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(54) **ADAPTIVE HEADLIGHT FOR VEHICLES**

(57) An adaptive headlight includes a light emitting module (1) including a first lens (3), a light emitting unit (4) and a control circuit (2). The light emitting unit (4) is disposed behind the first lens (3) and includes light emitting diodes (42) arranged transversely, emitting light beams for forming virtual light sources (F) by the first lens (3), and being controlled by the control circuit (2) to change intensity of the light beam emitted thereby. The second lens (6) is disposed in front of the first lens (3) and is configured to form a focal curve (C) on which the virtual light sources (F) are arranged. The light beams of the virtual light sources project forwardly through the first and second lenses (3, 4) as collimated light beams to provide a relatively good concentration and collimation.

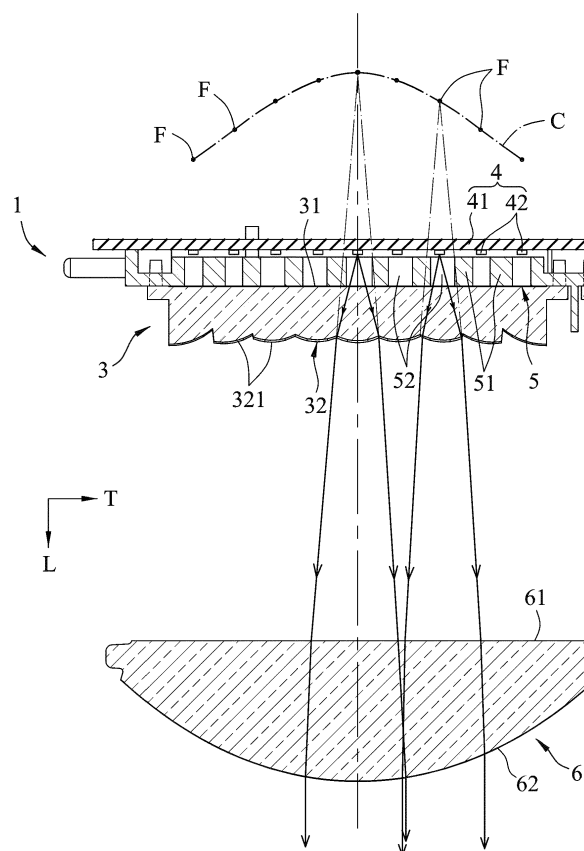


FIG.5

Description

[0001] The disclosure relates to a headlight, more particularly to an adaptive headlight.

[0002] A conventional adaptive headlight mounted on a vehicle is capable of adjusting illumination intensity and range of the conventional adaptive headlight on the road area in front of the vehicle. Referring to FIG. 1, a vehicle 91 mounted with a conventional adaptive headlight is traveling on a road 90, and an illumination area formed by the conventional adaptive headlight is indicated by grey regions.

[0003] Further referring to FIG. 2, when there are objects, for example, two vehicles 92 traveling on the oncoming lane toward the vehicle 91, the conventional adaptive headlight turns off those of the light emitting elements which irradiate on portions of the illumination area within which the drivers in the oncoming vehicles 92 are subject to discomforting glare.

[0004] Therefore, an object of the disclosure is to provide an adaptive headlamp capable of providing light beams with a relatively high collimation and directivity.

[0005] According to one aspect of the disclosure, an adaptive headlight is provided. The adaptive headlight includes at least one light emitting module and a control circuit. The light emitting module includes a first lens, a light emitting unit, and a second lens. The first lens has a first light incident surface facing rearward and a first light output surface facing forward and opposite to the first light incident surface along a front-rear direction. The light emitting unit is disposed behind the first lens and includes a plurality of light emitting diodes arranged side-by-side along a left-right direction which is transverse to the front-rear direction. The second lens is disposed in front of the first lens, is spaced apart from the first lens 3 in the front-rear direction, and is configured to form a focal curve behind the light emitting diodes.

[0006] The control circuit is communicatively connected to the light emitting diodes and is configured to change intensity of a light beam that is emitted by at least one of the light emitting diodes according to a position of a moving object in front of the adaptive headlight and a distance between the at least one light emitting module and the moving object. The light beam emitted by the at least one of the light emitting diodes corresponds to the moving object.

[0007] For each of the light emitting diodes, the light beam emitted from the light emitting diode propagates into the first light incident surface of the first lens, and is refracted by the first lens to form a virtual light source of the light emitting diode. The virtual light source of each of the light emitting diodes is arranged on the focal curve formed by the second lens. The light beam of each of the virtual light sources propagates outwardly of the first lens 3 via the first light output surface and then propagates through the second lens.

