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(54) **REMOVABLE LENS SYSTEM FOR A LUMINAIRE**

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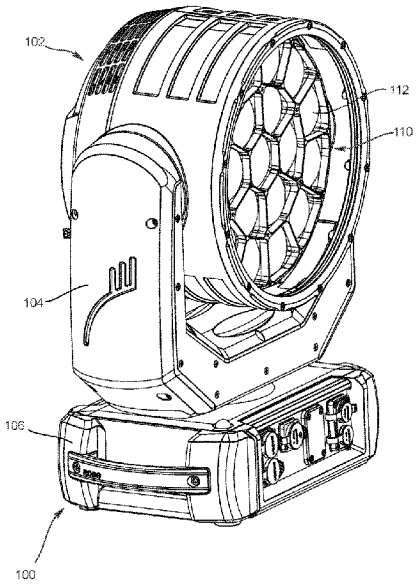
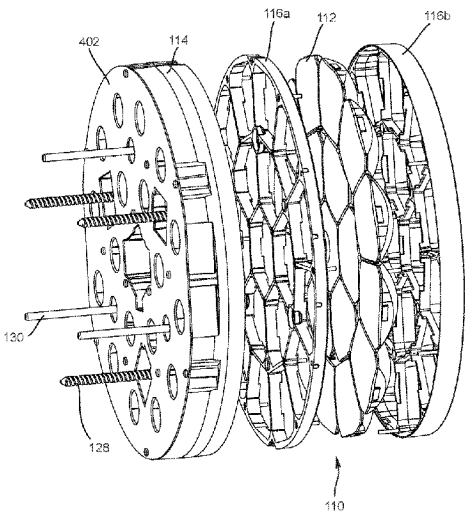
(57) **ABSTRACT**

A luminaire and optical system are provided. The luminaire includes a head and power circuits configured to provide electrical power to electrical circuits of the head. The head includes an optical system with a light source support plate, a support structure movably coupled to the light source support plate, and a lens support assembly removably coupled to the support structure. The light source support plate includes LED light sources, each configured to emit a light beam. The support structure includes a plurality of apertures, configured to pass the light beam from the LED light sources without modifying the light beam. The lens support assembly includes lenses, each aligned with an optical axis of one of the LED light sources when the lens support assembly is coupled to the support structure. The lens support assembly is removable from the head without removing the support structure from the head.

19 Claims, 5 Drawing Sheets





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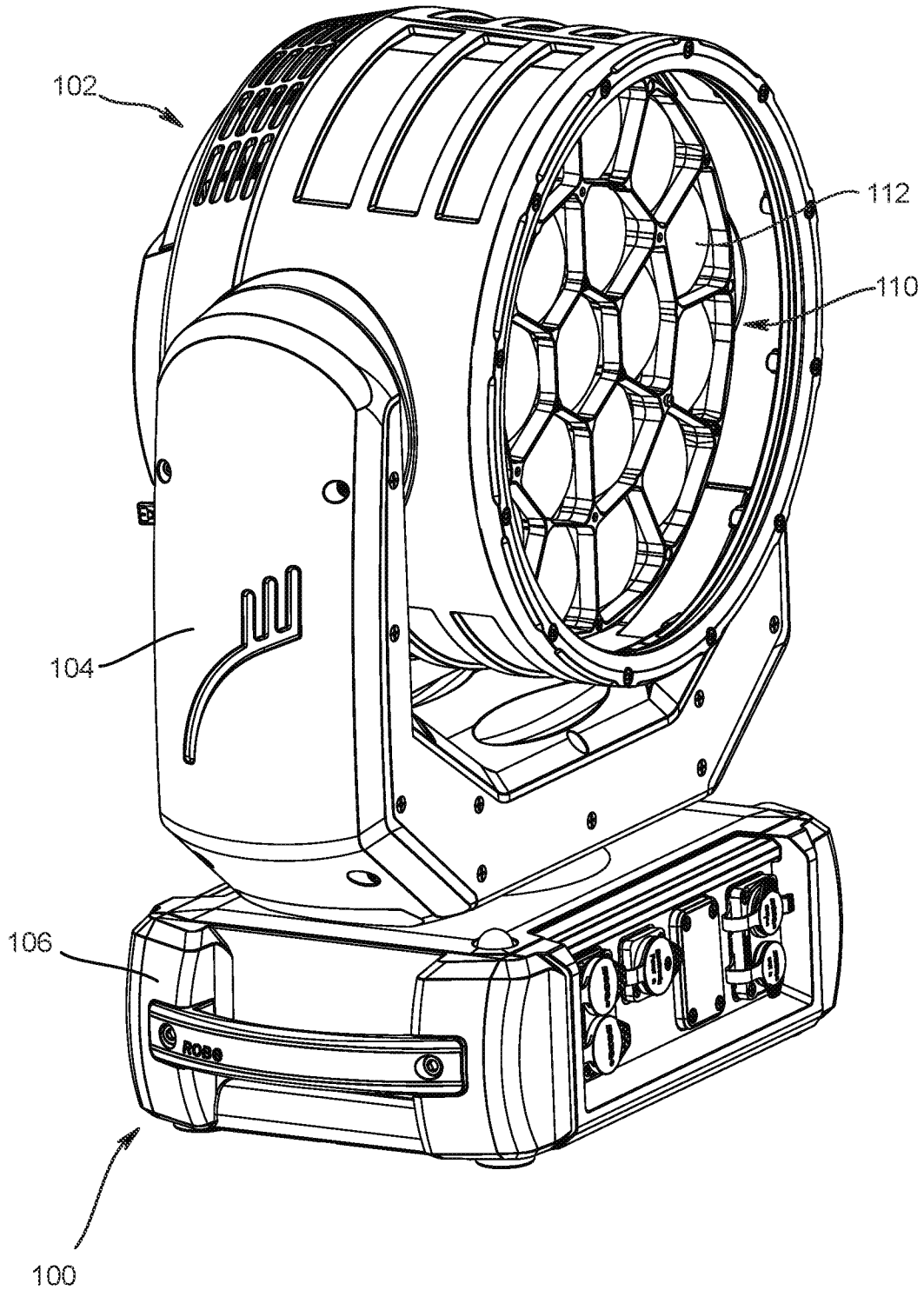

