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(54) **Title:** LUMINAIRE WITH ARTICULATED ELONGATED LIGHT BEAM HOMOGENIZER

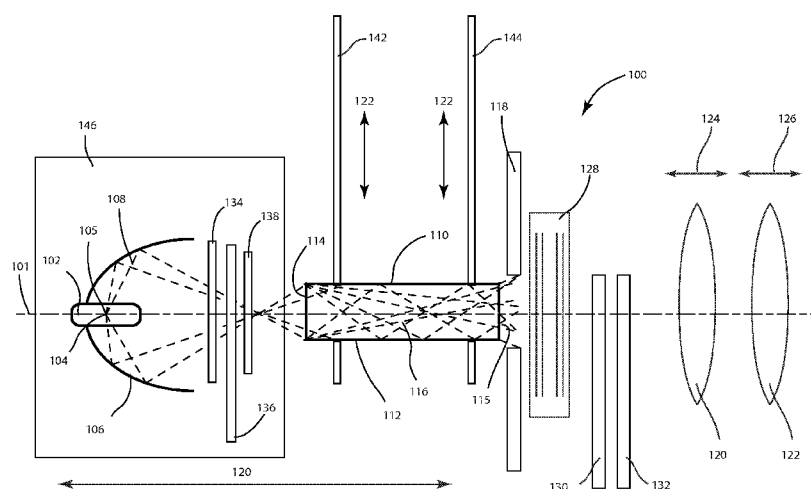


FIG 6

(57) **Abstract:** Described are improved automated luminaire and luminaire systems employing an articulated elongated light homogenizer the articulation of which allows for the homogenizer to be remotely selectable by the user whereby the articulation inserts the homogenizer into the light path in the light engine or removes the homogenizer from said light path.

LUMINAIRE WITH ARTICULATED ELONGATED LIGHT BEAM HOMOGENIZER

RELATED APPLICATION

This application is a utility application claiming priority of United States provisional application with the same title Serial No. 61/691,237 filed on 20 Aug 2012.

TECHNICAL FIELD OF THE INVENTION

[0001] The present invention generally relates to a method for controlling the light output from a light source when used in a light beam producing luminaire, specifically to a method relating to adjusting the homogenization of the light source.

BACKGROUND OF THE INVENTION

[0002] Luminaires with automated and remotely controllable functionality are well known in the entertainment and architectural lighting markets. Such products are commonly used in theatres, television studios, concerts, theme parks, night clubs and other venues. A typical product will typically provide control over the pan and tilt functions of the luminaire allowing the operator to control the direction the luminaire is pointing and thus the position of the light beam on the stage or in the studio. This position control is often done via control of the luminaire's position in two orthogonal rotational axes usually referred to as pan and tilt. Many products provide control over other parameters such as the intensity, color, focus, beam size, beam shape and beam pattern. The beam pattern is often provided by a stencil or slide called a gobo which may be a steel, aluminum or etched glass pattern. The products manufactured by Robe Show Lighting such as the Robin 600E Spot are typical of the art.

[0003] **Figure 1** illustrates a typical multiparameter automated luminaire system **10**.

These systems commonly include a plurality of multiparameter automated luminaires **12** which typically each contain on-board a light source (not shown), light modulation devices, electric motors coupled to mechanical drives systems and control electronics (not shown). In addition to being connected to mains power either directly or through a power distribution system (not shown), each luminaire is connected in series or in parallel to data link **14** to one or more control desks **15**. The luminaire system **10** is typically controlled by an operator through the control desk **15**. Consequently to effect this control both the control desk **15** and the individual luminaires typically include electronic circuitry as part of the electromechanical control system for controlling the automated lighting parameters.

[0004] **Figure 2** illustrates a prior art automated luminaire **12**. A lamp **21** contains a light source **22** which emits light. The light is reflected and controlled by reflector **20** through an aperture or imaging gate **24**. The resultant light beam may be further constrained, shaped, colored and filtered by optical devices **26** and **27** which may include dichroic color filters, dimming shutters, and other optical devices well known in the art. The final output beam may be transmitted through output optical system **31** which may contain multiple elements and form a zoom lens system.

[0005] Such prior art automated luminaires use a variety of technologies as the light sources for the optical system. For example it is well known to use incandescent lamps, high intensity discharge lamps, plasma lamps, and LEDs as light sources in such a luminaire. These light sources and associated optical systems may suffer from limitations that make them less than ideal for such an application. Incandescent lamps, for example, typically have

a large filament which performs inefficiently in the small size optics typical of such a product necessitated by the requirement to pan and tilt the luminaire rapidly and thus to keep the size and weight down to a minimum. This mismatch will significantly reduce the output of the luminaire. High intensity discharge lamps and plasma lamps have small light sources, which provide more efficient optical systems and a smaller unit. However, the light distribution from a combination of a small light source and an ellipsoidal reflector, although of high efficiency, is usually very peaky. It often has a bright center beam and drops off rapidly to the edges. For some applications this light distribution is useful, particularly if used with a small aperture, as it is possible to obtain a very high intensity light beam. However, for other applications it is more useful to have a better homogenized, flatter light distribution. Such a flat distribution may provide better projection of imagery from gobos or patterns and better homogenization of color mixing.

[0006] Without homogenization of the light beam the prior art optical systems often produce uneven and irregular coloring and dimming across the output beam. The light passing through optical devices **26** is already partially collimated by reflector **20** such that, for example, a yellow filter partially inserted into the beam within optical device **26** will color the edges of the output beam yellow and not, as desired, color the entire beam. Similarly the insertion of dimming shutters, flags or other mechanical dimmer will not produce an even dimming effect across the beam but will instead tend to vignette the beam and produce visible patterning. An effective homogenization system is needed to correct these problems so as to evenly distribute the color across the entire beam and to provide an evenly distributed optical dimming system.

[0007] There is a need for an automated luminaire using a light source with a homogenization system that may be dynamically adjusted to provide the user with the option of a high output peaky light beam, or a flattened homogenized light beam.