[0008] Other features and advantages of the disclosure will become apparent in the following detailed de-

scription of the embodiments with reference to the accompanying drawings, of which:

FIG. 1 is a schematic top view of a road area illuminated by a conventional adaptive headlight mounted on a vehicle;

FIG. 2 is a schematic top view illustrating that the conventional adaptive headlight is controlled to adjust its illumination area because of two oncoming vehicles;

FIG. 3 is a perspective view of an adaptive headlight of an embodiment according to the present disclosure;

FIG. 4 is an exploded perspective view of the embodiment; and

FIG. 5 is a fragmentary schematic cross-sectional view of the embodiment, illustrating paths of light beams emitted by light emitting diodes of the adaptive headlight of the embodiment.

[0009] Referring to FIGS. 3 to 5, an adaptive headlight, also known as an adaptive driving beam (ADB) headlight, according to an embodiment of the present disclosure is shown. The adaptive headlight is to be mounted on a vehicle (not shown). The adaptive headlight includes two light emitting modules 1 and a control circuit 2.

[0010] The light emitting modules 1 are arranged side-by-side in a left-right direction (T). Each of the light emitting modules 1 includes a first lens 3, a light emitting unit 4, a light grating 5 and a second lens 6. Since the structures of the light emitting modules 1 are the same, only one of the light emitting modules 1 will be described in the following disclosure for the sake of brevity.

[0011] The first lens 3 has a first light incident surface 31 facing rearward, and a first light output surface 32 facing forward and opposite to the first light incident surface 31 along a front-rear direction (L) transverse to the left-right direction (T). The first lens 3 includes a plurality of lens portions 321 arranged along the left-right direction (T). Each of the lens portions 321 has a front surface facing forward and protruding forwardly along the front-rear direction (L), and the front surfaces of the lens portions 321 cooperatively form the first light output surface 32. In this embodiment, each of the lens portions 321 is a convex lens. The first lens 3 is made of, e.g., an acrylic material but the material adopted for making the first lens 3 is not limited to this example. The acrylic material provides advantages of low cost, and a relatively good manufacturing accuracy and molding stability, let alone the cost of a mold for forming an acrylic lens is relatively low.

[0012] The light emitting unit 4 is disposed behind the first lens 3, and includes a substrate 41 and a plurality of light emitting diodes 42 arranged side-by-side along the left-right direction (T) on the substrate 41. The light emitting diodes 42 face the first light incident surface 31 and are aligned respectively with the lens portions 321 along the front-rear direction (L).

[0013] The light grating 5 is disposed between the light

emitting unit 4 and the first lens 3, and includes a plurality of elongated walls 51 that are spaced apart from one another along the left-right direction (T). Each adjacent pair of the elongated walls 51 defines a light channel 52 that is aligned with a respective one of the light emitting diodes 42 along the front-rear direction (L) and that is aligned with a respective one of the lens portions 321 along the front-rear direction (L). Each of the light channels 52 allows a portion of a light beam emitted by the respective one of the light emitting diodes 42 to pass therethrough.

[0014] In this embodiment, the light grating 5 can be made of plastic or metal and each of the light channels 52 is, e.g., rectangular in shape.

[0015] The second lens 6 is disposed in front of the first lens 3, is spaced apart from the first lens 3 in the front-rear direction (L), and is configured to form a focal curve (C), i.e., a Petzval curve, behind the light emitting diodes 42. Further detail of the focal curve (C) will be described hereinafter. The second lens 6 has a second light incident surface 61 and a second light output surface 62. The second light incident surface 61 faces the first light output surface 32 of the first lens 3. The second light output surface 62 faces forward and is opposite to the second light incident surface 61 along the front-rear direction (L). The second lens 6 is constituted by a plurality of lens structures arranged along the left-right direction (T). Each of the lens structures is a convex lens and is configured to have a focal point falling behind the light emitting diodes 42. The focal points of the lens structures cooperatively define the focal curve (C), and the focal curve (C) disposed behind the light emitting diodes 42 protrudes rearwardly. In this embodiment, the second lens 6 is substantially a convex lens, and includes a peripheral portion and a center portion having a thickness along the front-rear direction (L) larger than that of the peripheral portion.

[0016] To assemble the adaptive headlight, the light grating 5 of the light emitting module 1 and the substrate 41 of the light emitting unit 4 are connected together and then the first lens 3 is mounted in front of the grating 5. A frame (not shown) can be provided to mount the second lens 6 and an assembly of the first lens 3, the light grating 5 and the light emitting unit 4 on the frame, so that the second lens 6 is connected to the assembly of the first lens 3, the light grating 5 and the light emitting unit 4 by the frame.

[0017] In this embodiment, the second lenses 6 of the light emitting modules 1 are disposed side-by-side along the left-right direction (T) and are molded as one piece. The first lenses 3 of the light emitting modules 1 are connected to each other, the substrates 41 of the light emitting modules 1 are connected integrally, and the light gratings 5 of the light emitting modules 1 are connected together. In this way, it is relatively simple for the adaptive headlight of the present disclosure to be manufactured and assembled. Note that the number of the light emitting modules 1 is not limited to the embodiment of the present

disclosure. That is to say, there may be one or more light emitting modules 1 in other embodiments of the present disclosure.

