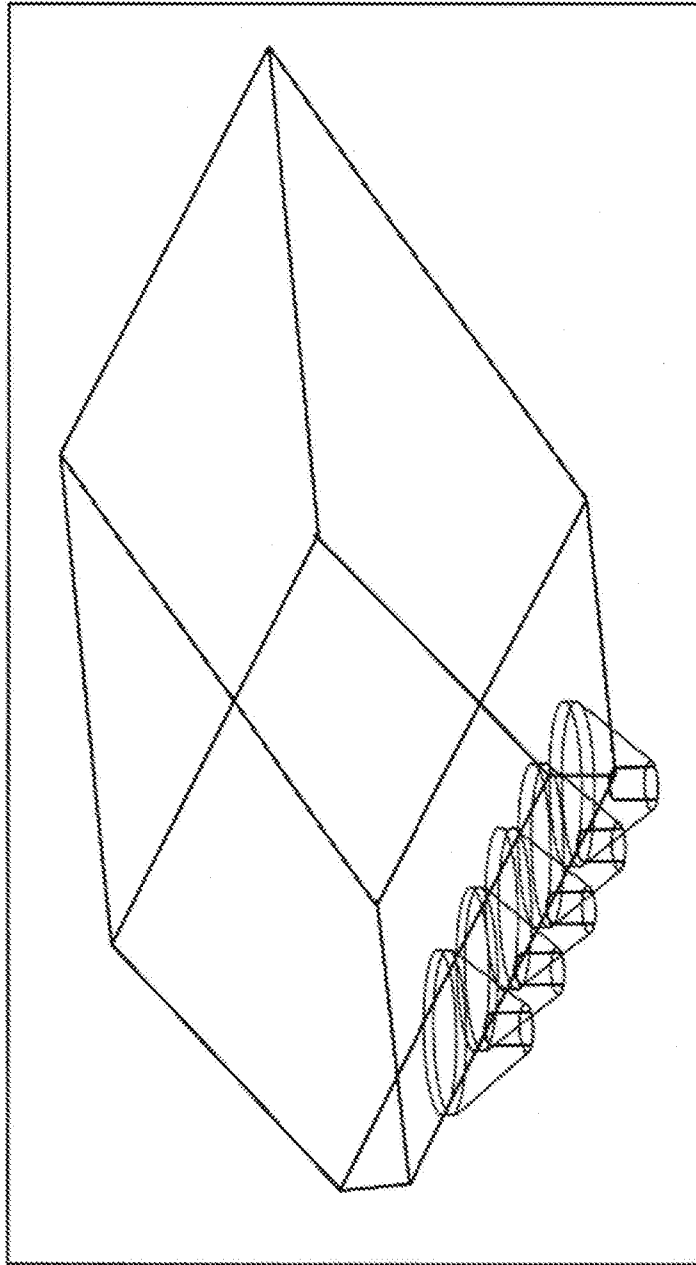


FIG. 11B

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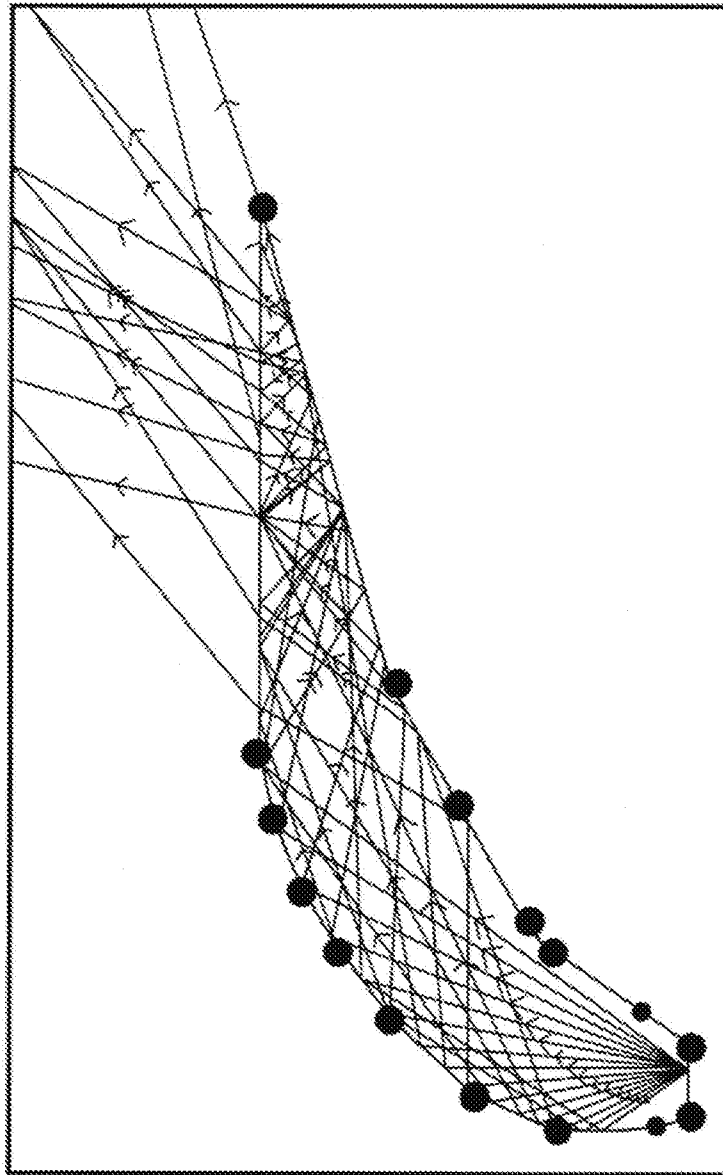


FIG. 12