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(54) **LUMINAIRE WITH ARTICULATED LEDS**

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F21V 21/15 (2006.01)
F21V 15/01 (2006.01)
(Continued)

(52) **U.S. Cl.**
CPC ***F21V 21/15*** (2013.01); ***F21V 7/0091*** (2013.01); ***F21V 14/02*** (2013.01); ***F21V 15/01*** (2013.01);
(Continued)

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CPC F21V 21/15; F21V 7/0091; F21V 14/02; F21V 15/01; F21V 21/30; F21Y 2115/10
See application file for complete search history.

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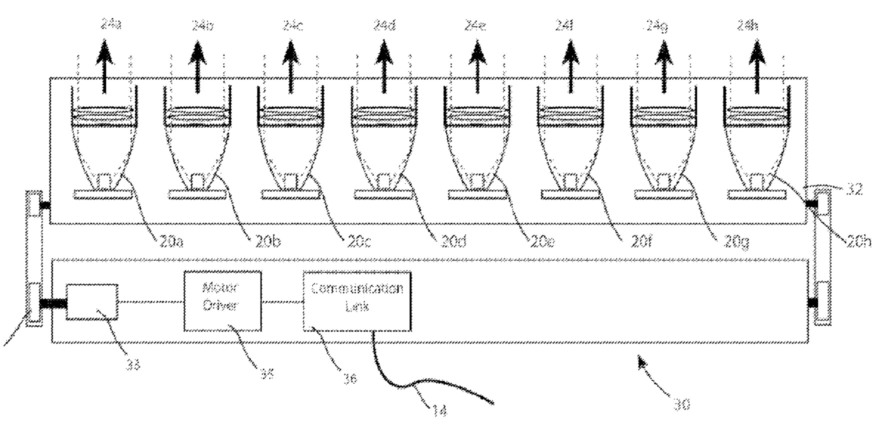
(57) **ABSTRACT**

Described is a method for controlling the movement of LED devices in luminaires, specifically to a method relating to allowing both synchronized and independent pan and tilt movement of LED light modules in a light curtain. The LEDs may be mounted in a plurality of modules. The modules may be in a linear arrangement. The LEDs may be mounted in a plurality of modules that are arrayed in a two dimensional array. The modules in the linear arrangement or in the two dimensional array may be mounted in groups forming modular group assemblies where modular group assembly are independently articulated to pan and/or tilt the modules mounted thereon independent of other modular group assemblies.

10 Claims, 10 Drawing Sheets



(51) **Int. Cl.**

F21V 14/02	(2006.01)
F21V 7/00	(2006.01)
F21V 21/30	(2006.01)
F21W 131/406	(2006.01)
F21Y 105/00	(2016.01)
F21Y 115/10	(2016.01)
F21Y 101/00	(2016.01)

(52) **U.S. Cl.**

CPC ***F21V 21/30*** (2013.01); *F21W 2131/406* (2013.01); *F21Y 2101/00* (2013.01); *F21Y 2105/00* (2013.01); *F21Y 2115/10* (2016.08)

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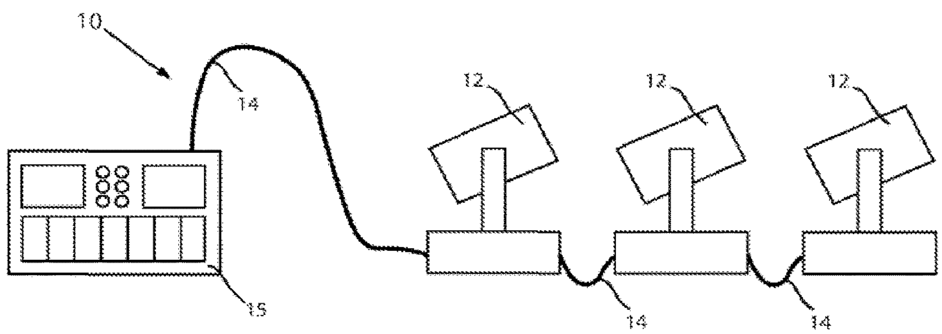
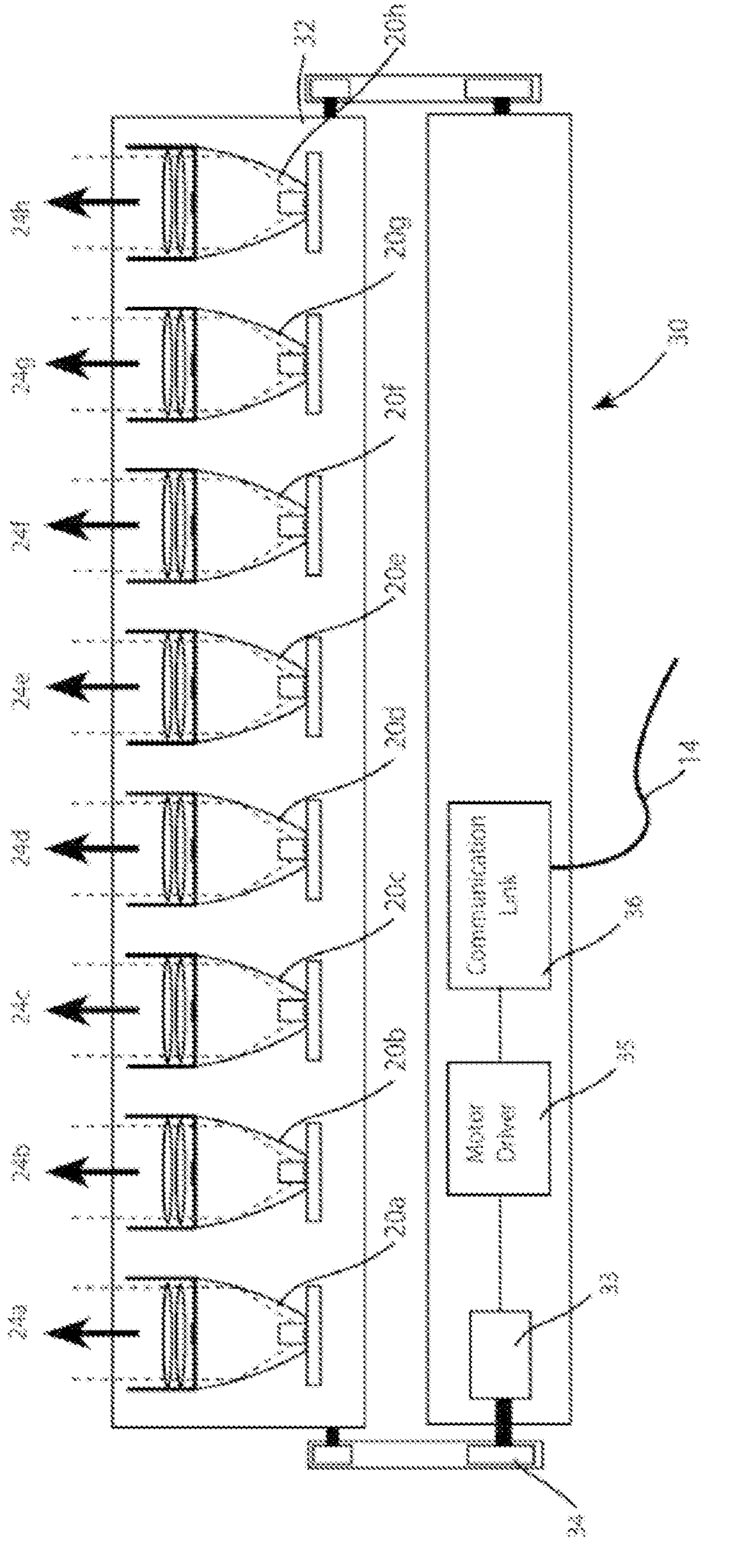