[0018] The control circuit 2 is communicatively connected to the light emitting diodes 42 and is configured to change intensity of the light beam that is emitted by at least one of the light emitting diodes 42 according to the surrounding driving condition of the vehicle mounted with the adaptive headlight. For example, the control circuit 2 is capable of turning on and off the at least one of the light emitting diodes 42 and/or decreasing and increasing illuminance of the at least one of the light emitting diodes 42. In one embodiment, the vehicle mounted with the adaptive headlight is further mounted with a sensor (not shown). The sensor is configured to detect a position of a moving object in front of the adaptive headlight, such as an approaching vehicle or a vehicle in front, and a distance between the adaptive headlight and the moving object, and to transmit a detection signal indicating the position and the distance thus detected to the control circuit 2. The control circuit 2 is capable of changing intensity of the light beam that is emitted by the at least one of the light emitting diodes 42 according to the detection signal thus received to prevent discomforting glare for drivers in oncoming or front vehicles. In this embodiment, the light beam emitted by the at least one of the light emitting diodes 42 corresponds to the moving object. For example, the moving object is located at an area illuminated by the light beam that is emitted by the at least one of the light emitting diodes 42. The control circuit 2 may be implemented with a microprocessor, a micro control unit (MCU), or any circuit configurable/programmable in a software manner and/or hardware manner to perform functionalities of this disclosure. Note that since the main feature of the present disclosure does not reside in the control of the intensity of a light beam emitted by one of the light emitting diodes 42, further details of the same are omitted for the sake of brevity.

[0019] During use, for each of the light emitting diodes 42 included in each of the light emitting modules 1, the light beam emitted from the light emitting diode 42 propagates through the respective one of the light channels 52 that is aligned with the light emitting diode 42 along the front-rear direction (L), into the first light incident surface 31 of the first lens 3, and is refracted by the respective one of the lens portions 321 of the first lens 3 to form a virtual light source (F) of the light emitting diode 42 behind the light emitting diode 42. The lens portions 321 are configured in such a manner that the virtual light sources (F) of the light emitting diodes 42 thus formed are arranged on the focal curve (C) of the second lens 6. Thus, there are a plurality of the virtual light sources (F) disposed respectively on the focal points of the lens structures of the second lens 6. Then, the light beam deemed to be emitted by each of the virtual light sources (F) propagates through a respective one of the light channels 52, propagates outwardly of the first lens 3 via the first light output surface 32, and then propagates through

the second lens 6 to be projected forwardly to illuminate a road area in front of the vehicle.

[0020] According to optical principles, light beams emitted from a light source disposed at a focal point of a convex lens are refracted by the convex lens and then propagate outwardly of the convex lens as parallel light beams. By virtue of the configurations of the first lens 3 and the second lens 6, the light beams emitted from the light emitting diodes 42 form the virtual light sources (F) disposed on the focal curve (C), and then the light beams deemed to be emitted by the virtual light sources (F) propagate through the light grating 5 and through the first lens 3, and further propagate outwardly of the second lens 6 via the second light output surface (62) as parallel light beams. In this way, the light beams respectively emitted from the light emitting diodes 42 of the adaptive headlight of the present disclosure are redirected as the parallel light beams to illuminate the road area in front of the adaptive headlight. There is thus provision of relatively concentrated light beams that meet the traffic regulations.

[0021] It should be noted that the light grating 5 serves as a collimator that causes the light beams emitted from the light emitting diodes 42 to be concentrated and to enter the respective lens portions 321 directly aligned in front of the respective light channels 52, and the structure of the elongated walls 51 blocks scattering light beams to thereby reduce light divergence. In this way, the virtual light sources (F) may be accurately located on the focal curve (C), and the light beams projected forwardly through the second lens 6 is relatively concentrated and collimated.

[0022] In one embodiment, a width of each of the light channels 52 along the left-right direction (T) ranges from 1 millimeter to 3 millimeters and a length of each of the light channels 52 in an upright direction (U) which is transverse to the left-right direction (T) and the front-rear direction (L) ranges from 3 millimeters to 10 millimeters. Note that the light beams passing through the light channels 52 are relatively few in number when the width and the length of each of the light channels 52 are too small, whereas light divergence may occur when the width and the length of each of the light channels 52 are too large. Further, the shape and dimension of the light channels 52 are specifically designed in this embodiment so a light pattern formed by the light beams emitted by the adaptive headlight may have specific dimensions and shape according to practical needs, but implementation of the light grating 5 is not limited to the examples described herein. In one embodiment, the grating 5 may be omitted, and the light beams emitted by the light emitting unit 4 directly propagate through the first lens 3 and are refracted by the first lens 3 to form the virtual light sources (F) on the focal curve (C).

