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**Joseph et al.**

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(54) **SPECIAL EFFECTS SYSTEM FOR GENERATING A MIDAIR LASER BLAST ILLUSION**

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***F21V 14/08*** (2006.01)
(Continued)

(52) **U.S. Cl.**
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See application file for complete search history.

(56) **References Cited**

U.S. PATENT DOCUMENTS

5,418,632 A 5/1995 Anderson
5,678,910 A 10/1997 Martin
(Continued)

OTHER PUBLICATIONS

"Propeller Clock," Mechanically Scanned LED Clock; http://www.bobblick.com/techref/projects/propclock/propclock.html; Copyright 1995-2002 Bob blick; retrieved Oct. 19, 2006.

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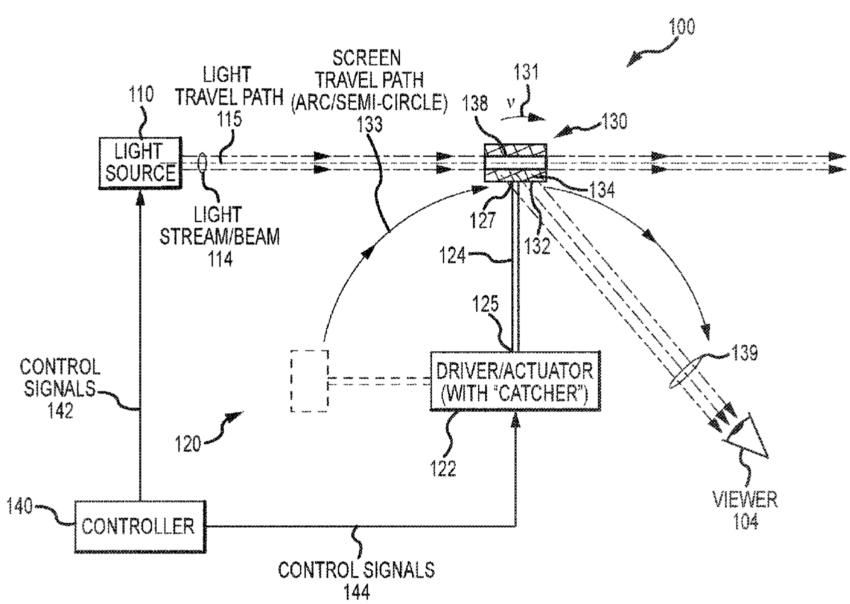
(57) **ABSTRACT**

A special effects apparatus for generating an illusion of a moving beam of light in midair. The apparatus includes a light source, such as a laser light source outputting colored light, generating a beam of light that is aimed along a linear light travel path. The apparatus further includes a dynamic light receiving assembly, and this assembly includes: an elongated support rod; a light receiving element attached to a first end of the support rod; and a driver coupled to a second end of the support rod opposite the first end of the support rod. The driver rotates the support rod about the second end at a high rotation rate, and the light receiving element moves along an arcuate travel path that intersects the linear light travel path of the beam of light. The arcuate travel path of the light receiving element and the linear light travel path are coplanar.

**19 Claims, 11 Drawing Sheets**



(51) **Int. Cl.**

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| ***F21V 11/18*** | (2006.01) |
| *F21Y 115/10* | (2016.01) |
| *F21W 131/406* | (2006.01) |
| *F21Y 115/30* | (2016.01) |

(52) **U.S. Cl.**
CPC .... *F21W 2131/406* (2013.01); *F21Y 2115/10* (2016.08); *F21Y 2115/30* (2016.08)