BRIEF DESCRIPTION OF THE DRAWINGS

[0008] For a more complete understanding of the present invention and the advantages thereof, reference is now made to the following description taken in conjunction with the accompanying drawings in which like reference numerals indicate like features and wherein:

[0009] **FIGURE 1** illustrates a typical automated lighting system;

[0010] **FIGURE 2** illustrates a prior art luminaire system;

[0011] **FIGURE 3** illustrates an embodiment of a luminaire with an articulated elongated homogenizer in place;

[0012] **FIGURE 4** illustrates an embodiment of the luminaire with the elongated homogenizer retracted from the light beam path;

[0013] **FIGURE 5** illustrates an embodiment of the elongated of the luminaire illustrated in **Figure 3** and **Figure 4**;

[0014] **FIGURE 6** illustrates in greater detail the embodiment of a luminaire with an articulated elongated homogenizer in place in the path of the light beam;

[0015] **FIGURE 7** illustrates an alternative embodiment of a luminaire with an articulated elongated homogenizer;

[0016] **FIGURE 8** illustrates the embodiment of the luminaire illustrated in **Figure 6** with the articulated elongated homogenizer retracted; and

[0017] **FIGURE 9** illustrates and alternative embodiment of a luminaire with an articulated elongated homogenizer.

DETAILED DESCRIPTION OF THE INVENTION

[0018] Preferred embodiments of the present invention are illustrated in the FIGURES, like numerals being used to refer to like and corresponding parts of the various drawings.

[0019] The present invention generally relates to an automated luminaire, specifically to a luminaire utilizing a small light source. Compact high intensity discharge (HID) lamps, LED light sources, and plasma light sources offer a compact light source with consequent high efficiency optical coupling to reflectors and down-stream optical systems.

[0020] **Figure 3** illustrates an embodiment of the invention utilizing a light engine **100** in an automated luminaire. A lamp **102** contains a light source **104** which emits light. This emitter may be the arc gap of an HID lamp, or the capsule of a plasma lamp or other light source. The light **108** is reflected and controlled by reflector **106** generally towards a focal point **103** along the optical axis **101** of the light engine **100**. The light beam may be further constrained, shaped, colored, filtered or otherwise modulated by optical devices **134**, **136** and **138** which may include dichroic color filters, color mixing systems, dimming flags, strobing flags, effects glass, homogenizers and other optical devices well known in the art.

[0021] The optical system illustrated incorporates an articulated elongated light collector/integrator **110**. Light integrator **110** is a device utilizing internal reflection so as to collect homogenize and constrain and conduct the light from light source **104** and reflector **106** to other optical element(s). Light integrator **110** may be a hollow tube **112** with a reflective inner surface such that light impinging into the entry port may be reflected multiple times along the tube before leaving at the exit port. Light **108** enters integrator **110** at **114**, light is then reflected down the tube in different directions from the light source such that the

light beams **116** will mix forming a composite beam where different colors of light are homogenized and an evenly colored and more evenly distributed beam is emitted through aperture **115**. Light integrator **110** may be a square tube, a hexagonal tube, a heptagonal tube, a circular tube, an octagonal tube or a tube of any other cross section. In a further embodiment light integrator **110** may be a solid rod constructed of glass, transparent plastic or other optically transparent material where the reflection of the incident light beam within the rod is due to total internal reflection (TIR) from the interface between the material of the rod and the surrounding air. The integrating rod may a square rod, a hexagonal rod, a heptagonal rod, an octagonal rod, a circular rod, or a rod of any other cross section. The homogenized light exits from the light integrator **110** and may then be further controlled and directed by other optical elements not shown in this figure.

[0022] A feature of a light integrator **110** of **Figure 3** which comprises a hollow or tube or solid rod where the sides of the rod or tube are essentially parallel and the entrance aperture **114** and exit aperture **115** are of the same size is that the divergence angle of light exiting the integrator **110** at exit port **115** will be the same as the divergence angle for light entering the integrator **110** at entry port **114**. Thus a parallel sided integrator **110** has no effect on the beam divergence and will transfer the position of the focal point of light engine **100** to the integrator's **110** exit aperture **115**. The light exiting integrator **110** will be well homogenized with the light mixed together into a single light beam and may be used as our output, or may be further modified by downstream optical systems.

[0023] Integrator **110** may advantageously have an aspect ratio where its length is much greater than its diameter. The greater the ratio between length and diameter, the better the

resultant mixing and homogenization will be. Integrator **110** may be enclosed in a tube or sleeve which provides mechanical protection against damage, scratches, and dust.

[0024] In order to allow the user to remove the light integrator from the optical system, the system illustrated has the capability of moving light integrator **110** out of the light path in the direction indicated by arrows **122**. It further has the ability to move all optical components **102, 104, 105, 106, 134, 136** and **138** in the direction indicated by arrows **120** as further described below.

[0025] After the light integrator **110** has been removed from the light beam path along beam axis **101** in the direction indicated by arrows **122**, the optical components **102, 204, 105, 106, 134, 136** and **138** are moved in the direction indicated by arrows **120** toward the aperture **118** until the light engine system **100** is reconfigured as illustrated in **Figure 4**.

[0026] **Figure 4** illustrates the luminaire **100** in a configuration with the elongated homogenizer removed from the light beam path and the remaining components are repositioned/reconfigured so that the light **108** is reflected and directed by reflector **106** generally towards aperture or imaging gate **118**. The light beam may be further constrained, shaped, colored, filtered or otherwise modulated by optical devices **134, 136** and **138** which may include dichroic color filters, color mixing systems, dimming flags, effects glass and other optical devices well known in the art. The elongated homogenizer **110** (not shown in **Figure 4**) is not in place and the light beam passes through aperture **118** without passing through the homogenizer **110**. Optical components **102, 104, 105, 106, 134, 136** and **138** have been moved forward, towards aperture **118**, such that the light beam correctly optically couples to aperture **118**.

[0027] As illustrated in **Figure 6**, **Figure 7**, **Figure 8** and **Figure 9**. The articulated movement of the homogenizer **110** and optical components **102**, **104**, **105**, **106**, **134**, **136** and **138** may be through motors and mechanisms as well known and understood in the art. Such motors may be stepper motors, servo motors, linear actuators, or other motors as known in the art. The motion of the homogenizer and optical components may be automatically controlled and coordinated by the control systems in the automated luminaire such that there is no possibility of collision of any of the moving components.

[0028] **Figure 5** is a perspective view of an embodiment of the light collector/integrator **110** as shown in **Figure 3**. In the illustrated embodiment light collector/integrator **110** comprises a hollow tube **112** reflective on its inside surfaces that is polygonal in cross section and has an entrance aperture **114** and an exit aperture **115**.