FIGURE 1

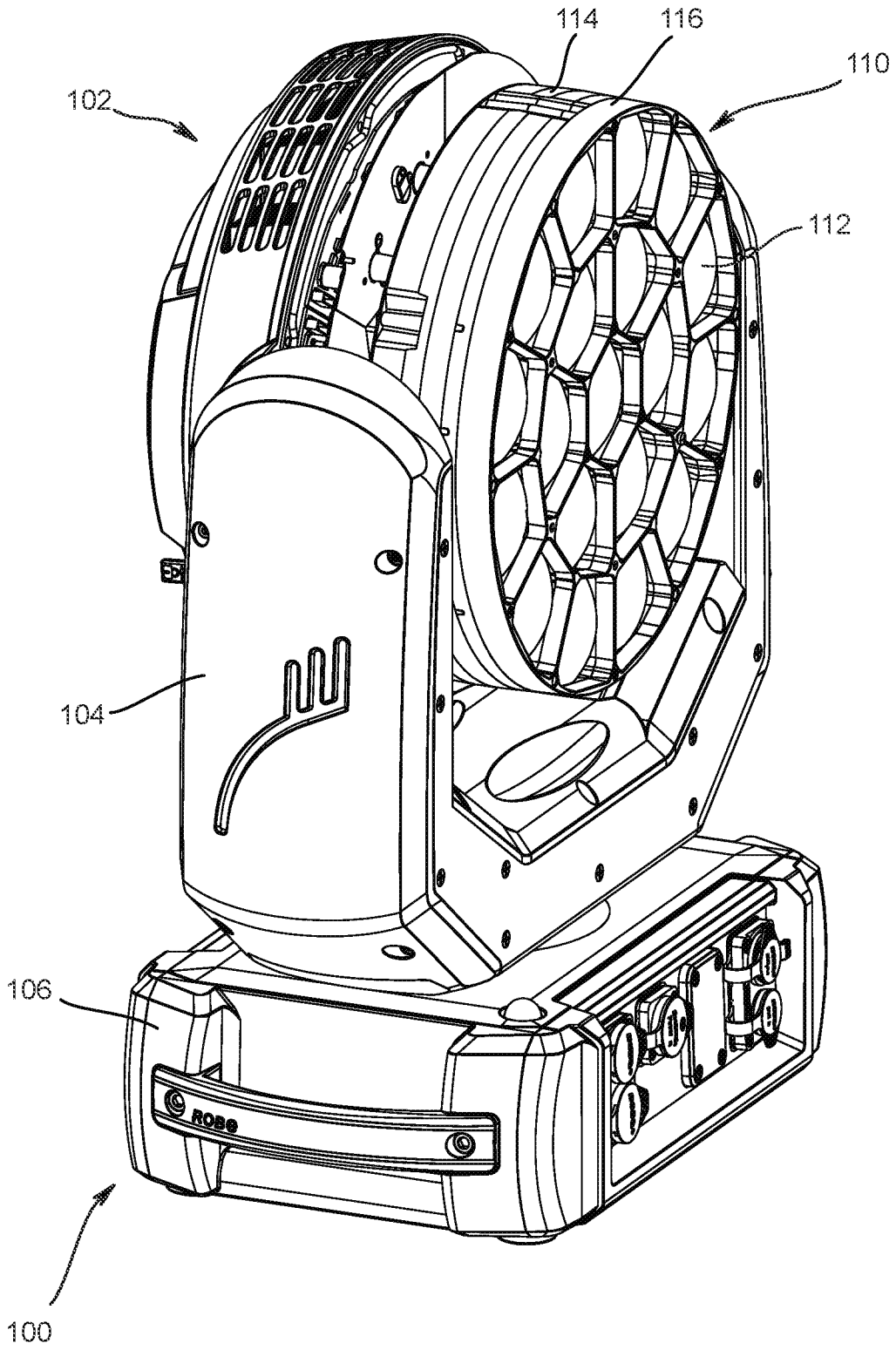

FIGURE 2

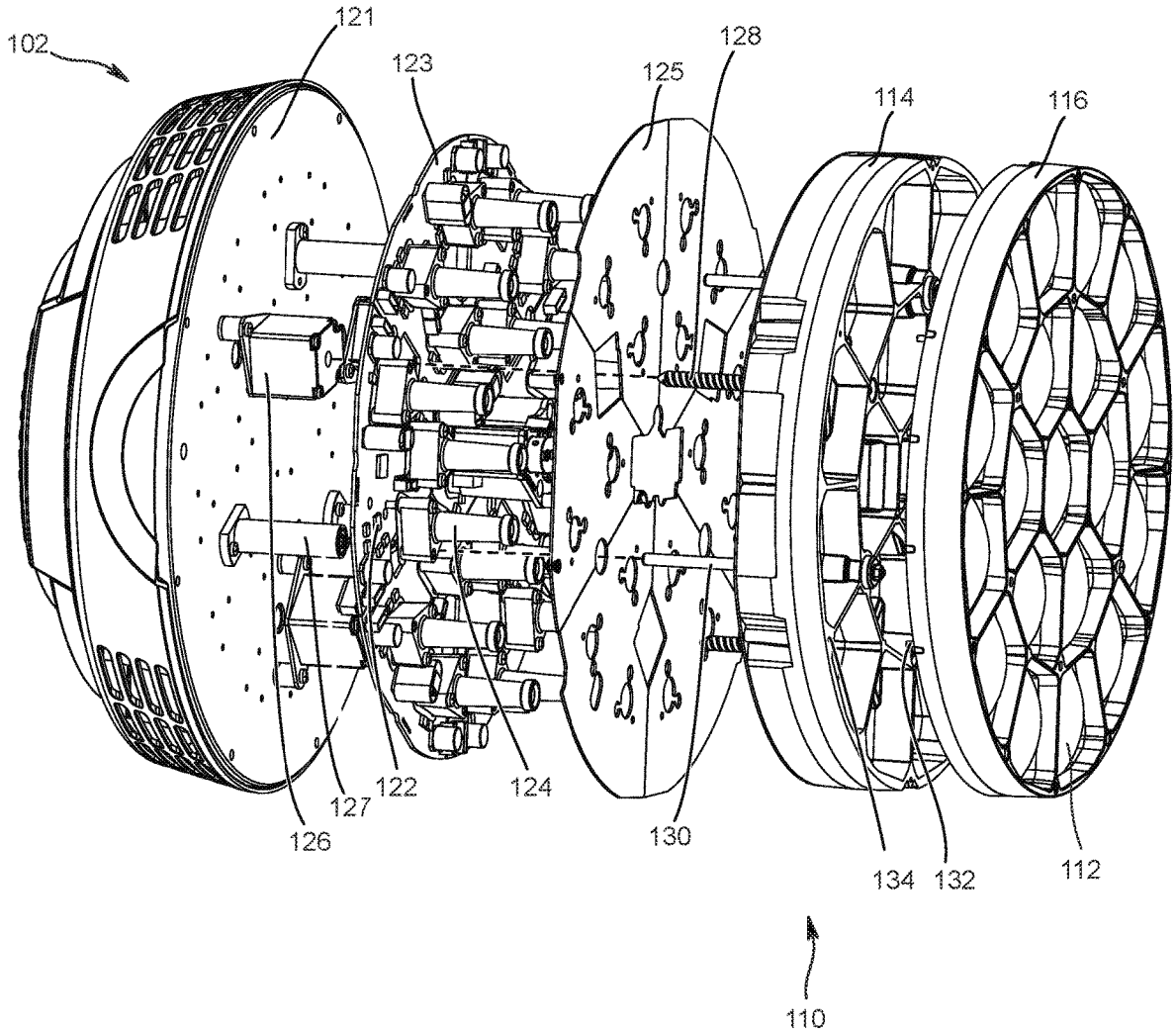

FIGURE 3

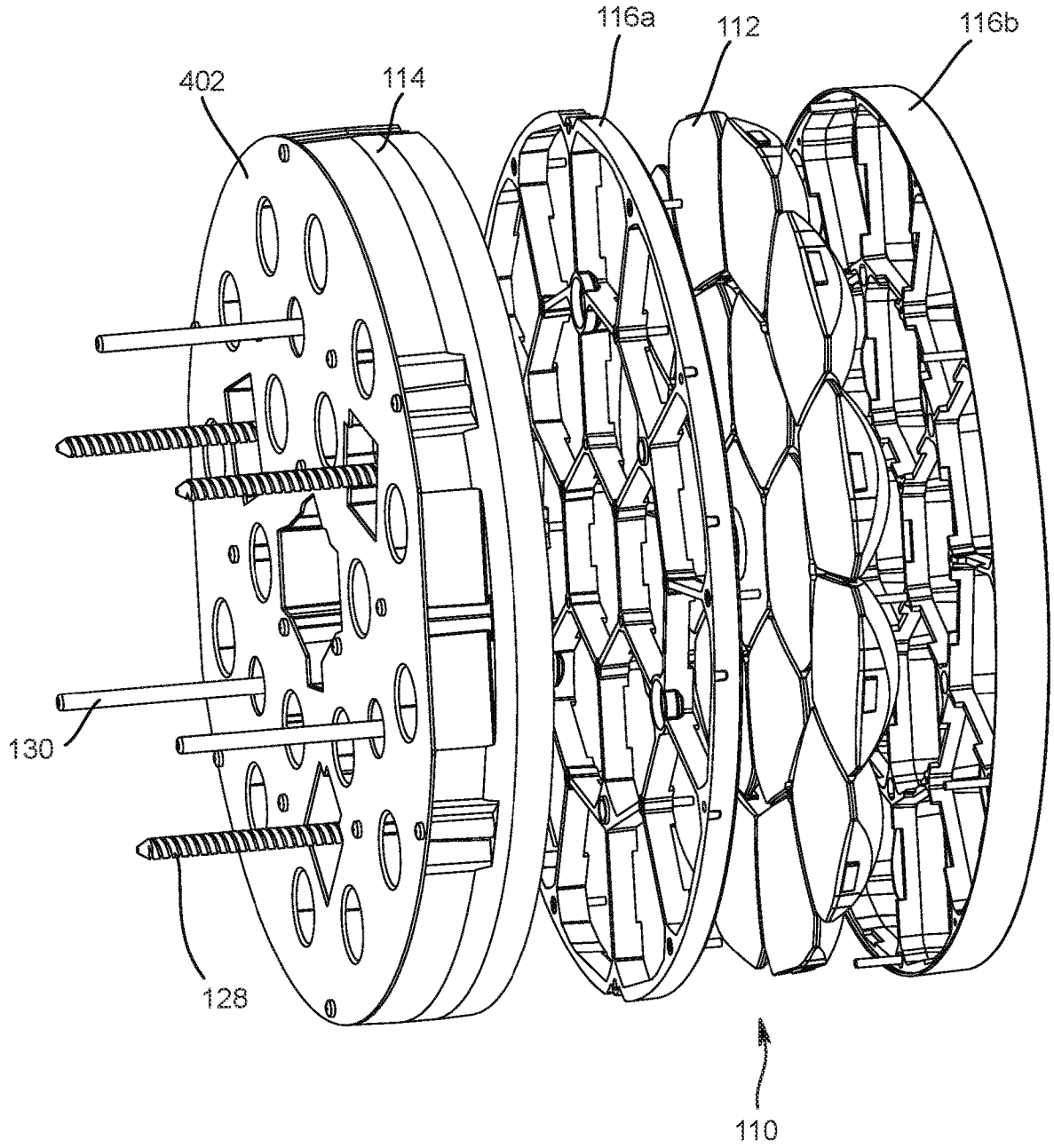

FIGURE 4

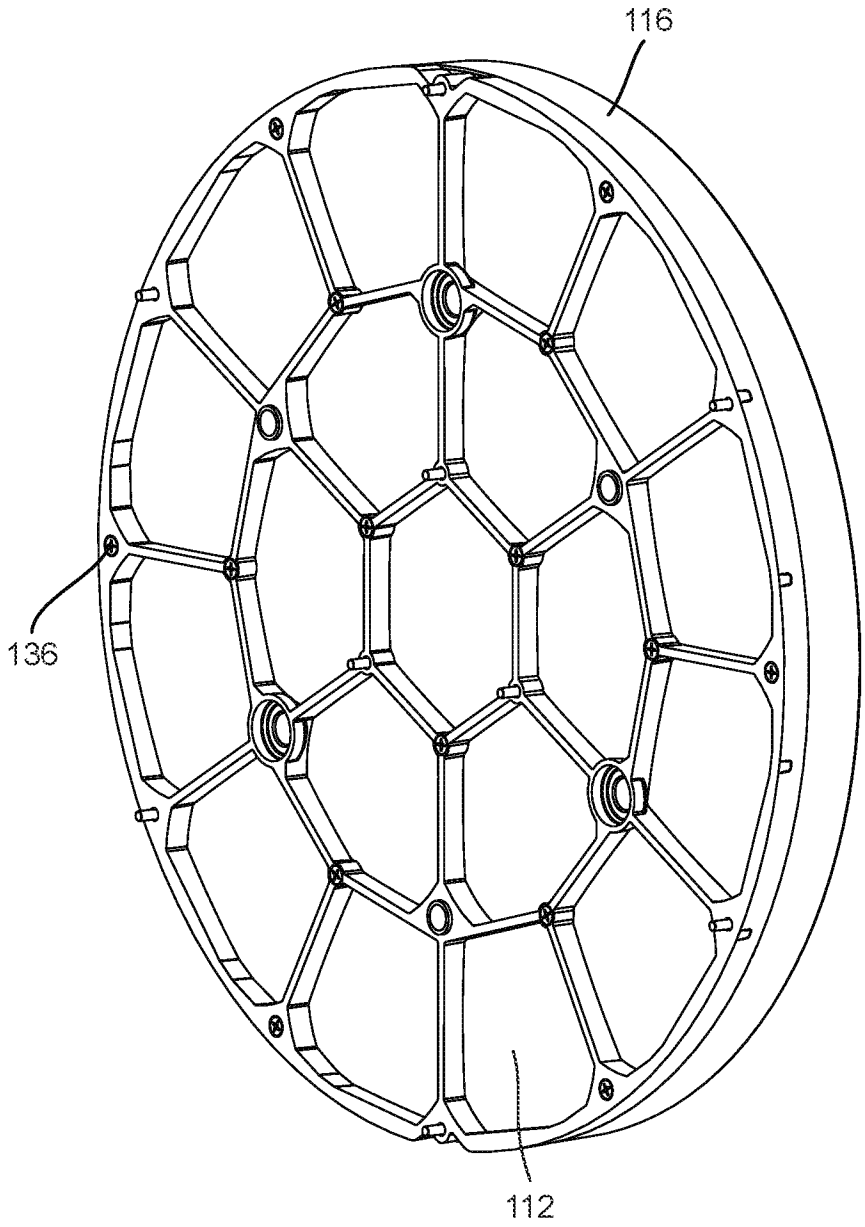

FIGURE 5

REMOVABLE LENS SYSTEM FOR A LUMINAIRE

TECHNICAL FIELD OF THE DISCLOSURE

The disclosure generally relates to luminaires, and more specifically to a system for a removable lens in a stage luminaire.

BACKGROUND

Luminaires with automated and remotely controllable functionality (referred to as automated luminaires) 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 automated luminaire provides control, from a remote location, of the output intensity, color and other functions of the luminaire allowing an operator to control such functions for many luminaires simultaneously. Many automated luminaires additionally or alternatively provide control from the remote location of other parameters such as position, focus, zoom, beam size, beam shape, and/or beam pattern of light beam(s) emitted from the luminaire.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of this disclosure, reference is now made to the following brief description, taken in conjunction with the accompanying drawings in which like reference numerals indicate like features.

FIG. **1** presents a view of a luminaire according to the disclosure;

FIG. **2** presents a view of the luminaire of FIG. **1** with some external covers removed;