FIG 1
Prior Art


32
20h
20g
20f
20e
20d
20c
20b
20a
24h
24g
24f
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24d
24c
24b
24a
30
14
Communication Link
36
Motor Driver
35
33
34

FIG 2

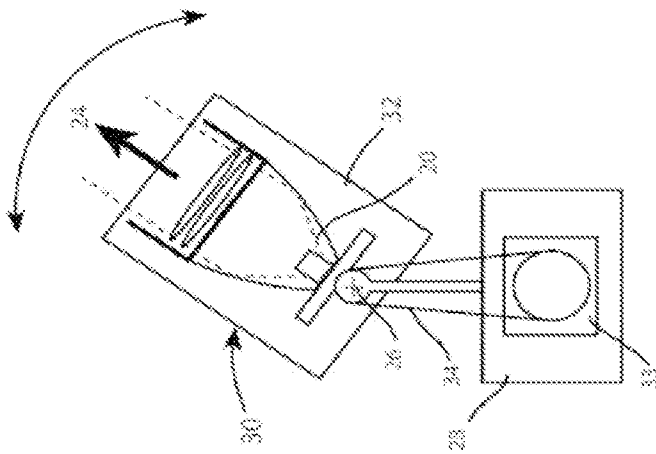


FIG 5

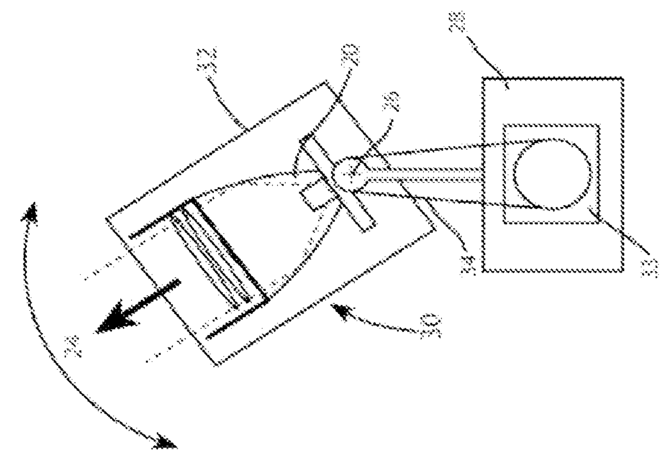


FIG 4

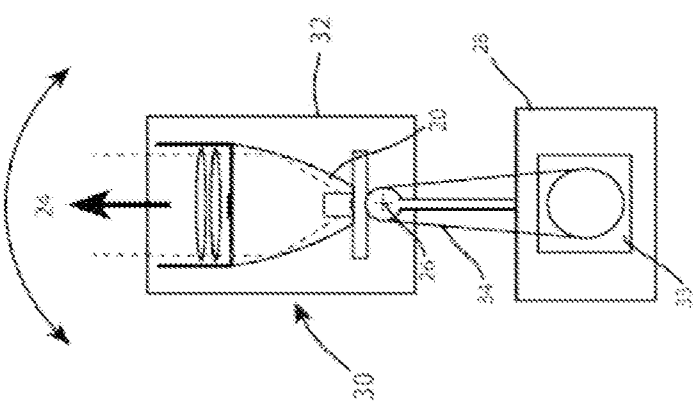
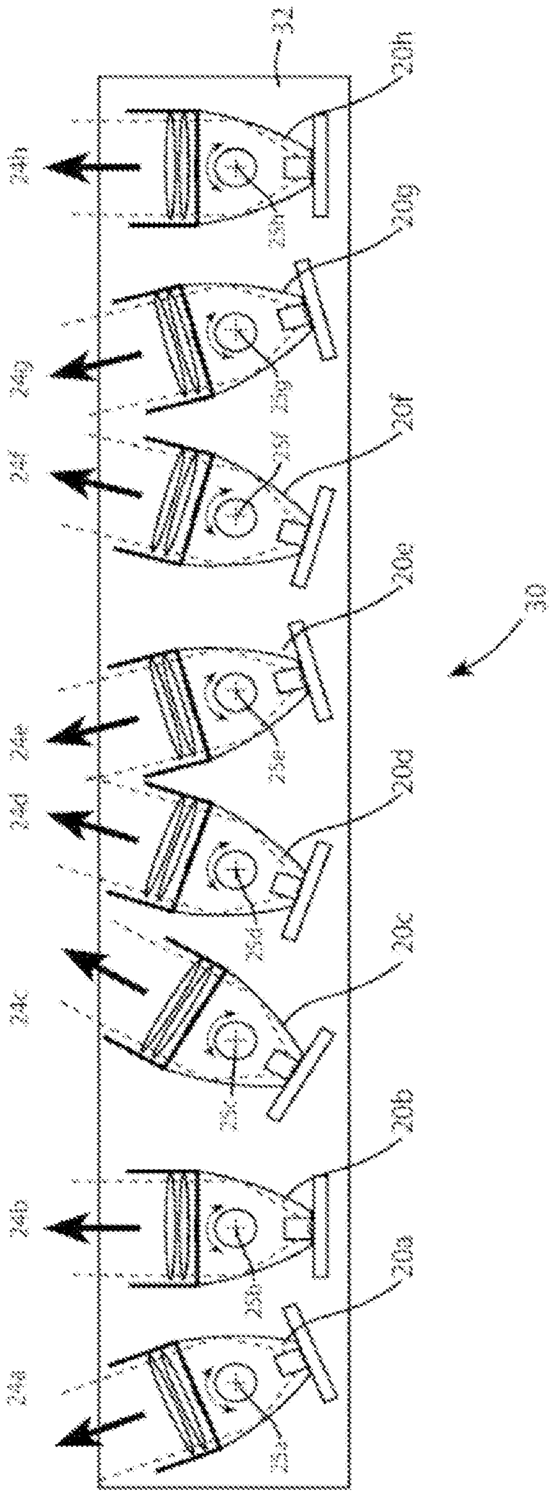