[0029] **Figure 6** illustrates in greater detail a layout diagram of an embodiment of a luminaire **100** with an articulated elongated homogenizer **110**. Light source **104** and reflector **106** direct light through optical devices **134**, **136**, and **138** into the entrance aperture **114** of light integrator **110**. Optical devices **134**, **136**, and **138** may comprise dichroic color filters, color mixing filters, dimming flags or shutters, strobing flags, and other optical devices known in the art where homogenization of the light beam after passing through them is advantageous. Within light integrator **110** the light beams **116** may reflect from the walls any number of times from zero to a number defined by the geometry of the tube **110** and the entrance angle and position of the incident light. This variation in path length and the different numbers of reflections causes homogenization of the light beams within light integrator **110**. A feature of a light integrator **110** which comprises a hollow or tube or solid

rod where the sides of the rod or tube are essentially parallel and the entrance aperture **114** and exit aperture **115** are of the same size is that the divergence angle of light exiting the integrator **110** will be the same as the divergence angle for light entering the integrator **110**. Thus a parallel sided integrator **110** has no effect on the beam divergence. Light exiting the light integrator **110** may pass through aperture **118** and then through optical elements **128**, **130**, and **132**. Optical elements **128**, **130**, and **132** may include but not be restricted to rotating gobos, static gobos, iris, color wheels, framing shutters, frost and diffusion filters, beam shapers and other optical devices known in the art. The light may then be further controlled and directed by optical elements **120** and **122** which may provide variable beam angle or zoom functionality as well as the ability to focus on various components of the optical system before emerging as the required light beam. Lenses **120** and **122** may be independently movable along the optical axis **124** and **126** so as to provide beam angle control over the exiting light beam. Although two optical elements **120** and **122** are herein illustrated the invention is not so limited and any optical system as known in the art may be utilized to control and focus the exiting light beam. In particular in further embodiments a single optical element alone may be utilized. In further embodiments, lenses **120** and **122** may form an achromatic optical system such that it provides the same degree of beam angle change to long wavelength red light as it does to short wavelength blue light and thus avoids chromatic aberration. This ensures that the beams from the different colors of light are all the same size resulting in a uniformly colored combined beam. In yet further embodiments any number of lenses may be used as the lens system. In all cases, lenses may contain one or more optical elements. Lenses **120** and **122** are illustrated herein as bi-convex lenses

however the invention is not so limited and lenses **120** and **122** may be any shaped optical element as well known in the art and may include any number of lenses including a single lens. This applies to any of the embodiments discussed herein.

[0030] In order to allow the user to remove the light integrator from the optical system, the system illustrated has the capability of moving light integrator **110** out of the light path in the direction indicated by arrows **122** via linear drives **142** and **144**. It further has the ability to move all optical components **102**, **104**, **105**, **106**, **134**, **136** and **138** in the direction indicated by arrows **120** toward or away from the aperture **118**. In the embodiment illustrated these components **102**, **104**, **105**, **106**, **134**, **136** and **138** are mounted on an articulated carrier **146** which carries the components **102**, **104**, **105**, **106**, **134**, **136** and **138** along the light beam axis **101** toward and away from the aperture **118**.

[0031] In some embodiments it is preferred that the articulation of the articulated carrier **146** of the light source **102** is initiated automatically in coordination with the articulated drives **142** and **144** of the elongated homogenizer **110** so that after the homogenizer is removed from the light path, the carrier **146** automatically moves components **102**, **104**, **105**, **106**, **134**, **136** and **138** toward the aperture **118** and before the elongated homogenizer is articulated into the light beam path, the carrier moves components **102**, **104**, **105**, **106**, **134**, **136** and **138** away from the aperture **118**. In some embodiments the light beam is automatically doused or dimmed out during these movements.

[0032] **Figure 7** illustrates a layout diagram of an embodiment of the invention. Light source **104** and reflector **106** direct light through optical devices **134**, **136** and **138** into the entrance aperture **214** of tapered light integrator **210**. Optical devices **134**, **136**, and **138** may

comprise dichroic color filters, color mixing filters, dimming flags or shutters and other optical devices known in the art where homogenization of the light beam after passing through them is advantageous. Within tapered light integrator **210** the light beams may reflect from the walls any number of times from zero to a number defined by the geometry of the tube and the entrance angle and position of the incident light. This variation in path length and the different numbers of reflections causes homogenization of the light beams within light integrator **210**. A feature of a tapered light integrator **210** which comprises a hollow or tube or solid rod where the sides of the rod or tube are tapered and the entrance aperture **214** is smaller than the exit aperture **215** is that the divergence angle of light exiting the integrator **210** will be smaller than the divergence angle for light entering the integrator **210**. The combination of a smaller divergence angle from a larger aperture **215** serves to conserve the etendue of the system. Thus a tapered integrator **210** may provide similar functionality to a condensing optical system and light may be delivered directly to aperture **118** without any need for further optical components to control and shape the beam.

[0033] Light exiting the light integrator **210** may pass through aperture **118** and then through optical elements **228**, **230**, and **232**. Optical elements **228**, **230**, and **232** may comprise gobo wheels, rotating gobo wheels, pattern or effects, irises, framing shutters or other optical devices as well known in the art. The light may then be further controlled and directed by optical elements **220** and **222** which may which may provide variable beam angle or zoom functionality as well as the ability to focus on various components of the optical system before emerging as the required light beam. Lenses **220** and **222** may be independently movable along the optical axis **224** and **226** so as to provide beam angle

control over the exiting light beam. Although two optical elements **220** and **222** are herein illustrated the invention is not so limited and any optical system as known in the art may be utilized to control and focus the exiting light beam. In particular in further embodiments a single optical element alone may be utilized. In further embodiments, lenses **220** and **222** may form an achromatic optical system such that it provides the same degree of beam angle change to long wavelength red light as it does to short wavelength blue light and thus avoids chromatic aberration. This ensures that the beams from the different colors of light are all the same size resulting in a uniformly colored combined beam. In yet further embodiments any number of lenses may be used as the lens system. In all cases, lenses may contain one or more optical elements. Lenses **220** and **222** are illustrated herein as bi-convex lenses however the invention is not so limited and lenses **220** and **222** may be any shaped optical element as well known in the art and may include any number of lenses including a single lens. This applies to any of the embodiments discussed herein.

[0034] In order to allow the user to remove the light integrator from the optical system, the system illustrated has the capability of moving light integrator **210** out of the light path in the direction indicated by arrows **122**. It further has the ability to move all optical components **102, 104, 105, 106, 134, 136** and **138** in the direction indicated by arrows **120**.

[0035] Optical elements such as **134, 136, 138, 128, 130, 132, 228, 230,** and **232** may be controlled and moved by motors. Motors may be stepper motors, servo motors or other motors as known in the art. In this embodiment the components **102, 104, 105, 106, 134, 136** and **138** are also mounted on a carrier **146** which operates with respect to these components as described above in regard to **Figure 6**.