FIG. **3** presents a front oblique exploded view of the head of the luminaire of FIG. **2**;

FIG. **4** presents a rear oblique exploded view of a lens support assembly according to the disclosure; and

FIG. **5** presents a rear view of the lens support assembly according to the disclosure.

SUMMARY

In a first embodiment, an optical system includes a light source support plate, a support structure movably coupled to the light source support plate, and a lens support assembly removably coupled to the support structure. The light source support plate includes a plurality of LED light sources, where each light source is configured to emit a light beam. The support structure includes a plurality of apertures, where each aperture is configured to pass the light beam from a corresponding one of the LED light sources without modifying the light beam. The lens support assembly includes a plurality of lenses and is removable from the support structure without removing the support structure from the light source support plate. Each lens is aligned with an optical axis of a corresponding one of the LED light sources when the lens support assembly is coupled to the support structure.

In a second embodiment, a luminaire includes a head and power circuits configured to provide electrical power to electrical circuits of the head. The head includes a light source support plate, a support structure movably coupled to the light source support plate, and a lens support assembly removably coupled to the support structure. The light source support plate includes a plurality of LED light sources, where each light source is configured to emit a light beam. The support structure includes a plurality of apertures, where each aperture is configured to pass the light beam from a corresponding one of the LED light sources without modifying the light beam. The lens support assembly includes a plurality of lenses where each lens is aligned with an optical axis of a corresponding one of the LED light sources when the lens support assembly is coupled to the support structure. The lens support assembly is removable from the head without removing the support structure from the head.

DETAILED DESCRIPTION

Preferred embodiments are illustrated in the figures, like numerals being used to refer to like and corresponding parts of the various drawings.

Some luminaires according to the disclosure have lens systems that include an array of multiple small lenses. Such luminaires may be used as a variable angle beam or wash lights and may use multiple colors of light emitters under control from a remotely positioned lighting desk, thus allowing an operator to control the color and intensity of the emitted light. Users of such luminaires may desire to clean the array of lenses to remove accumulated dirt, as well as residue from theatrical fog or haze or other sources. Such cleaning may be complicated by mechanisms that move the lenses to change beam angle.

Arrays of multiple small lenses may be used in luminaires having multiple light emitting diodes (LEDs) as light sources, more so than in luminaires that utilize incandescent or discharge lamps. Individual LEDs are small, but not as bright as the prior art light sources, so using them in arrays where each LED cluster has its own optical system is advantageous. A consequence of this is that such luminaires include one or more structures to support and move the array of multiple lenses relative to the LEDs. In some luminaires, such support and movement structures may complicate user access for cleaning and maintenance of the array of lenses.

Productions in which such luminaires are used may also operate theatrical fog or haze machines to provide atmosphere and emphasize lighting effects. Such theatrical fog—as well as dust and other materials in the atmosphere—can condense on surfaces such as the lenses in luminaires, diminishing light output and beam quality. Such depositions on lens arrays may be cleaned off to restore the output of the luminaire. Additionally, cleaning such depositions from a lens support assembly that holds the lenses may improve the external appearance of the luminaire.