FIG 3


32
20h
24h
25h
20g
24g
25g
20f
24f
25f
30
20e
24e
25e
20d
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20c
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20b
24b
25b
20a
24a
25a

FIG 6

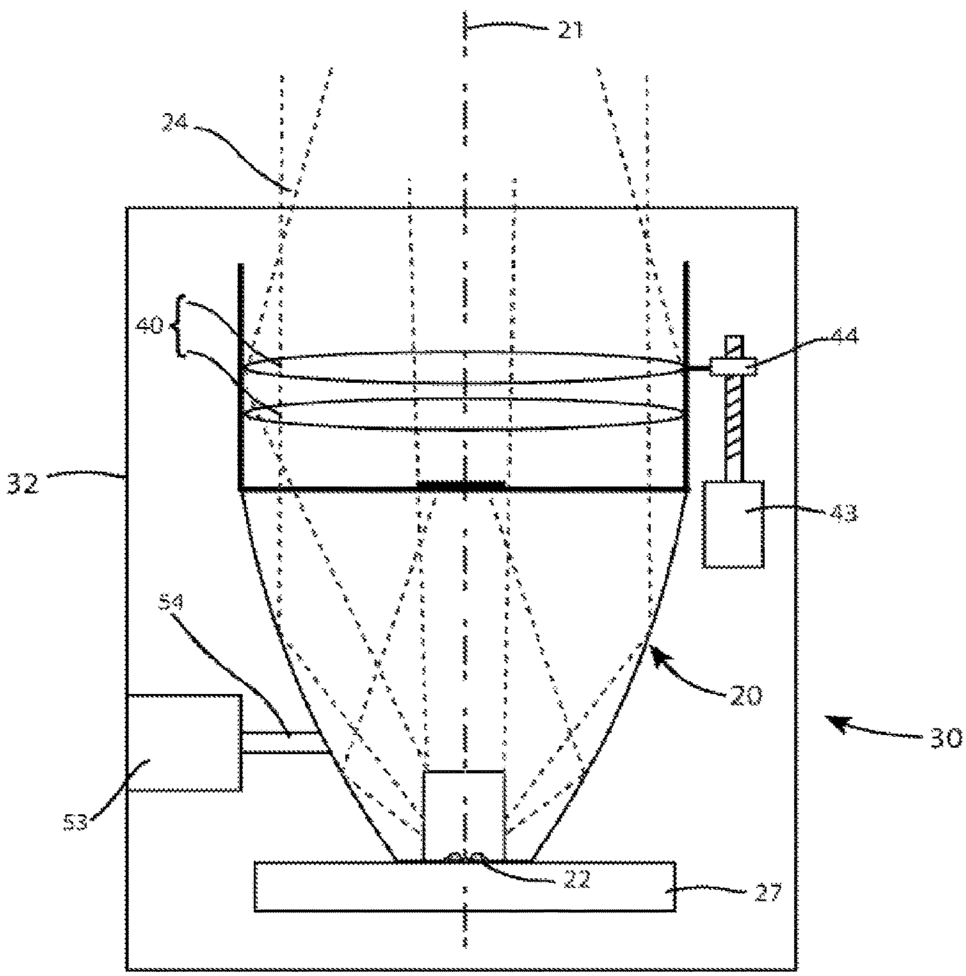