[0036] **Figure 8** shows the embodiment illustrated in **Figure 6** after the light integrator **110** has been removed in the direction indicated by arrows **122** by articulating linear drives **142** and **144** and optical components **102**, **104**, **105**, **106**, **134**, **136**, and **138** have been moved by articulated carrier **146** in the direction indicated by arrows **120** toward aperture **118**. In this configuration the light **108** is reflected and controlled by reflector **106** through optical devices **134**, **136**, and **138** into the aperture or imaging gate **118**, and then through optical elements **128**, **130**, and **132**. Optical elements **128**, **130**, and **132** may include but not be restricted to rotating gobos, static gobos, iris, color wheels, framing shutters, frost and diffusion filters, beam shapers and other optical devices known in the art. The light may then be further controlled and directed by optical elements **120** and **122** which may provide variable beam angle or zoom functionality as well as the ability to focus on various components of the optical system before emerging as the required light beam. Lenses **120** and **122** may be independently movable along the optical axis **124** and **126** so as to provide beam angle control over the exiting light beam. Although two optical elements **120** and **122** are herein illustrated the invention is not so limited and any optical system as known in the art may be utilized to control and focus the exiting light beam. In particular in further embodiments a single optical element alone may be utilized. In further embodiments, lenses **120** and **122** may form an achromatic optical system such that it provides the same degree of beam angle change to long wavelength red light as it does to short wavelength blue light and thus avoids chromatic aberration. This ensures that the beams from the different colors of light are all the same size resulting in a uniformly colored combined beam. In yet further embodiments any number of lenses may be used as the lens system. In all cases, lenses may

contain one or more optical elements. Lenses **120** and **122** are illustrated herein as bi-convex lenses however the invention is not so limited and lenses **120** and **122** may be any shaped optical element as well known in the art and may include any number of lenses including a single lens. This applies to any of the embodiments discussed herein.

[0037] In all embodiments of the invention optical elements **128**, **130**, **132**, **228**, **230**, and **232** may include rotating gobos and static gobos. In one embodiment of the invention the rotating gobos may be of a larger diameter than the static gobos. The larger rotating gobos may be used for image projection when homogenizer **110** or **210** is inserted in to the light beam. In this configuration the large homogenized beam is most suitable for accurate sharp image projection. Such rotating gobos may be complex patterns and images designed for projection effects. Alternatively smaller static gobos may be used when homogenizer **110** or **210** is removed from the light beam. In this configuration the light beam has a peaky distribution such that it is most powerful in the center of the beam and is most suitable for beam projection effects. Such static gobos may be simple shapes such as circles and multiple apertures, designed for beam effects.

[0038] **Figure 9** illustrates an alternative embodiment. In this embodiment the aperture **118** and the components **128**, **130**, **132**, **120** and **122** are mounted on articulated carrier **147** down the light beam axis **101** from the aperture **118**. **Figure 9** illustrates the configuration of the components of the system **100** when the homogenizer **110** is in a position out of the light beam path as articulated by linear drives **142** and **144**. In further embodiments of this embodiment, the articulation of drives **142** and **144** are coordinated with the articulation of the carrier **147** so that: before the homogenizer is placed into the light beam via linear drives

142 and **144** in direction **122** toward the light beam access, the carrier **147** is automatically articulated in direction **145** away from the light source and other components **102**, **104**, **105**, **106** **134**, **136** and **138** upstream from the aperture **118** to make space for the elongated homogenizer **110** and similarly after the homogenizer **110** is removed from the light beam path, the carrier **147** is automatically articulated in direction **145** to close the gap created by the removal of the homogenizer **110** from the light beam path.

[0039]

[0040] While the disclosure has been described with respect to a limited number of embodiments, those skilled in the art, having benefit of this disclosure, will appreciate that other embodiments may be devised which do not depart from the scope of the disclosure as disclosed herein. The disclosure has been described in detail, it should be understood that various changes, substitutions and alterations can be made hereto without departing from the spirit and scope of the disclosure.

WHAT IS CLAIMED IS:

1. A luminaire comprising:

a light source for generating a light beam with a light beam axis and a light beam origin at the light source and a light beam exit down the axis from the light source;

a first articulated carrier for deploying a light beam axis elongated light beam homogenizer into the light beam and removing the elongated homogenizer from the light beam;

a second articulated carrier which articulates other optical components of the luminaire along the optical axis of the light beam in coordination with the deployment or removal of the elongated homogenizer from the light beam path.

2. The luminaire of claim 1 where the automated coordination of the first and second carriers is such that before the first articulated carrier deploys the homogenizer into the light beam the second carrier is articulated to move other optical components to make space for the elongated homogenizer.

3. The luminaire of claim 2 where the automated coordination of the carriers is also such that after the homogenizer is removed from the light beam by the first carrier, the second carrier is articulated to close the gap created along the optical axis by removal of the elongated homogenizer.

4. A luminaire comprising:

a light source for generating a light beam with a light beam axis and a light beam origin at the light source and a light beam exit down the axis from the light source;

a articulated carrier for deploying a light beam axis elongated light beam homogenizer into the light beam and removing the elongated homogenizer from the light beam.