The present disclosure describes a removable lens support assembly that enables lenses to be removed for cleaning and maintenance with reduced disassembly of the luminaire. In addition, the materials used in the manufacture of the lens support assembly also simplify cleaning by allowing the lenses and the lens support assembly to be cleaned together in a single process. Furthermore, the lens support assembly simplifies maintenance of the lenses by allowing removal from the luminaire and transport to a workspace of only the lens support assembly, rather than the entire luminaire Once at the workspace, a technician has a simpler task of disassembling only the lens support assembly to enable replacement of damaged lenses. This is in contrast to the more extensive disassembly of the luminaire in order to extract the damaged lenses as required by other luminaire designs.

FIG. **1** presents a view of a luminaire **100** according to the disclosure. The luminaire **100** comprises a head **102** which, in turn, includes an array of lenses **112** through which pass light beams emitted by corresponding light emitters. The

lenses **112** are mounted in a lens assembly **110**. In the example shown, the lens assembly **110** includes nineteen lenses, however other numbers of lenses may be used in other embodiments. The head **102** is mounted in a yoke assembly **104** that, in turn, is mounted on a base **106**. The yoke assembly **104** is rotatably mounted on the base **106** to provide rotation about a pan axis and the head **102** is rotatably mounted in the yoke assembly **104** to provide rotation about a tilt axis. The base **106** includes power circuits configured to provide electrical power to electrical circuits of one or more of the base **106**, the yoke assembly **104**, and the head **102**.

FIG. **2** presents a view of the luminaire **100** of FIG. **1** with some external covers removed. The lens assembly **110** comprises a support structure **114** and a lens support assembly **116**. The lenses **112** are mounted in the lens support assembly **116**.

FIG. **3** presents a front oblique exploded view of the head **102** of the luminaire **100** of FIG. **2**. The lens support assembly **116** is shown as separated from the support structure **114**. The luminaire head **102** includes LED light sources **122**, mounted on a light source support plate (or PCB) **123**. Each LED light source **122** has an associated homogenizing optical system **124**. The LED light sources **122** and the triangular bottom portions of their homogenizing optical systems **124** are covered by a light shield **125** that reduces light emitting from the LED light sources **122** and the triangular bottom portions of the homogenizing optical systems **124** from spilling onto and through the lenses of the lens support assembly **116**. The head **102** is shown in FIG. **3** with external covers removed only for clarity of illustration. In some embodiments, the lens support assembly **116** may be uncoupled from the support structure **114** without removal of the external covers.

The LED light sources **122** may comprise one or more LED emitters in the same or multiple colors. In some embodiments, the LED emitters may be red, green, blue, and white. Any other mix of colors or white LED emitters may be used in other embodiments. Such embodiments may include red, green, blue, or amber LED emitters, warm white or cold white LED emitters, or a tunable mix of white LED emitters. The homogenizing optical systems **124** may comprise light pipes, lenses, diffusing material, or other optical components suitable for homogenizing light from the associated LED light sources **122**.

Each LED light source **122** and its associated homogenizing optical system **124** emits a light beam that passes through a corresponding aperture of the support structure **114**. The light beam is not modified by the aperture of the support structure **114**. Each light beam then passes through a corresponding one of the lenses **112**, the corresponding lens **112** aligned with an optical axis of the LED light source **122** emitting the light beam.

To alter a beam angle of the light output of the luminaire **100**, the lens assembly **110** is moved toward and away from the luminaire head **102**, thereby moving the lenses **112** along their optical axes toward and away from the LED light sources **122** and the homogenizing optical systems **124**. In the embodiment shown, this movement is caused by stepper motors **126** and associated lead screws **128**. The stepper motors **126** are attached to a motor support plate **121**. Each stepper motor **126** is coupled at its output shaft to the associated lead screw **128**. The lead screws **128** engage with corresponding travel nuts that are fixedly mounted to the support structure **114**. As the stepper motors **126** and the lead screws **128** rotate, the support structure **114** is moved toward and away from the light source support plate **123** along linear support rods **130**. As such, the support structure **114** is moveably coupled to the light source support plate **123**. The linear support rods **130** are fixedly attached to the support structure **114** and slide within corresponding bearing sleeves **127**, which are fixedly mounted to the motor support plate **121**.

The lead screws **128** and the linear support rods **130** operate to maintain alignment of the apertures of the support structure **114**, as well as the lenses **112**, with their corresponding LED light sources **122**. In other embodiments, other mechanical systems may be used to move the lens assembly **110** toward and away from the luminaire head **102** while maintaining alignment of the apertures of the support structure **114**, as well as the lenses **112**, with their corresponding LED light sources **122**.

In some embodiments, the motor support plate **121** is a metal plate comprising aluminum or copper (or a similar material with high heat transmissivity). In such embodiments, the PCB **123** is mounted on the motor support plate **121**, enabling heat from the light sources **122** and the PCB **123** to transfer to the heatsinks attached to a rear side of the motor support plate **121**.