FIG 7

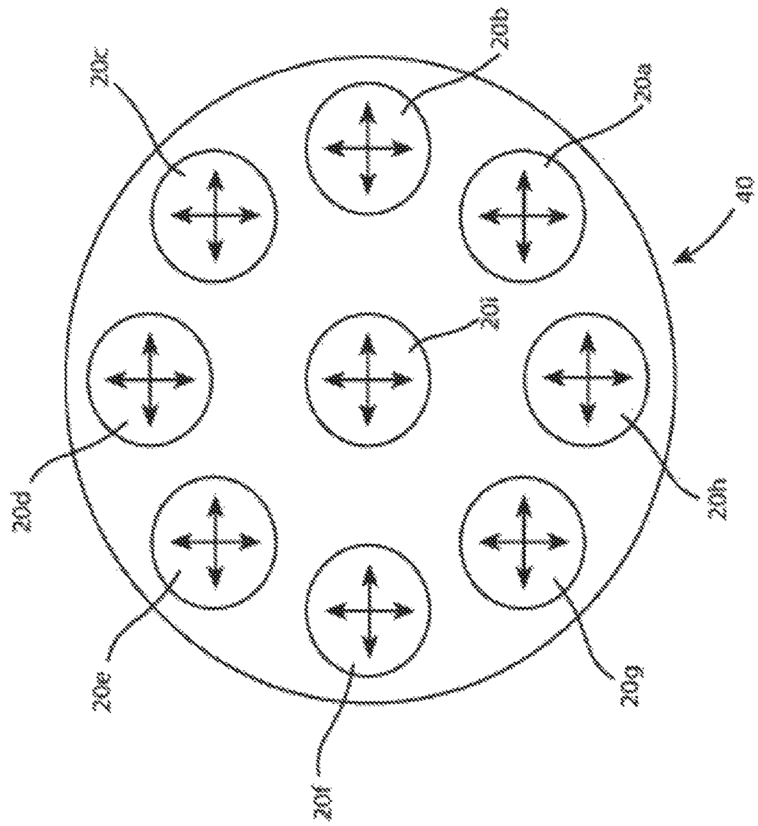

FIG 8

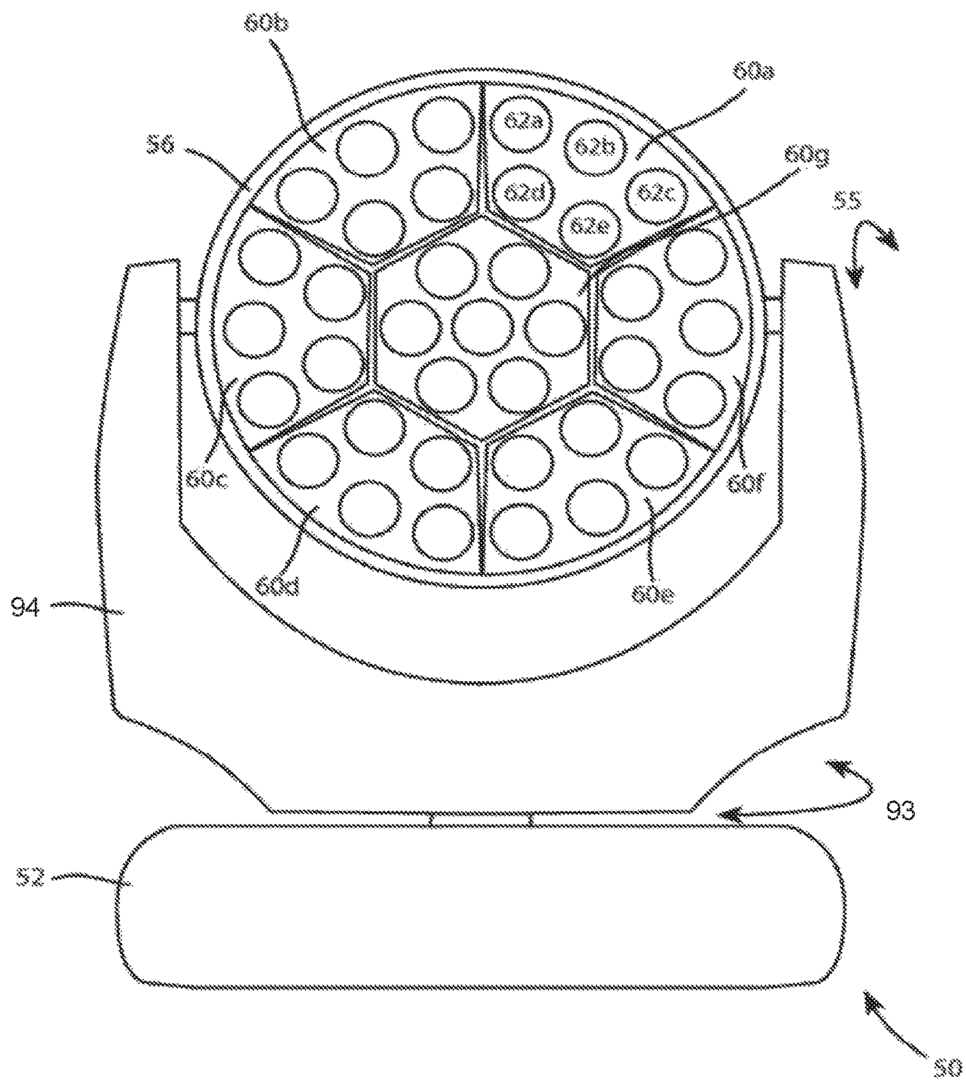

FIG 9

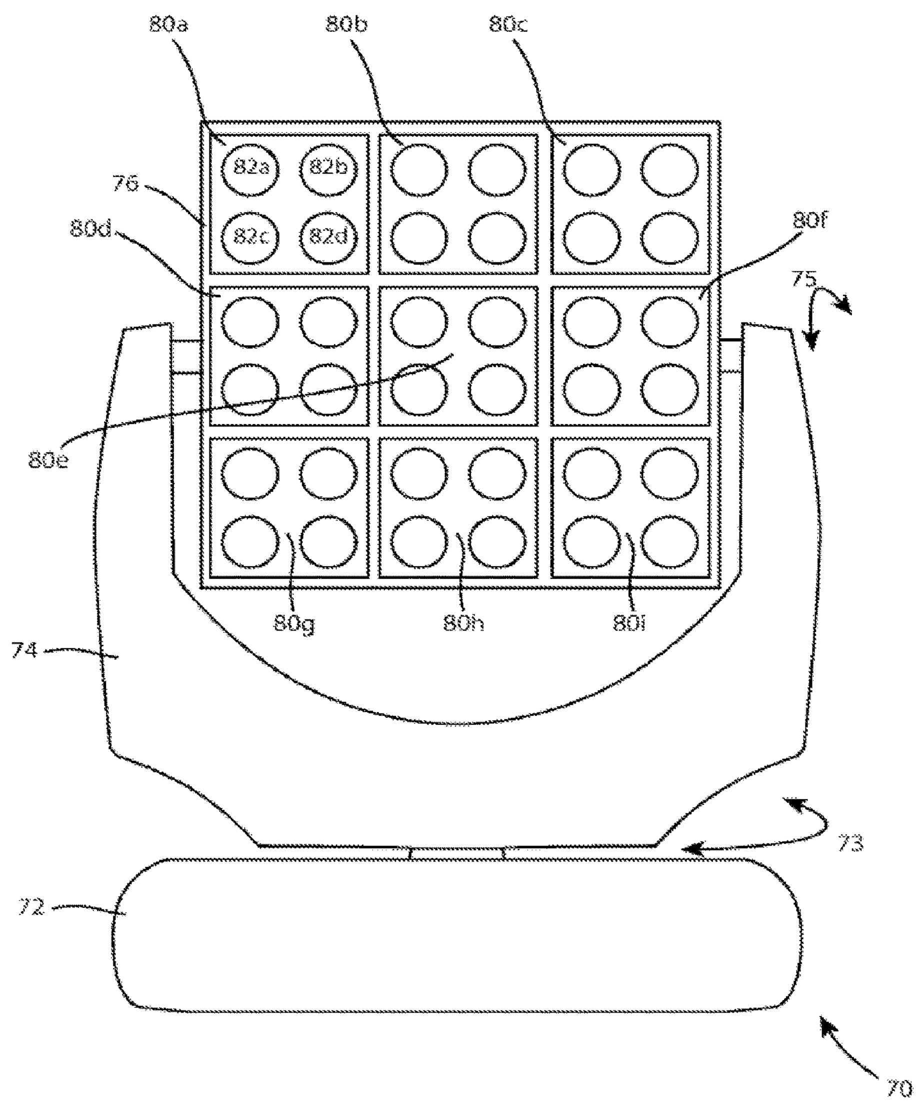
80a
80b
80c
82a
82b
82c
82d
76
80d
80f
75
80e
80g
80h
80i
74
73
72
70