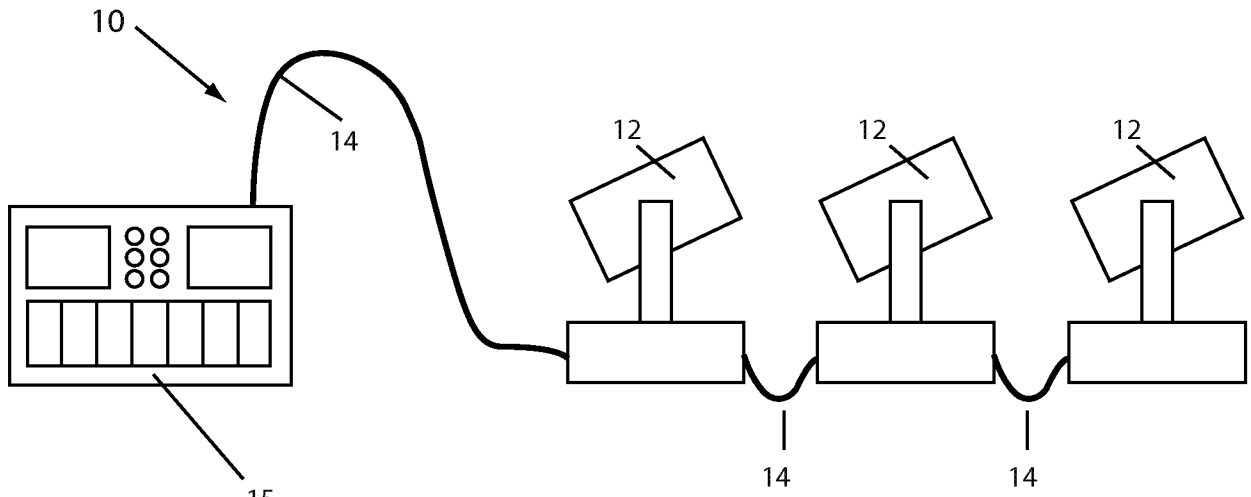


FIG 1

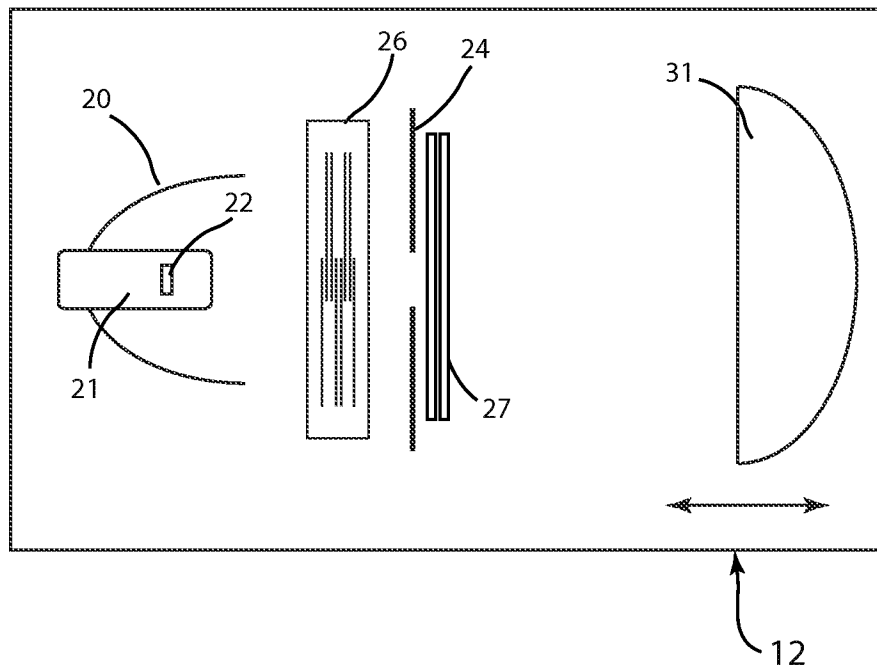


FIG 2
Prior art

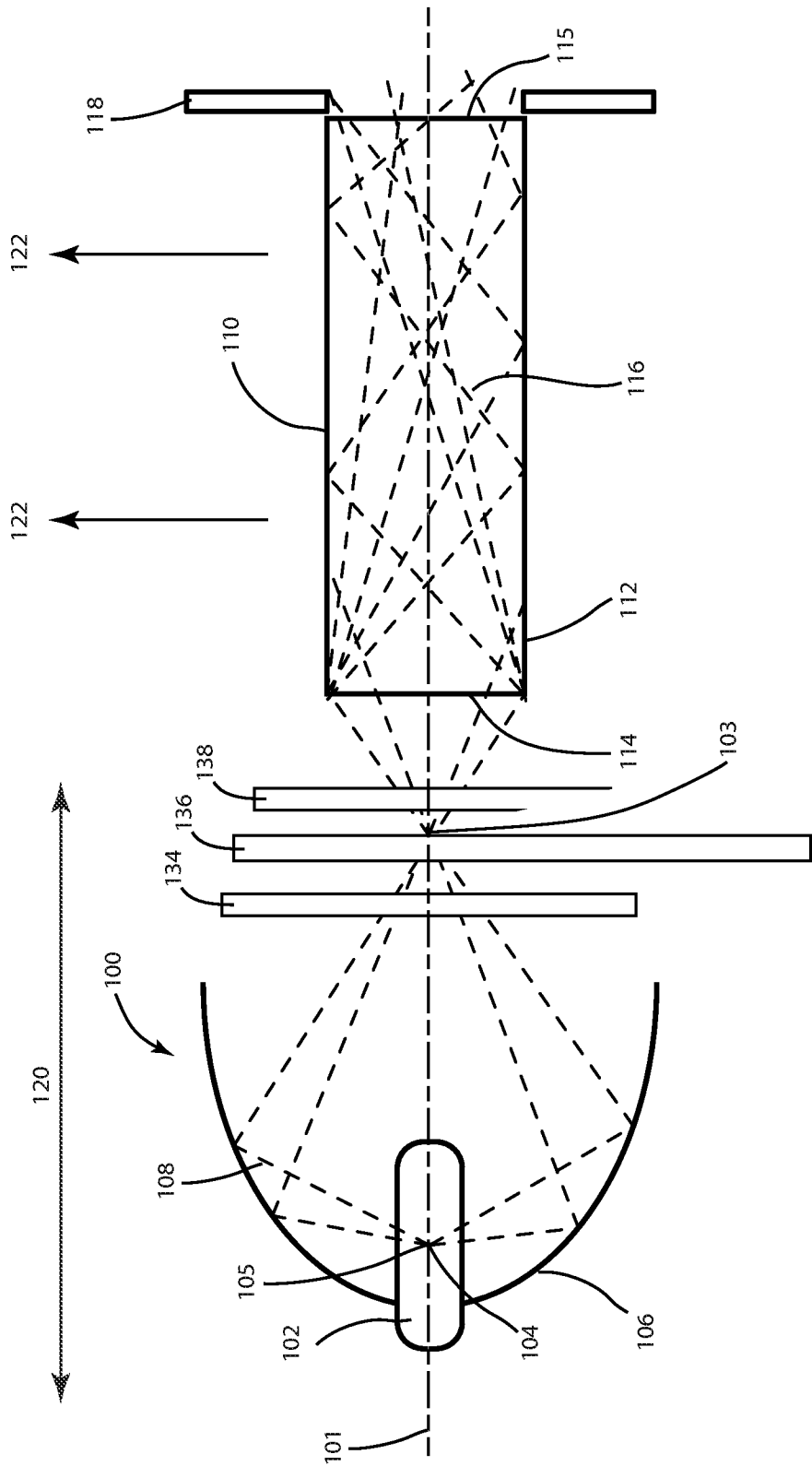
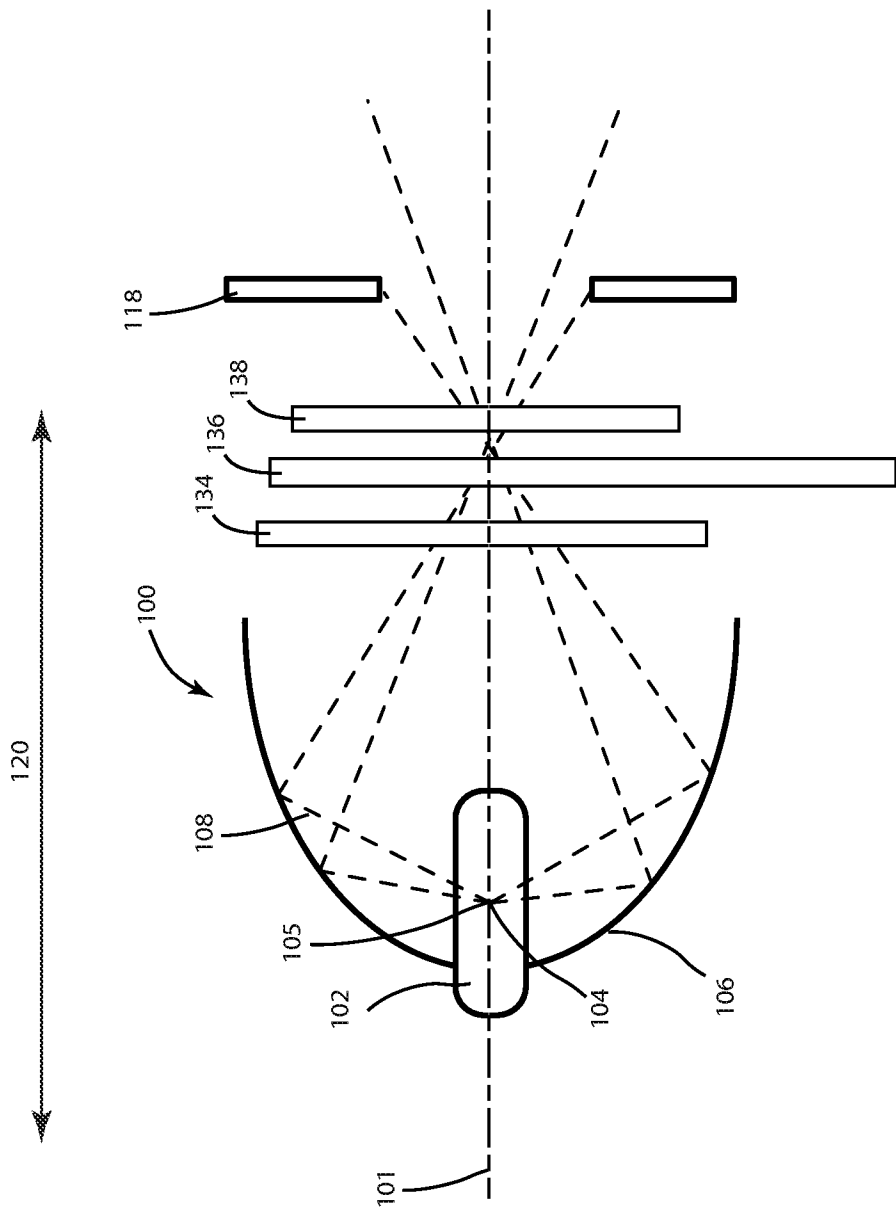