[0023] To sum up, by virtue of the configurations of the first lens 3 and the second lens 6, the light beams emitted by the light emitting diodes 42 propagate through the light channels 52 and are respectively refracted by the lens

portions 321 of the first lens 3 to form the virtual light sources (F) on the focal curve (C). In this way, the light beams deemed to be emitted by the virtual light sources (F) further propagate through and are refracted respectively by the lens structures of the second lens 6 to project forwardly as parallel light beams so as to provide a relative good concentration and collimation for the adaptive headlight.

[0024] In the description above, for the purposes of explanation, numerous specific details have been set forth in order to provide a thorough understanding of the embodiment (s). It will be apparent, however, to one skilled in the art, that one or more other embodiments may be practiced without some of these specific details. It should also be appreciated that reference throughout this specification to "one embodiment," "an embodiment," an embodiment with an indication of an ordinal number and so forth means that a particular feature, structure, or characteristic may be included in the practice of the disclosure. It should be further appreciated that in the description, various features are sometimes grouped together in a single embodiment, figure, or description thereof for the purpose of streamlining the disclosure and aiding in the understanding of various inventive aspects, and that one or more features or specific details from one embodiment may be practiced together with one or more features or specific details from another embodiment, where appropriate, in the practice of the disclosure.

[0025] While the disclosure has been described in connection with what are considered the exemplary embodiments, it is understood that this disclosure is not limited to the disclosed embodiments but is intended to cover various arrangements included within the spirit and scope of the broadest interpretation so as to encompass all such modifications and equivalent arrangements.

Claims

1. An adaptive headlight, **characterized by:**

at least one light emitting module (1) including

a first lens (3) that has a first light incident surface (31) facing rearward and a first light output surface (32) facing forward and opposite to said first light incident surface (31) along a front-rear direction (L),

a light emitting unit (4) that is disposed behind said first lens (3) and that includes a plurality of light emitting diodes (42) arranged side-by-side along a left-right direction (T) which is transverse to the front-rear direction (L), and

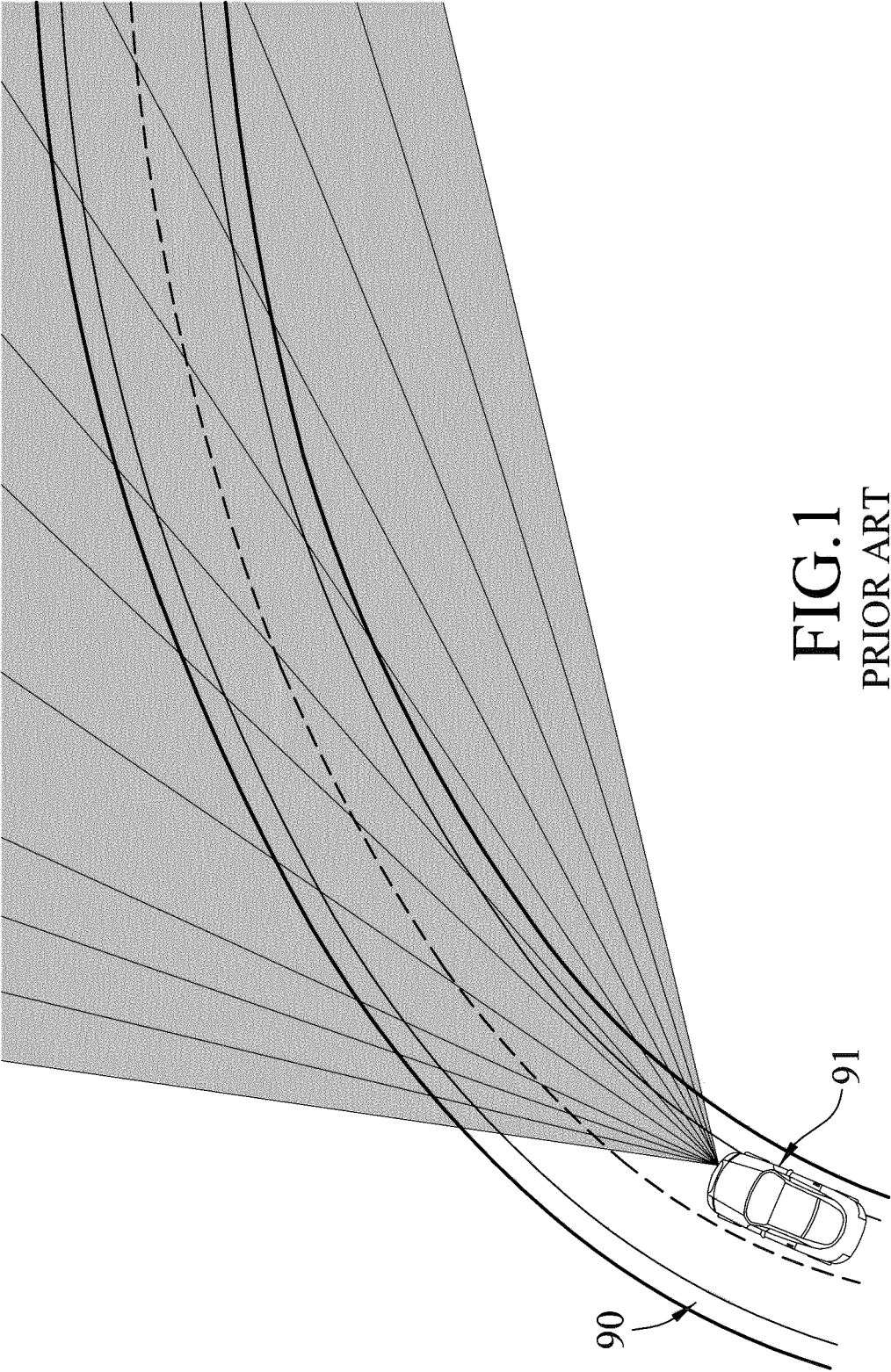
a second lens (6) that is disposed in front of said first lens (3), that is spaced apart from said first lens (3) in the front-rear di-