FIG 10

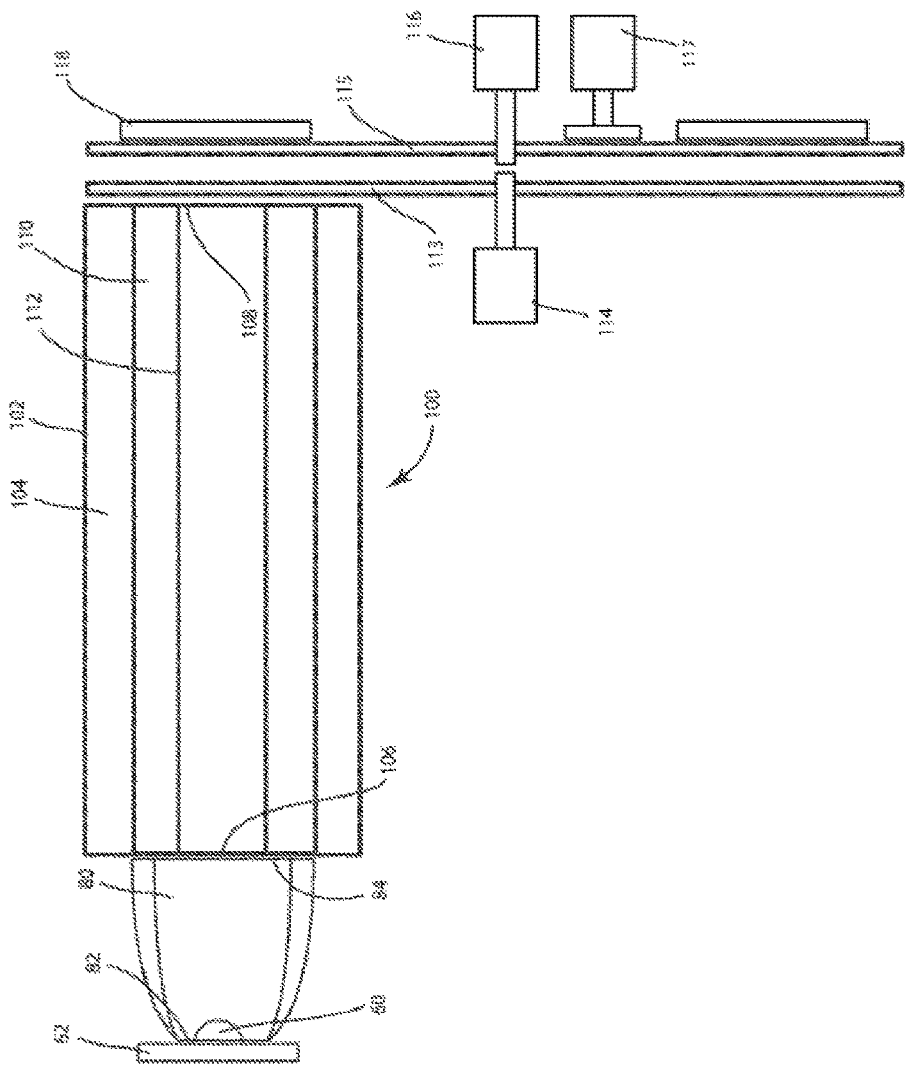

FIG 11

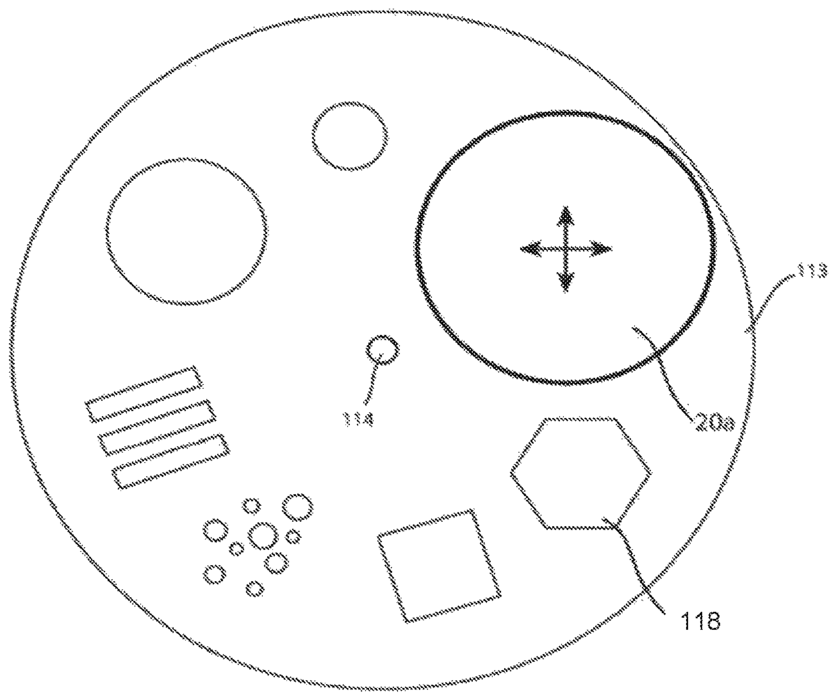

FIG 12

LUMINAIRE WITH ARTICULATED LEDS

CROSS-REFERENCE TO RELATED APPLICATIONS

This application is a U.S. National stage of International Patent Application No. PCT/US2014/066478 filed Nov. 20, 2014 by Pavel Jurik, et al. entitled, "Luminarie with Articulated LEDs", which claims priority to U.S. Provisional Application No. 61/950,381 filed Mar. 10, 2014 by Pavel Jurik, et al. entitled, "Method for Controlling the Movement of LEDs in a Luminarie". International Patent Application No. PCT/US2014/066478 also claims priority to U.S. Provisional Application No. 61/907,818 filed Nov. 22, 2013 by Pavel Jurik, et al. entitled, "System and Method for Controlling the Movement of LEDs in a Luminarie."