FIG 3



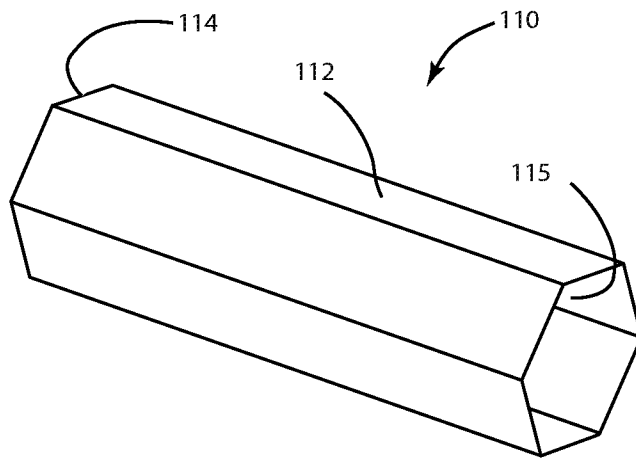
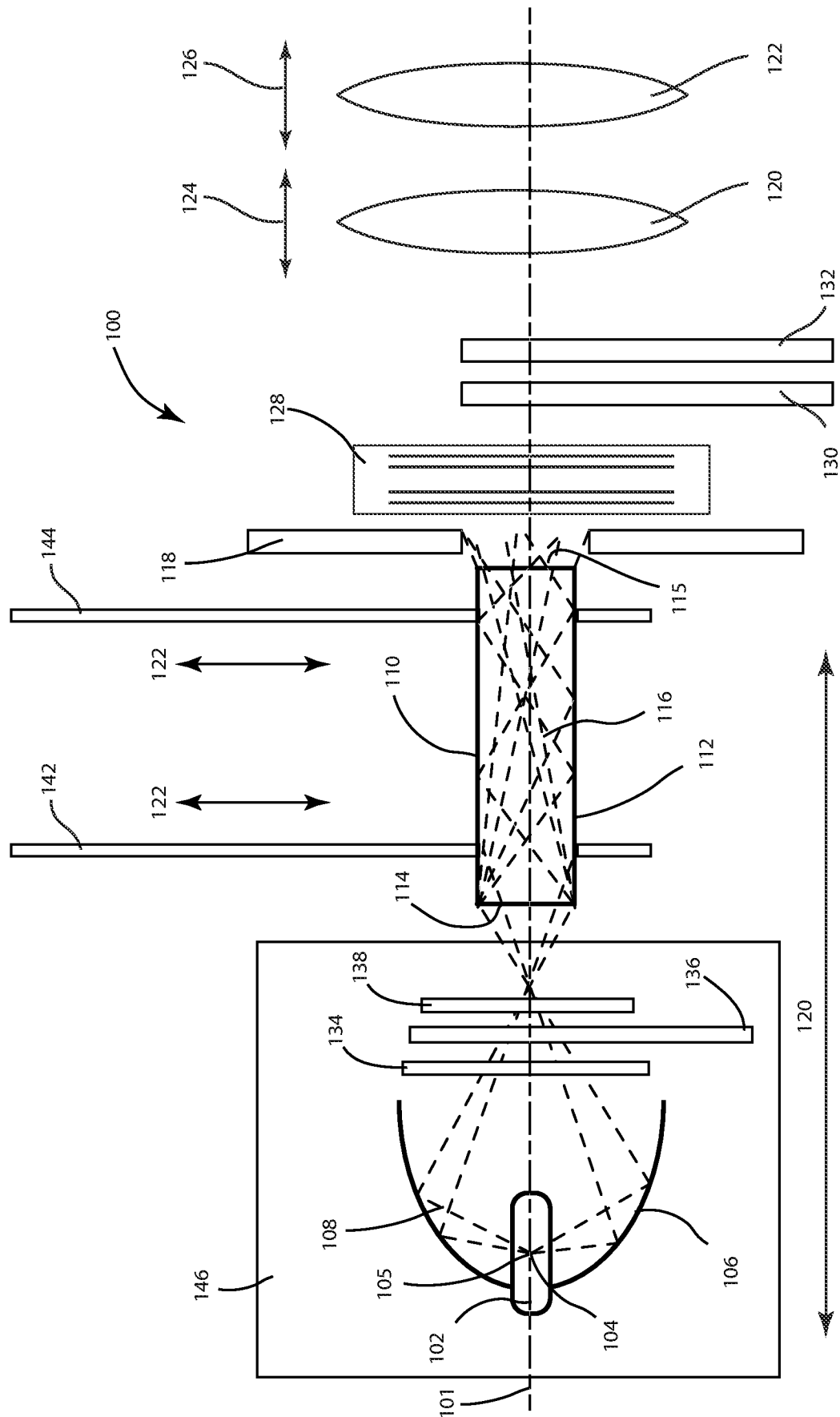