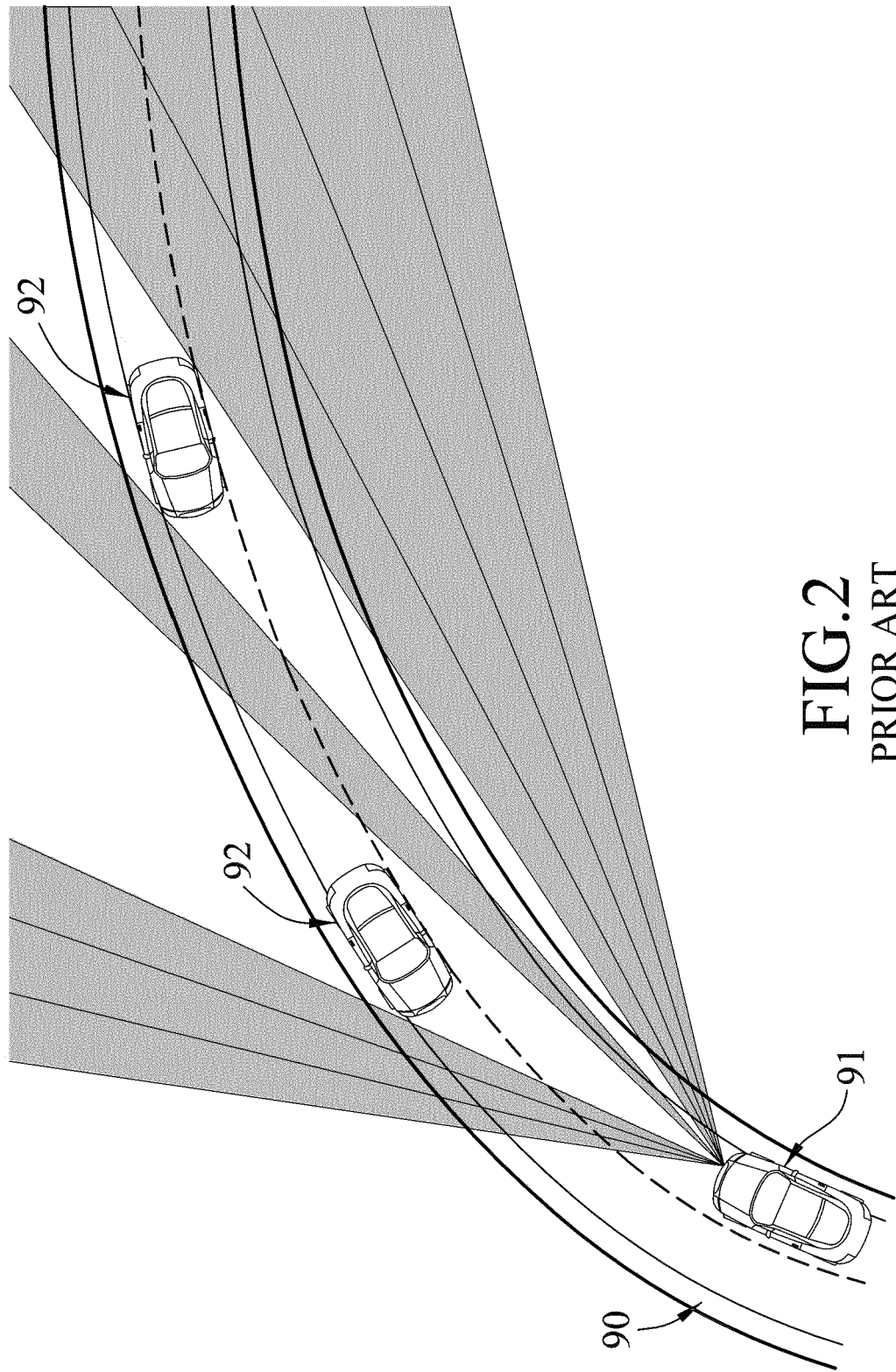
rection (L), and that is configured to form a focal curve behind said light emitting diodes (42); and