TECHNICAL FIELD OF THE DISCLOSURE

The present disclosure generally relates to a method for controlling the movement of light emitting diode (LED) devices in luminaires, specifically to a method relating to allowing both synchronized and independent movement of LEDs in a light curtain.

BACKGROUND OF THE DISCLOSURE

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 provide control over the functions of the luminaire allowing the operator to control the intensity and color of the light beam from the luminaire that is shining on the stage or in the studio. Many products also provide control over other parameters such as the position, focus, beam size, beam shape and beam pattern. In such products that contain light emitting diodes (LEDs) to produce the light output it is common to use more than one color of LEDs and to be able to adjust the intensity of each color separately such that the output, which comprises the combined mixed output of all LEDs, can be adjusted in color. For example, such a product may use red, green, blue, and white LEDs with separate intensity controls for each of the four types of LED. This allows the user to mix almost limitless combinations and to produce nearly any color they desire.

FIG. **1** illustrates a typical multiparameter automated luminaire system **10**. These systems typically 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 drive 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 automated luminaire system **10** is typically controlled by an operator through the control desk **15**.

A known arrangement for luminaires used in the entertainment or architectural market is that of a light curtain. A light curtain consists of a row or line of light emitters arranged so that they produce a plane of light, like a curtain thus the name. Prior art automated products have allowed the combined movement of all the light emitters together in tilting or rocking motion so as to be able to direct the curtain of light as desired. An example of such a prior art luminaire is the CycFX 8 from Robe Lighting. However, the prior art devices don't allow individual light emitters in the curtain to be adjusted from position(s) independently of each other. Such adjustment would be useful, as it would allow the user or lighting designer to produce converging or diverging curtains, and to direct the light more accurately where it is needed. It would also be useful with other shapes and types of luminaires, not just light curtains, to be able to individually adjust the position of individual light emitters.

There is a need for a method for controlling the movement of LED devices in luminaires, specifically to a method relating to allowing both synchronized and independent movement of LEDs in a light curtain or other luminaires.

BRIEF DESCRIPTION OF THE DRAWINGS

For a more complete understanding of the present disclosure 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:

FIG. **1** illustrates a multiparameter automated luminaire lighting system;

FIG. **2** illustrates an embodiment of a luminaire with a linear arrangement of a plurality of light emitting modules;

FIG. **3** illustrates the global tilting motion of the light emitting modules in an embodiment of the luminaire illustrated in FIG. **2** where the modules are centrally oriented;

FIG. **4** illustrates the global tilting motion of the light emitting modules in an embodiment of the luminaire illustrated in FIG. **2** where the modules are tilted off of the central orientation illustrated in FIG. **3**;

FIG. **5** illustrates the global tilting motion of the light emitting modules in an embodiment of the luminaire illustrated in FIG. **2** where the modules are tilted off of the central orientation illustrated in FIG. **3** but in the opposite direction as illustrated in FIG. **4**;

FIG. **6** illustrates an embodiment with independent panning motion of the light emitting modules in an embodiment of the disclosure;

FIG. **7** illustrates an embodiment of a light emitting module;

FIG. **8** illustrates a further embodiment of independent panning and tilting motion of the light emitting modules;

FIG. **9** illustrates a further embodiment of independent panning and tilting motion of the light emitting modules;

FIG. **10** illustrates a further embodiment of independent panning and tilting motion of the light emitting modules;

FIG. **11** illustrates an embodiment of the disclosure using a gobo wheel; and

FIG. **12** illustrates detail of a gobo wheel embodiment of FIG. **11**.

DETAILED DESCRIPTION OF THE DISCLOSURE

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

The present disclosure generally relates to a method for controlling the movement of LED devices in luminaires, specifically to a method relating to allowing both synchronized and independent movement of LED light modules in a light curtain or other LED luminaires.

FIG. **2** illustrates an embodiment of a luminaire **30** with a linear arrangement of a plurality of light-emitting modules. In the embodiment illustrated eight light-emitting modules

20*a-h* are mounted within luminaire body **32** which serves as a common carrier to carry the light-emitting modules **20***a-h* in a linear arrangement to form light curtain luminaire **30**. Each light-emitting module **20***a-h* emits collimated and controlled light beams **24***a-h*. Each of these light-emitting modules **24***a-h* may be individually adjusted for color, by adjusting the output mix of its LED emitters, and for beam angle, by adjusting each modules optical elements. In this configuration all the light-emitting modules are aligned to point in the same direction and same plane. The luminaire body **32** may be articulated to be capable of a global tilting motion through motor **33** and drive mechanism **34**. Motor **33** may be controlled from data link **14** through communication link **36** and motor driver **35**. Though not shown in this figure the common carrier may also be articulated to be capable of a global panning motion through motors and motor drivers which are controlled by an operator through the communication link **36**.

FIGS. **3**, **4**, and **5** illustrate the global tilting motion of the light-emitting modules in an embodiment of the disclosure. The view in FIGS. **3**, **4**, and **5** is an elevation view of the luminaire **30** shown in FIG. **2**, viewed from the end of the luminaire, orthogonal to that shown in FIG. **2**. Luminaire body **32** may be pivotably mounted to frame **28** such that the luminaire body can rotate about pivot axis **26**. FIG. **3** shows the luminaire body **32** positioned such that the light-emitting modules **20** are vertical and light beams **24** are emitted vertically. FIGS. **4** and **5** show the luminaire body rotated around pivot axis **26** such that the light-emitting modules **20**, and thus the light beams **24**, are tilted to the left and right respectively.

This tilting motion around pivot axis **26** is controlled through a motor **33** and drive mechanism **34** actuation/articulation system. The actuation/articulation system may be a stepper motor, servo motor, linear actuator, solenoid, direct current (DC) motor, or other mechanism many of which are well known in the art. The drive mechanism **34** of the embodiment shown in FIGS. **2-5** is a belt drive mechanism mechanically coupling the motor **33** to the luminaire body **32**. This tilting motion may be controlled remotely as with other features of an automated luminaire, perhaps through an industry standard protocol such as DMX-512 through data link **14**, communication link **36** and motor driver **35** on board the luminaire. In other embodiments, configurations are possible. This tilting motion imparts the same movement to each and every light-emitting module in luminaire **30** identically. They will all move in parallel and mechanical synchronization.