FIG 5



65E

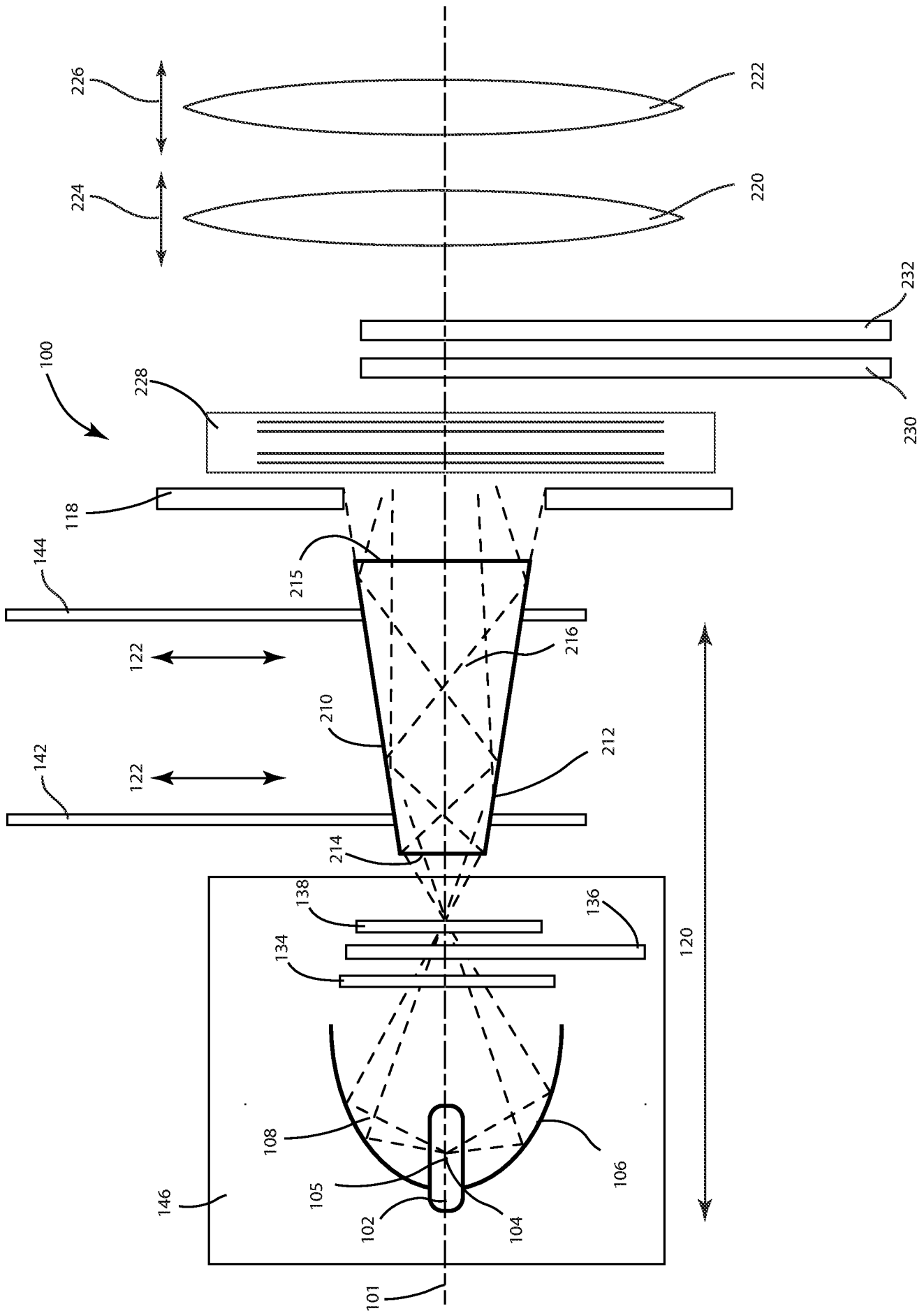


FIG 7