(56) **References Cited**

U.S. PATENT DOCUMENTS

| | | | | | |
|---|---|---|---|---|---|
| 5,975,720 | A * | 11/1999 | Adkins | F21V 9/40 | 362/293 |
| 6,302,542 | B1 | 10/2001 | Tsao | | |
| 6,554,430 | B2 | 4/2003 | Dorval et al. | | |
| 6,665,048 | B2 | 12/2003 | Gelbart | | |
| 7,740,359 | B2 | 6/2010 | Schnuckle et al. | | |
| 8,876,295 | B2 | 11/2014 | Scanlon | | |
| 2007/0097681 | A1* | 5/2007 | Chich | F21V 14/02 | 362/232 |
| 2009/0046258 | A1 | 2/2009 | Schnuckle et al. | | |
| 2012/0327631 | A1* | 12/2012 | Tsang | F21V 9/40 | 362/84 |
| 2013/0286355 | A1* | 10/2013 | Lin | G03B 21/206 | 353/7 |
| 2014/0043589 | A1 | 2/2014 | Chifu et al. | | |
| 2014/0328085 | A1* | 11/2014 | Johnson | F21S 10/00 | 362/644 |
| 2015/0176788 | A1* | 6/2015 | Isayama | F21S 10/00 | 362/147 |
| 2017/0241610 | A1 | 8/2017 | Yen | | |
| 2017/0332442 | A1 | 11/2017 | Strecker | | |

* cited by examiner

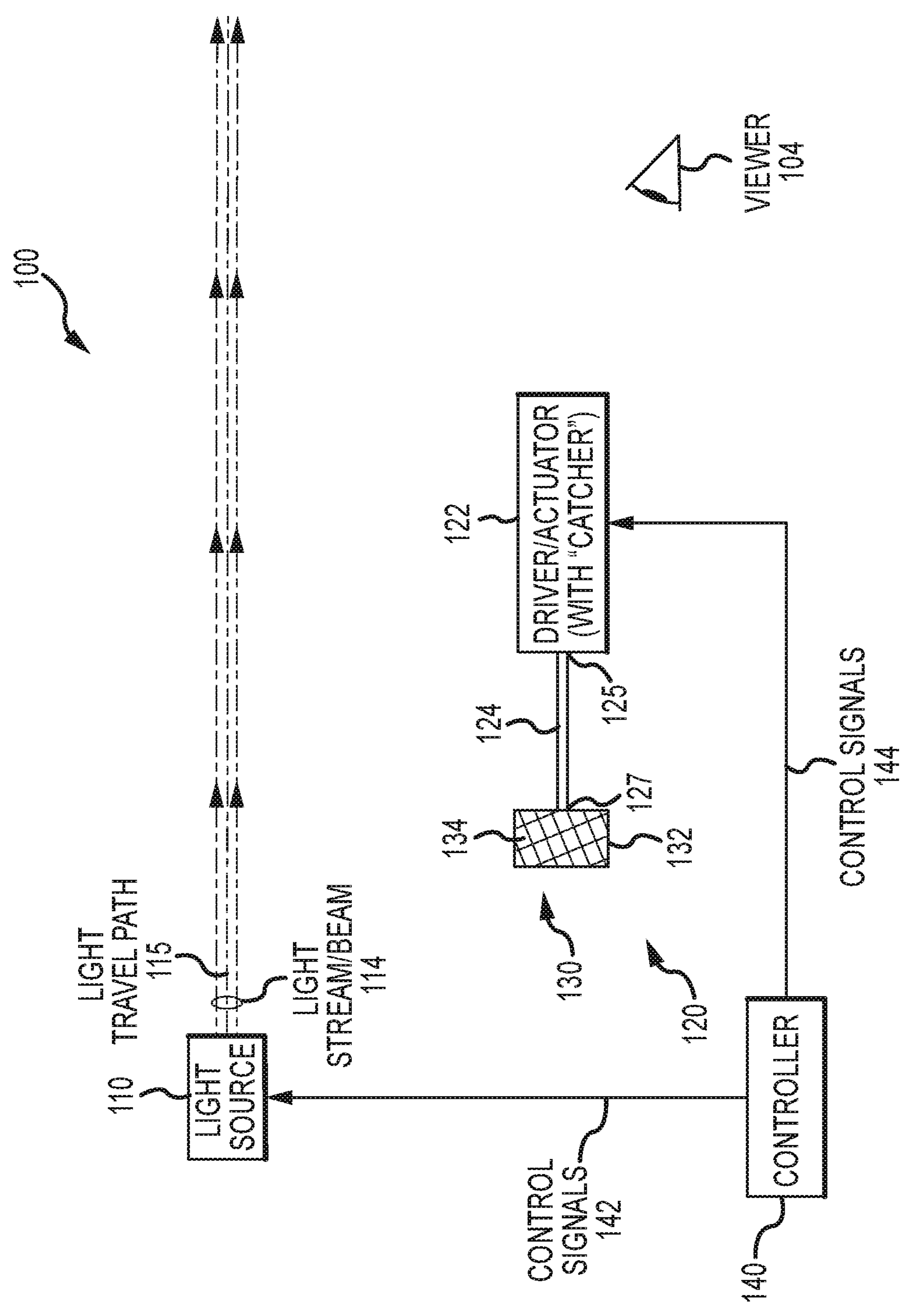
100
LIGHT TRAVEL PATH 115
LIGHT STREAM/BEAM 114
LIGHT SOURCE
110
VIEWER 104
DRIVER/ACTUATOR (WITH "CATCHER")
122
124
125
127
134
132
130
120
CONTROLLER
140
CONTROL SIGNALS 142
CONTROL SIGNALS 144