The lens support assembly **116** is removably coupled to the support structure **114** by one or more releasable fasteners **132**. In the embodiment shown in FIG. **3**, the releasable fasteners **132** are screws which pass through the lens support assembly **116** and engage with corresponding threaded holes **134** in the support structure **114**. In some embodiments, nuts or captive nuts may be used instead of the threaded holes **134**. In other embodiments, the releasable fasteners **132** may comprise other types of releasable fasteners, e.g., captive screws. In still other embodiments, the releasable fasteners **132** may comprise fasteners that do not require a tool to unfasten (quick release fasteners), e.g., clips, slide latches, or quarter turn fasteners.

The user undoes the one or more releasable fasteners **132** that couple the lens support assembly **116** to the support structure **114** in order to remove only the lens support assembly **116** for cleaning of the lenses **112**. The complete lens support assembly **116**, including the lenses **112**, may then be cleaned—with access to both sides of lenses **112**—without the need for further disassembly of the luminaire head **102** or the lens support assembly **116**. Disassembly of the support structure **114**, the lead screws **128**, the linear support rods **130**, and/or the homogenizing optical systems **124** is not required for cleaning the lens support assembly **116** and the lenses **112**.

FIG. **4** presents a rear oblique exploded view of the lens support assembly **116** according to the disclosure. The support structure **114** is shown separate from the head **102** only for context. In use, when the lens support assembly **116** is removed from the head **102** and the luminaire **100**, the support structure **114** remains in the head **102**, with the lead screws **128** coupled to their associated stepper motors **126** and the linear support rods **130** engaged with their corresponding bearing sleeves **127**. The support structure **114** includes a light shield **402** that comprises individual circular orifices through which the homogenizing optical systems **124** extend.

The walls of the ribs of the support structure **114** form apertures in the support structure **114**. Each homogenizing optical system **124** emits a light beam from its associated LED light source **122**. Each light beam passes through a corresponding aperture of the support structure **114**. Each light beam then passes through a corresponding one of the lenses **112**, the corresponding lens **112** aligned with an optical axis of the LED light source **122** emitting the light

beam. The light beams emitted from the homogenizing optical system **124** are not modified by the apertures of the support structure **114**. However, the circular orifices of the light shield **402** and the walls of the ribs of the support structure **114** reduce other light within the head **102** from spilling onto and through the lenses of the lens support assembly **116**.

The lens support assembly **116** is shown in FIG. **4** exploded into a rear plate **116***a* and a front plate **116***b* (also referred to as support section plates), between which are clamped the individual lenses **112**. The rear plate **116***a* and the front plate **116***b* are configured to clamp the individual lenses **112** at their edges, to reduce or avoid modification of the light beams passing through the individual lenses **112**, as well as to prevent light spilling from one lens **112** to another lens **112**.

The rear plate **116***a* and the front plate **116***b* of the lens support assembly **116** are shown separated in FIG. **4** only for clarity of explanation. The lens support assembly **116** may remain assembled for cleaning, but may be disassembled for cleaning and/or replacement of individual lenses. As such, the front plate **116***b* is removably coupled to the rear plate **116***a*. Similar to coupling the lens support assembly **116** to the support structure **114**, the rear plate **116***a* and the front plate **116***b* may be coupled by screws or other suitable fasteners, such as screws **136**, visible in FIG. **5**.

The support section plates **116***a* and **116***b* are constructed of materials that are selected to allow the entire lens support assembly **116**, including the lenses **112**, to be cleaned in a single process, using the same cleaning materials used to clean the individual lenses **112**. One such process is manual cleaning with a cloth plus a cleaning fluid of some kind. The fluid could be water, water plus detergent, isopropyl alcohol, or a commercial lens cleaning fluid. Another such process is cleaning in a dishwasher with detergent. In some embodiments, a commercial dishwasher may be used to clean the lenses at a higher temperature and/or in less time than in a residential dishwasher. Such a process may be used where lens support assemblies **116** from a large number of luminaires are to be cleaned at the same time.

The support section plates **116***a* and **116***b* may comprise a metal (e.g., magnesium alloy, aluminum or an aluminum alloy, or other suitable metal) or a plastic material with a heat deflection temperature of at least 125° Celsius, to avoid shape deformation during the washing process (e.g., Nylon 6, Polycarbonate, or a polymer filled or reinforced with a glass fiber). In further embodiments, one of the support section plates **116***a* and **116***b* may comprise a metal and the other comprise a plastic material. Such a combination of materials may reduce cracking of the lenses **112** caused by differential heat expansion of the support section plates **116***a* and **116***b*.

FIG. **5** presents a rear view of the lens support assembly **116** according to the disclosure. It may be seen in FIG. **5** that the rear surfaces of the lenses **112** are available for cleaning.