a control circuit (2) communicatively connected to said light emitting diodes (42) and configured to change intensity of a light beam that is emitted by at least one of said light emitting diodes (42) according to a position of a moving object in front of said adaptive headlight and a distance between said at least one light emitting module (1) and the moving object, where the light beam emitted by the at least one of said light emitting diodes (42) corresponds to the moving object; wherein, for each of said light emitting diodes (42), the light beam emitted from the light emitting diode (42) propagates into said first light incident surface (31) of said first lens (3), and is refracted by said first lens (3) to form a virtual light source of the light emitting diode (42), said virtual light source of each of said light emitting diodes (42) being arranged on said focal curve formed by said second lens (6), the light beam of each of the virtual light sources propagating outwardly of said first lens (3) via said first light output surface (32) and then propagating through said second lens (6).

2. The adaptive headlight as claimed in Claim 1, **characterized in that** said at least one light emitting module (1) further includes a light grating (5) disposed between said light emitting unit (4) and said first lens (3), and including a plurality of elongated walls (51) that are spaced apart from one another along the left-right direction (T), each adjacent pair of said elongated walls (51) defining a light channel (52) that is aligned with a respective one of said light emitting diodes (42) along the front-rear direction (L).
3. The adaptive headlight as claimed in claim 2, further **characterized in that** a width of each of said light channels (52) along the left-right direction (T) ranges from 1 millimeter to 3 millimeter and a length of each of the light channels (52) in an upright direction (U) which is transverse to the left-right direction (T) and the front-rear direction (L) ranges from 3 millimeter to 10 millimeter.
4. The adaptive headlight as claimed in any one of claims 1 to 3, **characterized in that** said first lens (3) includes a plurality of lens portions (321) arranged along the left-right direction (T) and aligned respectively with said light emitting diodes (42) along the front-rear direction (L), each of said lens portions (321) having a front surface facing forward, said front surfaces of said lens portions (321) cooperatively forming said first light output surface (32).

5. The adaptive headlight as claimed in claim 4, further **characterized in that** said front surface of each of said lens portions (321) protrudes forwardly along the front-rear direction (L).
6. The adaptive headlight as claimed in any one of claims 1 to 5, **characterized in that** said adaptive headlight comprising two of said light emitting modules (1), said second lenses (6) of said light emitting modules (1) being disposed side-by-side along the left-right direction (T) and being molded as one piece, each of said second lenses (6) being a convex lens, having a second light output surface (62) that faces forward, and including a peripheral portion and a center portion that has a thickness along the front-rear direction (L) larger than that of said peripheral portion.
7. The adaptive headlight as claimed in any one of claims 1 to 6, **characterized in that** said second lens (6) is further configured to have the focal curve protruding rearwardly.