FIG. 1A

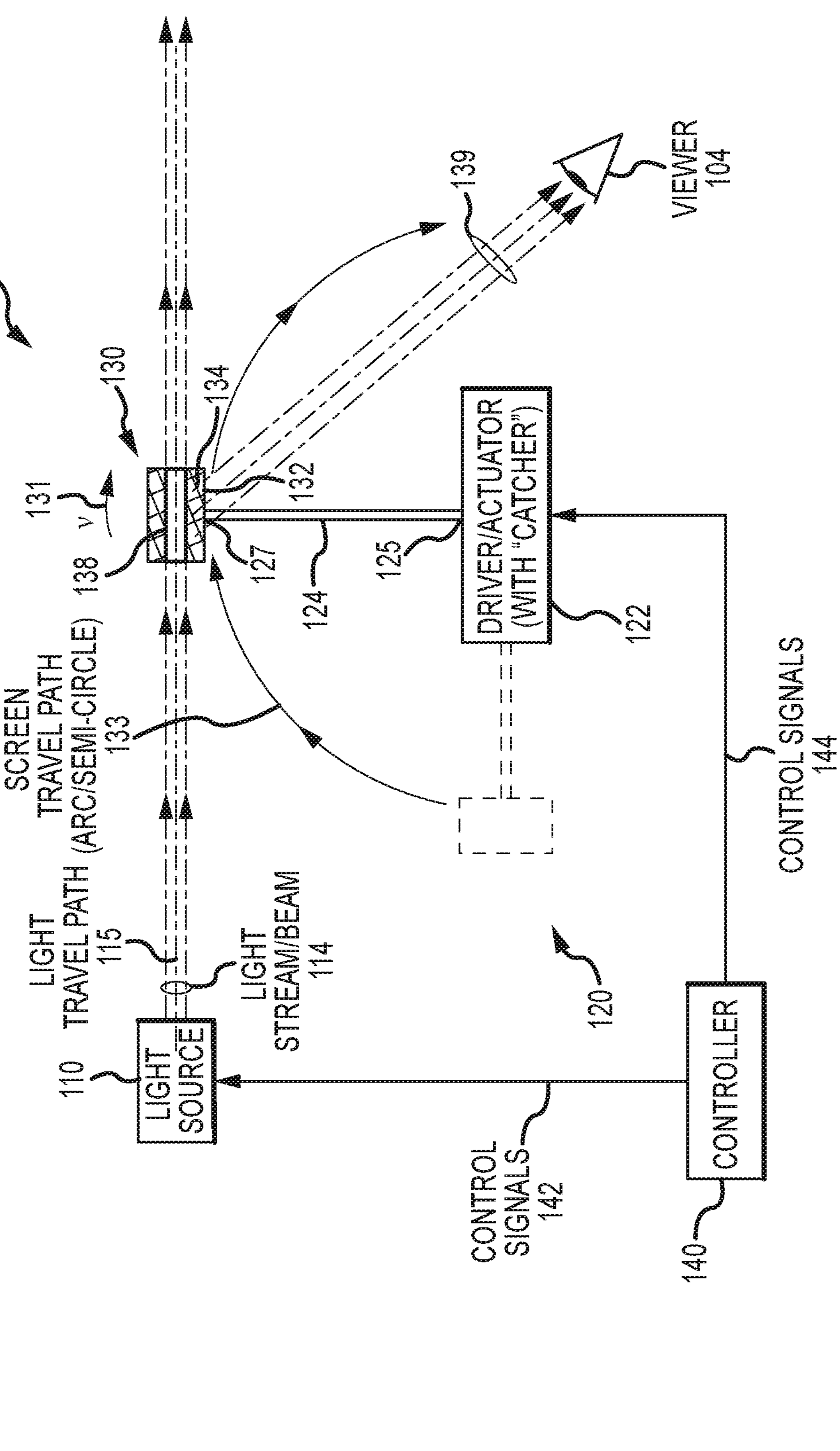
100
130
131
v
134
132
138
127
124
125
DRIVER/ACTUATOR (WITH "CATCHER")
122
139
VIEWER 104
SCREEN TRAVEL PATH (ARC/SEMI-CIRCLE) 133
LIGHT TRAVEL PATH 115
LIGHT STREAM/BEAM 114
LIGHT SOURCE
110
120
CONTROL SIGNALS 144
CONTROL SIGNALS 142
CONTROLLER
140