Some luminaires permit cleaning only the front surfaces of lenses and require the disassembly of multiple components of the luminaire head to access the back side of the lenses. In order to remove the lenses from such luminaires, steps such as removing luminaire head covers, unscrewing leadscrew nuts from their associated leadscrews, and pulling the linear support rods from their bearing sleeves may be required. The back side of the lenses can then be accessed, but the linear support rods remain extending from the back side of such a lens assembly and have lubrication on their surfaces. Cleaning the lenses or disassembly of the lens assembly to remove individual lenses for replacement may require removal of the linear support rods and/or their relubrication after replacement. When the lens assembly is returned to the luminaire, all linear support rods must be simultaneously reseated in their bearing sleeves, the leadscrew nuts reattached and adjusted to ensure the lens assembly is parallel to the plane of the luminaire light sources, and the luminaire head covers reattached.

A luminaire according to the disclosure solves such problems by requiring only the removal of the lens support assembly **116** from the luminaire **100** to clean both sides of the lenses and/or to replace lenses. No other components of the head **102** remain attached to the lens support assembly **116** to interfere with such activities. The support structure **114** remains in the luminaire **100** and thus, the travel nuts remain attached to the lead screws **128** and the linear support rods **130** remain seated in the bearing sleeves **127**. Furthermore, the lens support assembly **116** is configured to be cleaned in the same process used to clean the lenses **112**. Additionally, for individual lens replacement, the lens support assembly **116** may easily be removed and taken to a workbench for disassembly and replacement of one or more lenses.

While only some embodiments of the disclosure have been described herein, 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 herein. While 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. An optical system comprising:

a light source support plate comprising a plurality of LED light sources, wherein each light source is configured to emit a light beam;

a support structure, movably coupled to the light source support plate, wherein the support structure comprises a plurality of apertures, each aperture configured to pass the light beam from a corresponding one of the LED light sources without modifying the light beam; and

a lens support assembly, removably coupled to the support structure, wherein:

the lens support assembly comprises a plurality of lenses, each lens aligned with an optical axis of a corresponding one of the LED light sources when the lens support assembly is coupled to the support structure,

the lens support assembly comprises a front plate removably coupled to a rear plate, the front plate and the rear plate configured, when coupled together, to clamp the lenses of the plurality of lenses into position, and

the lens support assembly is removable from the support structure without removing the support structure from the light source support plate.

2. The optical system of claim **1**, wherein the lens support assembly is removably coupled to the support structure by a quick release fastener.

3. The optical system of claim **1**, wherein the front plate is removably coupled to the rear plate by a quick release fastener.

4. The optical system of claim **1**, wherein the front plate and the rear plate comprise materials selected to allow the front plate, the rear plate, and the plurality of lenses to be cleaned in a single process.

5. The optical system of claim 4, wherein the lens support assembly is configured to be cleaned in a commercial dishwasher.

6. The optical system of claim 4, wherein one of the front plate and the rear plate comprises a metal and another one of the front plate and the rear plate comprises a plastic.

7. The optical system of claim 4, wherein the front plate and the rear plate each comprises a material having a heat deflection temperature of at least 125° Celsius.

8. The optical system of claim 4, wherein the lens support assembly is removably coupled to the support structure by a quick release fastener.

9. A luminaire comprising:

a head comprising:

a light source support plate comprising a plurality of LED light sources, wherein each light source is configured to emit a light beam;

a support structure, movably coupled to the light source support plate, wherein the support structure comprises a plurality of apertures, each aperture configured to pass the light beam from a corresponding one of the LED light sources without modifying the light beam; and

a lens support assembly, removably coupled to the support structure, wherein:

the lens support assembly comprises a plurality of lenses, each lens aligned with an optical axis of a corresponding one of the LED light sources when the lens support assembly is coupled to the support structure,

the lens support assembly comprises a front plate removably coupled to a rear plate, the front plate and the rear plate configured, when coupled together, to clamp the lenses of the plurality of lenses into position, and

the lens support assembly is removable from the head without removing the support structure from the head; and

power circuits configured to provide electrical power to electrical circuits of the head.

10. The luminaire of claim 9, further comprising:

a yoke assembly, wherein the head is rotatably mounted in the yoke assembly for rotation about a tilt axis.

11. The luminaire of claim 10, further comprising:

a base, wherein the yoke assembly is rotatably mounted to the base for rotation about a pan axis.

12. The luminaire of claim 9, wherein the lens support assembly is configured to be removed from the head without removing an external cover of the head.

13. The luminaire of claim 9, wherein the lens support assembly is removably coupled to the support structure by a releasable fastener.

14. The luminaire of claim 13, wherein the releasable fastener comprises a quick release fastener.

15. The luminaire of claim 13, wherein the releasable fastener comprises a screw.

16. The luminaire of claim 9, wherein the front plate and the rear plate comprise materials selected to allow the front plate, the rear plate, and the plurality of lenses to be cleaned in a single process.

17. The luminaire of claim 16, wherein the lens support assembly is configured to be cleaned in a commercial dishwasher.

18. The luminaire of claim 16, wherein one of the front plate and the rear plate comprises a metal and another one of the front plate and the rear plate comprises a plastic.

19. The luminaire of claim 16, wherein the front plate and the rear plate each comprises a material having a heat deflection temperature of at least 125° Celsius.

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