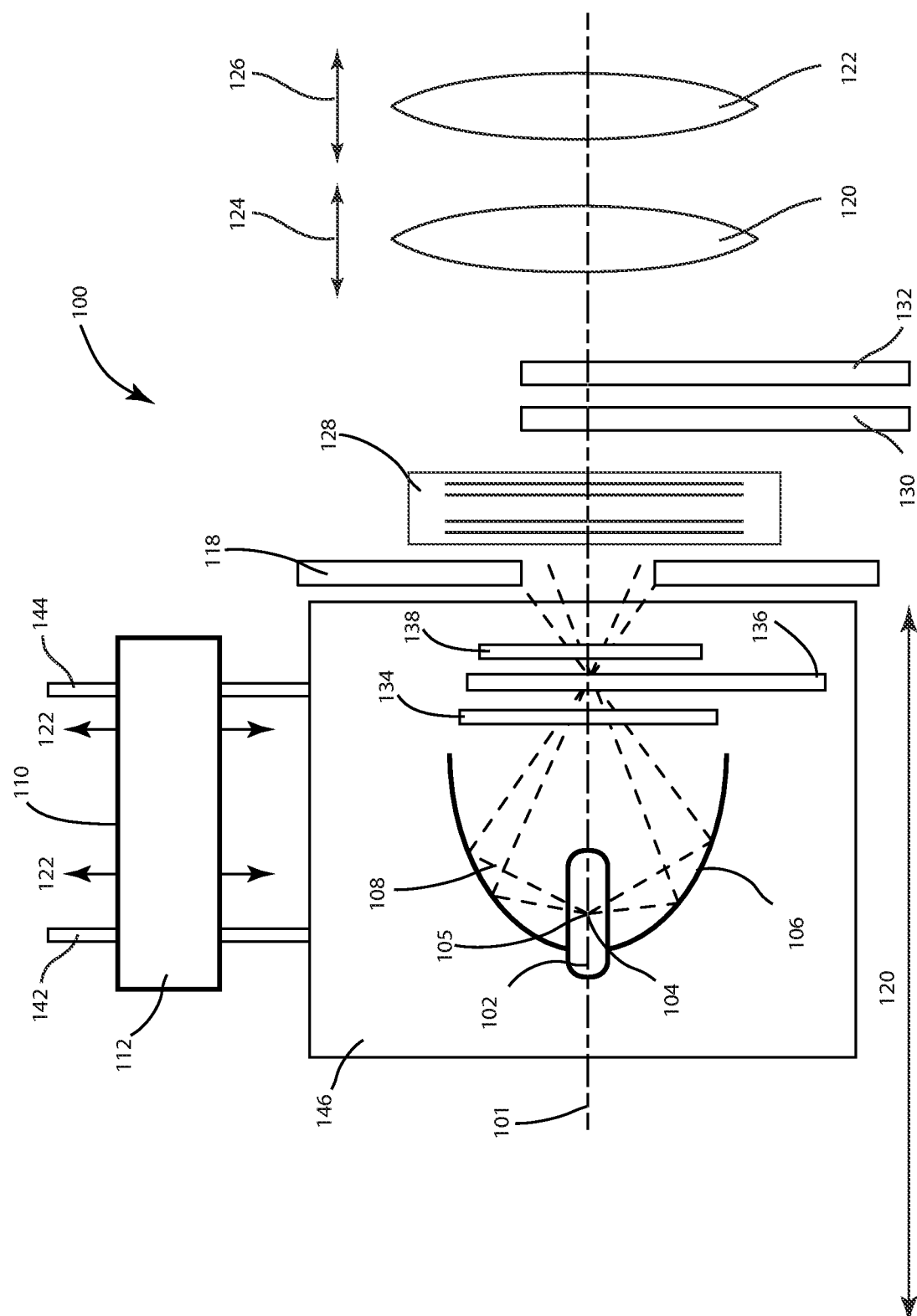


FIG 8

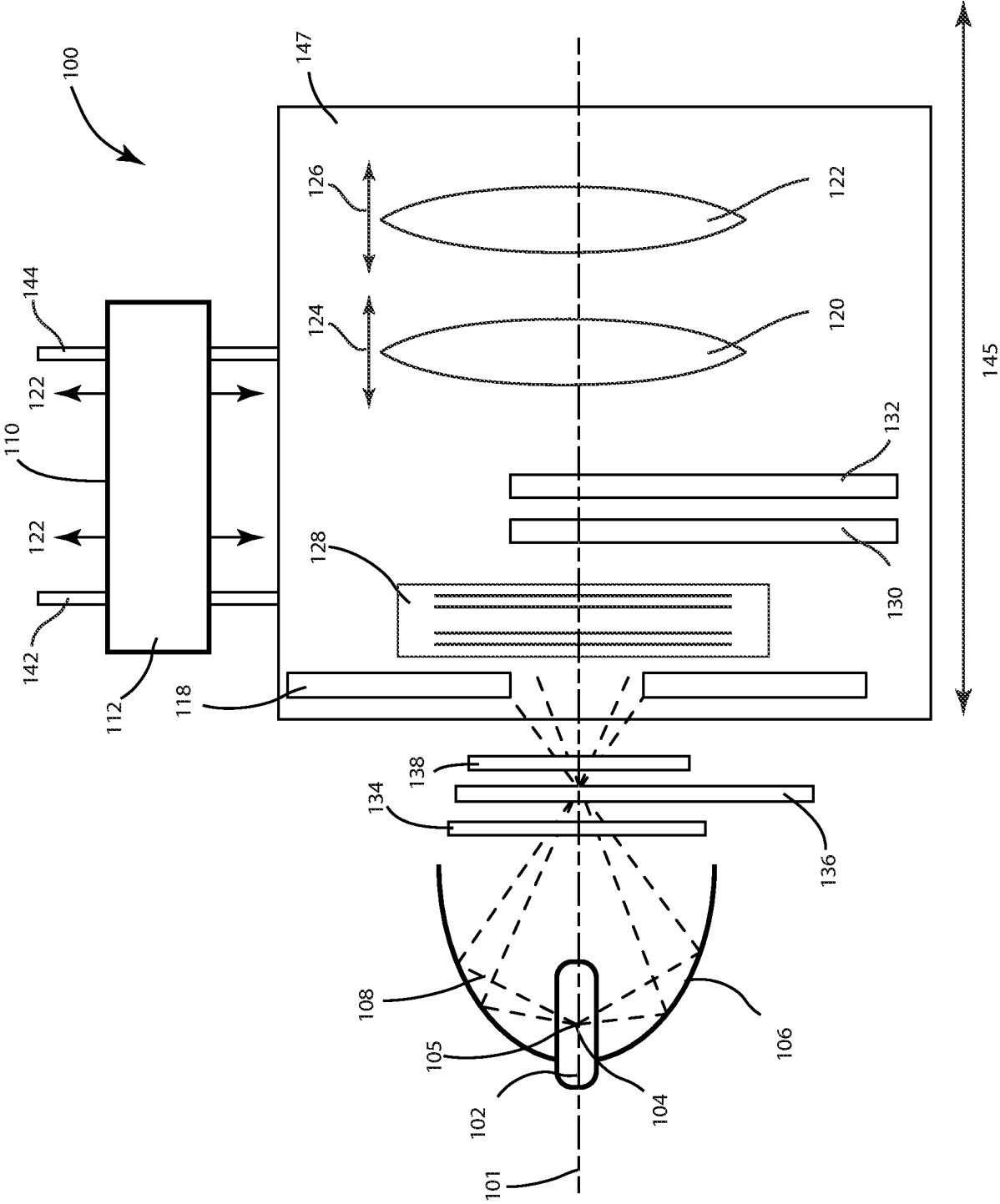


FIG 9