FIG. **6** illustrates the independent panning motion of the light emitting modules in an embodiment of the disclosure. FIG. **6** shows the same view of luminaire **30** as FIG. **2**. In this embodiment light-emitting modules **20***a-h* are each individually and separately pivotably mounted to luminaire body **32** such that the light-emitting modules **20***a-h* can individually rotate about respective pivot axes **25***a-h*. The plane of rotation of pivot axes **25***a-h* is orthogonal to pivot axis **26** shown in FIGS. **3**, **4**, and **5**. Pivot axes **25***a-h* allow each light-emitting module **20***a-h* to pan from side to side individually and independent of the position of its neighboring light-emitting modules, thus allowing light beams **24***a-h* to be individually and separately steered. These individual independent tilt articulators tilting motion around pivot axes **25***a-h* may be actuated through a stepper motor, servo motor, linear actuator, solenoid, DC motor, or other mechanism as well known in the art.

FIG. **7** illustrates the light-emitting module **20** of an embodiment of the disclosure. LED emitters **22** may be mounted to or be otherwise in thermal contact with a heat sink **27**. The optics of light-emitting module **20** may comprise total internal reflection (TIR) optical systems or standard reflectors such as are well known in the art so as to provide a collimated light beam **24** along the optical axis **21**. Light-emitting module **20** may further contain optical elements **40** such that the focal length and thus the beam angle of the emitted light may be adjusted. Such focal length adjusting optical elements **40** are coupled via drive mechanism **44** to a motor **43** such that the beam angle change can be remotely controlled. This actuation system may be a stepper motor, servo motor, linear actuator, solenoid, DC motor, or other mechanism many of which are well known in the art.

In various embodiments of the disclosure each LED emitter **22** may comprise a single LED die of a single color or a group of LED dies of the same or differing colors. For example in one embodiment LED emitter **22** may comprise one each of a Red, Green, Blue and White LED die. In further embodiments LED emitter **22** may comprise LED chip or package while in yet further embodiments LED emitter **22** may comprise multiple LED chips or packages either under a single primary optic or each package with its own primary optic. In some embodiments these LED die(s) may be paired with optical lens element(s) as part of the LED light-emitting module.

The two orthogonal movements described herein about pivot axes **25***a-h*, and **26** are commonly referred to as pan and tilt directions. In operation, the user or lighting designer may rotate the entire luminaire **30** around the tilt pivot axis **26**, and individually pan each light-emitting module **20***a-h* in order to achieve the desired effect from the luminaire light curtain. FIG. **7** illustrates an independent pan articulator employing a direct motor drive **53**, **54** of the actuation system for panning an individual light-emitting module **20**. This actuation system may be a stepper motor, servo motor, linear actuator, solenoid, DC motor, or other mechanism many of which are well known in the art.

FIG. **8** illustrates a further embodiment of the disclosure. In this embodiment, 9 light-emitting modules **20***a*-**20***i* are mounted in a luminaire **40**. Each light-emitting module **20***a*-**20***i* emits collimated and controlled light. Each of the light beams from the light-emitting modules **20***a*-**20***i* may be individually adjusted for color, by adjusting the output mix of its LED emitters, and for beam angle, by adjusting each modules optical elements as previously described. Further, each light-emitting module **20***a*-**20***i* may be individually articulated to adjust for both pan and tilt. This differs from the prior embodiment where each light-emitting module had a single independent axis of tilt movement, and a global movement of the luminaire provided pan. In the embodiment illustrated in FIG. **8** each light-emitting module **20***a*-**20***i* is capable of both independent pan and independent tilt. Further, luminaire **40** may also have global pan and global tilt available. Independent pan and tilt of each light-emitting module **20***a*-**20***i* provides the ability to widen and narrow the combined beam produced by the modules, while the global pan and tilt of luminaire **40** provides the ability, as usually provided by an automated luminaire, to steer the resultant combined beam as desired.

FIG. **9** illustrates a further embodiment of the disclosure. In this embodiment, **37** light-emitting modules are mounted in the head **56** of luminaire **50**. The light-emitting modules are mounted in groups to form seven module group assemblies, **60***a*-**60***g*. For example, module group assembly **60***a* contains five light-emitting modules **62***a*-**62***e*. Each of the **37** light-emitting modules emits collimated and controlled light. Each of the light beams from the light-emitting modules may be individually adjusted for color, by adjusting the output mix of its LED emitters, and for beam angle, by adjusting each modules optical elements as previously described. In the embodiment illustrated in FIG. **9** each module group assembly **60***a*-**60***g* is capable of both independent pan and independent tilt.

Head **56** may be mounted in a yoke assembly **94** that, in turn, is mounted on base **52**. Yoke assembly **94** is rotatably mounted on base **52** so as to provide global pan rotation **93** and head **56** is rotatably mounted in yoke assembly **94** so as to provide global tilt rotation **55**.

FIG. **10** illustrates a further embodiment of the disclosure. In this embodiment **36** light-emitting modules are mounted in the head **76** of luminaire **70**. The light-emitting modules are mounted in groups to form nine module group assemblies, **80***a*-**80***i*. For example, module group assembly **80***a* contains four light-emitting modules **82***a*-**82***d*. Each of the **36** light-emitting modules emits collimated and controlled light. Each of the light beams from the light-emitting modules may be individually adjusted for color, by adjusting the output mix of its LED emitters, and for beam angle, by adjusting each modules optical elements as previously described. In the embodiment illustrated in FIG. **10** each module group assembly **80***a*-**80***i* is capable of both independent pan and independent tilt.

Head **76** may be mounted in a yoke assembly **74** that, in turn, is mounted on base **72**. Yoke assembly **74** is rotatably mounted on base **72** so as to provide global pan rotation **73** and head **76** is rotatably mounted in yoke assembly **74** so as to provide global tilt rotation **75**.

Although the embodiments illustrated herein show specific numbers of light-emitting modules mounted in specific numbers of module assemblies, in practice the disclosure is not so limited and any number of light-emitting modules may be mounted in any number of module assemblies to form a luminaire. In any of the possible arrangements, each of the light-emitting modules and/or each of the module assemblies may be capable of independent pan and independent tilt movement in one or more axes. Further, the light-emitting modules and/or module assemblies may be arranged in any shape or layout. Embodiments herein illustrate linear, round and square arrangements, but any arrangement shape may be used.