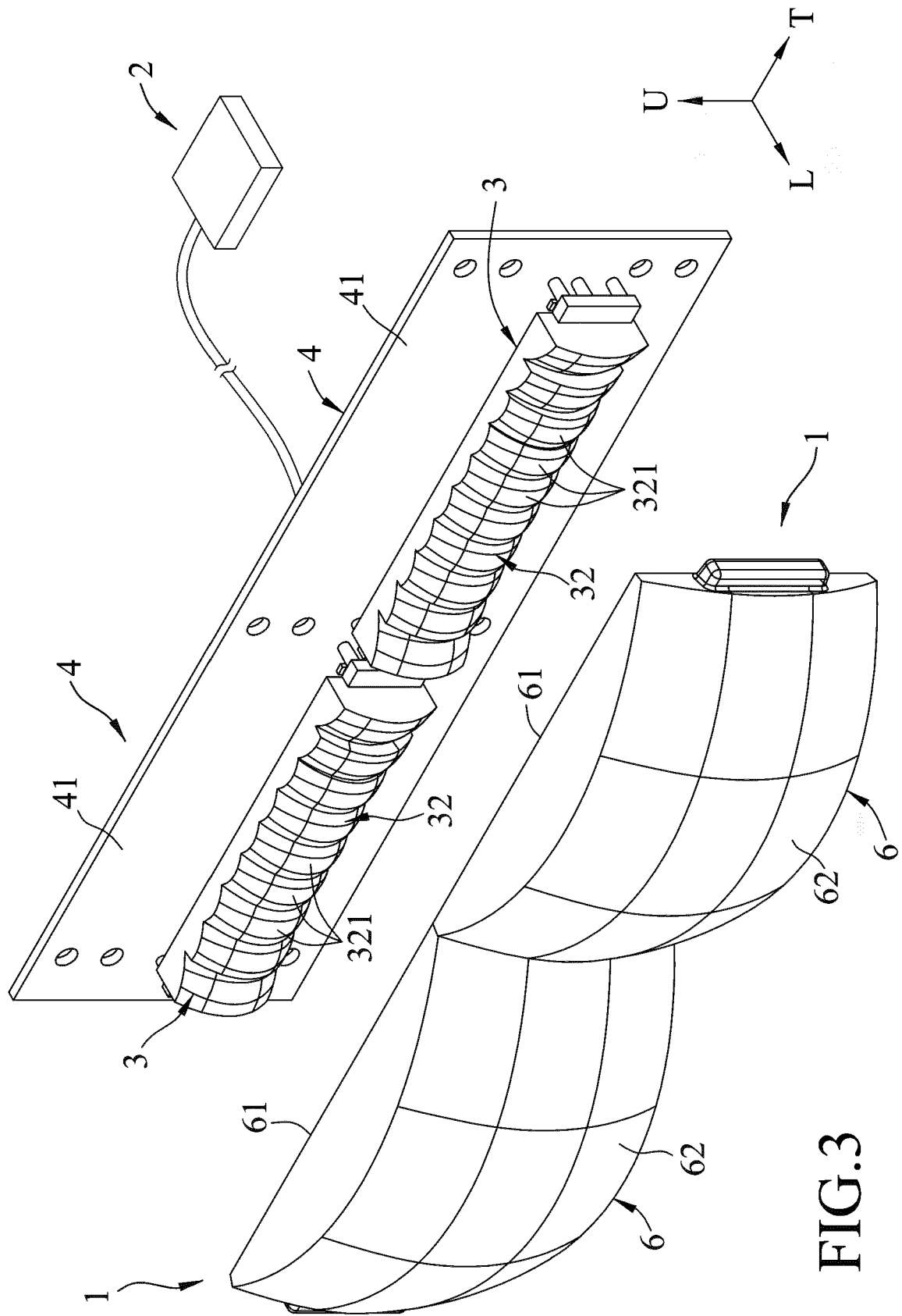


FIG. 3

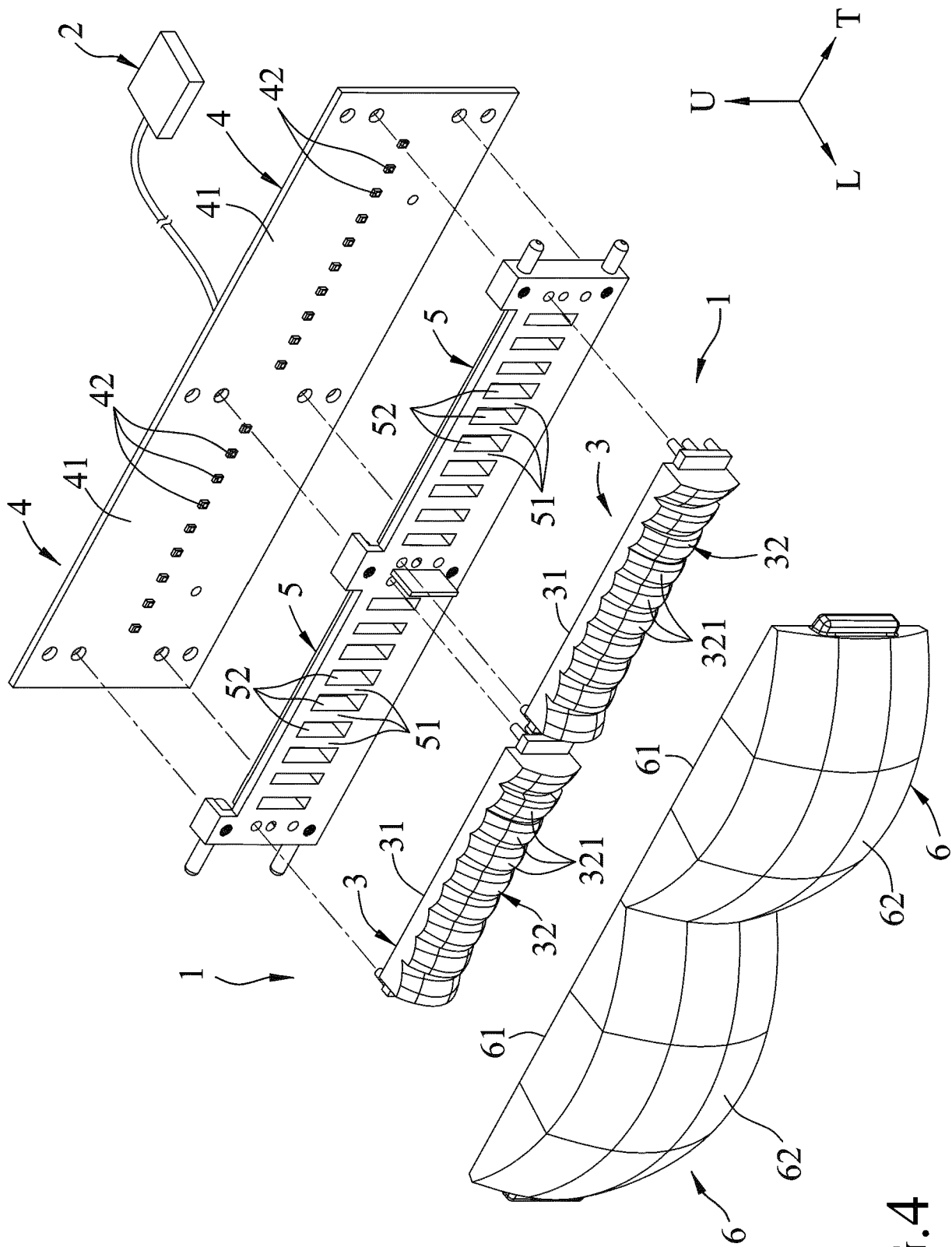


FIG. 4

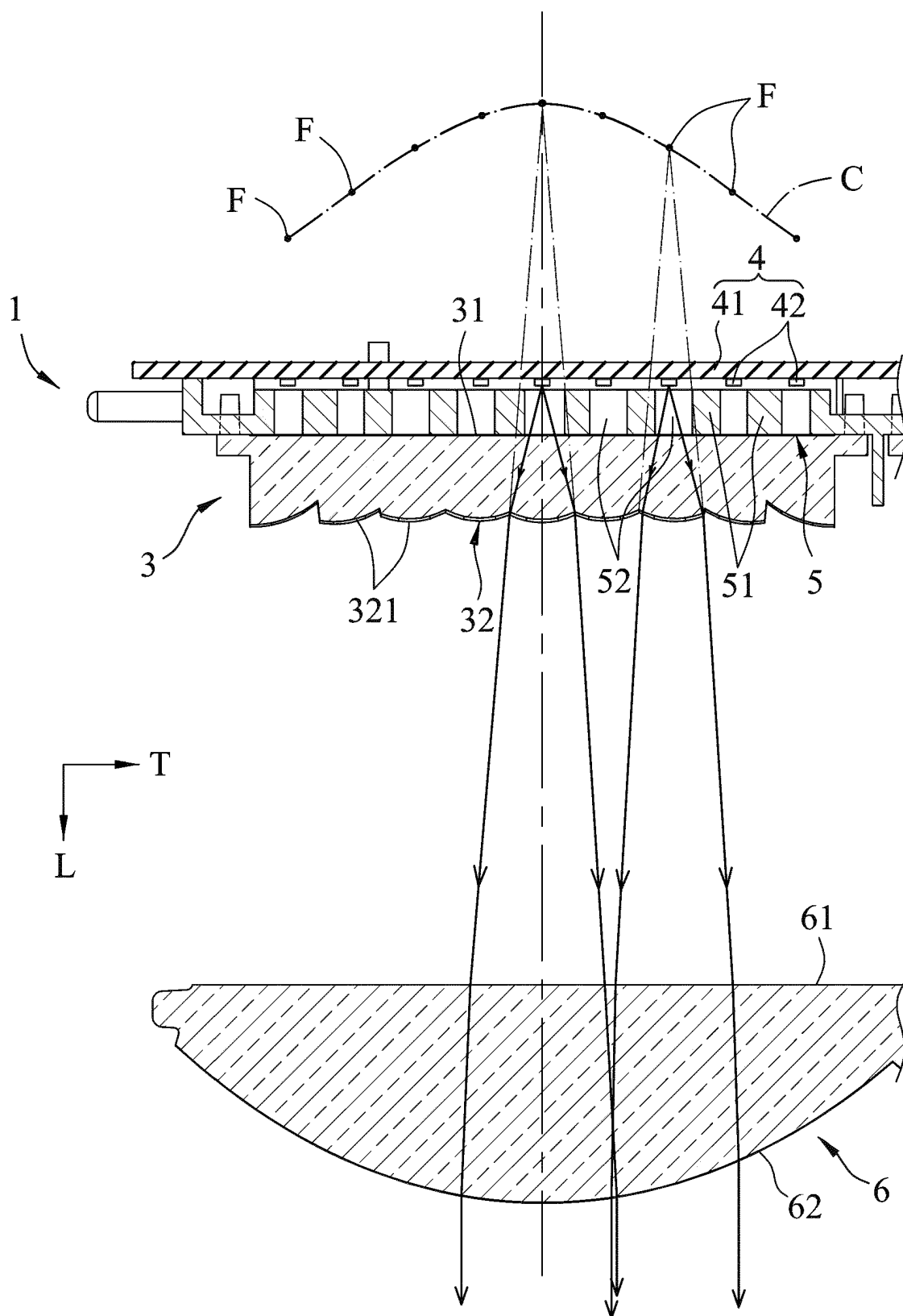


FIG.5



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Application Number
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