FIG. **11** illustrates a further embodiment of the light-emitting module **100** of the disclosure. LED **60**, which may include a primary optic, is mounted on substrate **62**. LED **60** may contain a single color die or may contain multiple dies, each of which may be of differing colors. The light output from the dies in LED **60** enters collimating and mixing optic **80** at light entry port **82**. Collimating and mixing optic **80** may be a solid optic using total internal reflection (TIR) to direct the light or may be a hollow reflective surface. Collimating and mixing optic **80** may have four sides, each of which may be curved with cornered sides. The combination square sided shape with curved sides provides excellent mixing of the light from the dies in LED **60**. A further feature of collimating and mixing optic **80** is that it directs the reflected light to an external focal point that is comparatively close to its output port **84** of the collimating and mixing optic **80**. In the embodiment shown in FIG. **11**, the reflected light exits collimating and mixing optic **80** at output port **84** and enters light integrator optic **102** at its entry port **106**. Light integrator optic **102** is a device utilizing internal reflection so as to collect, homogenize and constrain and conduct the light from collimating and mixing optic **80**. Light integrator optic **102** may be a hollow tube with a reflective inner surface such that light impinging into the entry port **106** may be reflected multiple times along the tube before leaving at the exit port **108**. Light integrator optic **102** may be a square tube, a hexagonal tube, a heptagonal tube, an octagonal tube, a circular tube, or a tube of any other cross section. In a further embodiment light integrator optic **102** 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 be a square rod, a hexagonal rod, a heptagonal rod, an octagonal rod, a circular rod, or a rod of any other cross section. Integrator embodiments with a polygonal cross section have reflective sides **110** and corners **112** between the reflective sides as seen in FIG. **11** which includes a side cross sectional view of the light integrator optic **102**.

A feature of a light integrator optic **102** which comprises a hollow tube or solid rod where the sides of the rod or tube are essentially parallel and the entry port **106** and exit port **108** are of the same size is that the divergence angle of light exiting the light integrator optic **102** at exit port **108** will be the same as the divergence angle for light entering the light integrator optic **102** at entry port **106**. Thus, a parallel sided light integrator optic **102** has no effect on the beam divergence and will transfer the position of the focal point of collimating and mixing optic **80** at its output port **84** to the light integrator optic's **102** exit port **108**. The light exiting light integrator optic **102** will be well homogenized with all the colors of LED **60** mixed together into a single colored light beam and may be used as our output, or may be further modified by downstream optical systems.

Light integrator optic **102** 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. Light integrator optic **102** may be enclosed in a tube or sleeve **104** that provides mechanical protection against damage, scratches, and dust.

In the embodiment illustrated in FIG. **11**, the optical system is further fitted with a gobo wheel **113**. A gobo wheel contains patterns or images that will controllably mask the light exiting through exit port **108**. These images will then be projected by downstream optical elements to create a pattern projecting light beam. The lens system after the gobo wheel **113** may be a zoom lens system **40** such as shown in FIG. **7** or any other projecting lens system as well known in the art. Gobo wheel **113** may be rotated through motor **114** in order to select different gobo patterns in front of exit port **108**. A rotating gobo wheel **115** may additionally or alternatively be utilized in the system. Rotating gobo wheel **115** may be rotated through motor **116** in order to select different gobo patterns **118** in front of exit port **108**. Gobo patterns **118** may then be rotated about the optical axis of the system through motor **117**.

FIG. **12** shows gobo wheel **113** in more detail in a further embodiment of the disclosure. Gobo wheel **113** contains a plurality of gobo patterns **118** that may be moved across and in front of light-emitting module **20***a* by rotation about motor **114** and will move with it as it is panned and tilted. In other embodiments every light-emitting module as illustrated in FIG. **7**, **8**, **9** or **10** may be fitted with a gobo wheel, all or any of which may be individually or cooperatively controlled. In further embodiments the gobo wheel may not be a complete circular disc as shown in FIG. **12**, but may be a portion of a disc, or a flag so as to save space and provide a more limited number of gobo patterns **118**. The gobo patterns **118** may be of any shape and may include colored images or transparencies. In yet further embodiments, individual gobo patterns **118** may be further rotated about their axes by supplementary motors in order to provide a moving rotating image. Such rotating gobo wheels are well known in the art.

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 plurality of LED modules into which are mounted at least one LED;

a common carrier in which the plurality of LED modules are mounted;

a global articulation motor;

a physical drive mechanism mechanically coupling the global articulation motor to the common carrier, the global articulation motor and the physical drive mechanism being configured to rotate the common carrier around a first pivot axis;

a plurality of independent articulators which independently articulate corresponding individual LED module around individual second pivot axes, wherein the second pivot axes are different from the first pivot axis;

wherein each LED module is individually and separately pivotably mounted to the common carrier, wherein movement of each LED module around its second pivot axis is independent of movement of a neighboring LED module around its second pivot axis.

2. The luminaire of claim **1**, wherein the second pivot axes are orthogonal to the first pivot axis.

3. The luminaire of claim **1**, wherein the global articulator further comprises:

a communication link configured to receive signals; and

a motor driver coupled to the communication link and the global articulation motor, and configured to control the global articulation motor based on the signals received by the communication link.

4. The luminaire of claim **1**, wherein at least one of the independent articulators comprises a motor configured to articulate the corresponding individual LED module.

5. The luminaire of claim **4**, wherein the corresponding individual LED module is articulated by direct motor drive.

6. The luminaire of claim **1**, wherein at least one of the plurality of LED modules comprises one each of red, green, blue, and white LED dies.

7. The luminaire of claim **1**, wherein at least one of the plurality of LED modules comprises an optical system configured to generate a collimated light beam.

8. The luminaire of claim **1**, wherein at least one of the plurality of LED modules comprises one or more lenses configured to move along an optical axis of the luminaire to control a beam angle of a light beam emitted by the luminaire.

9. The luminaire of claim **8**, further comprising a motor configured to adjust a position of the one or more lenses to provide remote control of the beam angle.

10. The luminaire of claim **1**, wherein the physical drive mechanism comprises a belt drive mechanism.

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