FIG. 1B

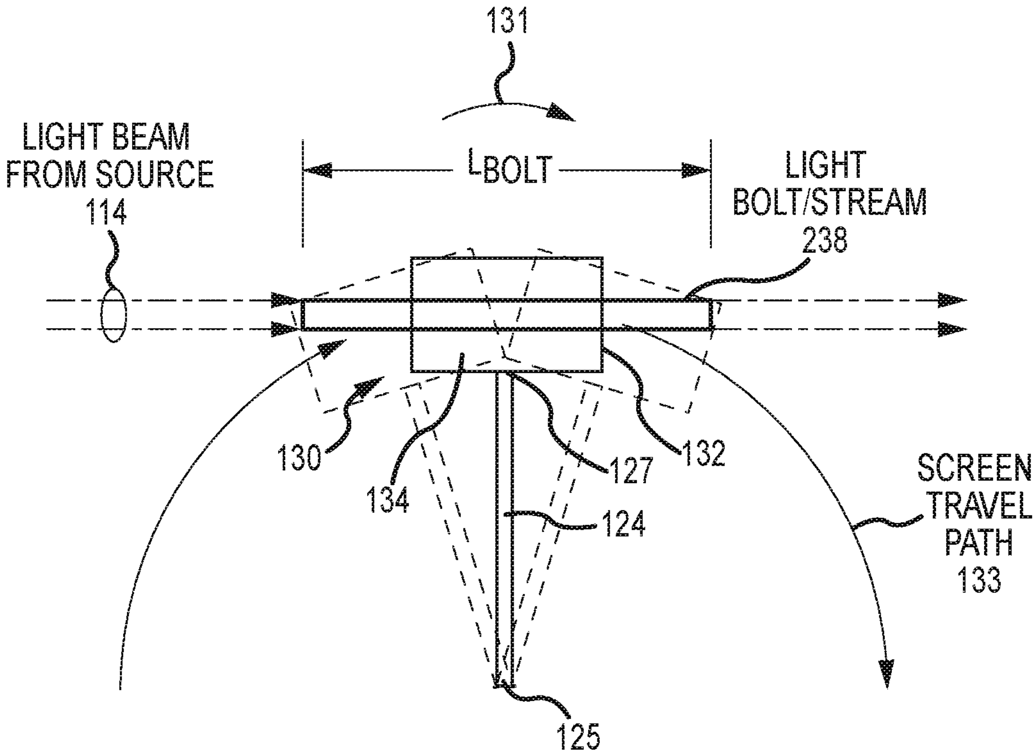
131
LIGHT BEAM
FROM SOURCE
114
$L_{BOLT}$
LIGHT
BOLT/STREAM
238
130
134
127
132
124
SCREEN
TRAVEL
PATH
133
125

FIG.2

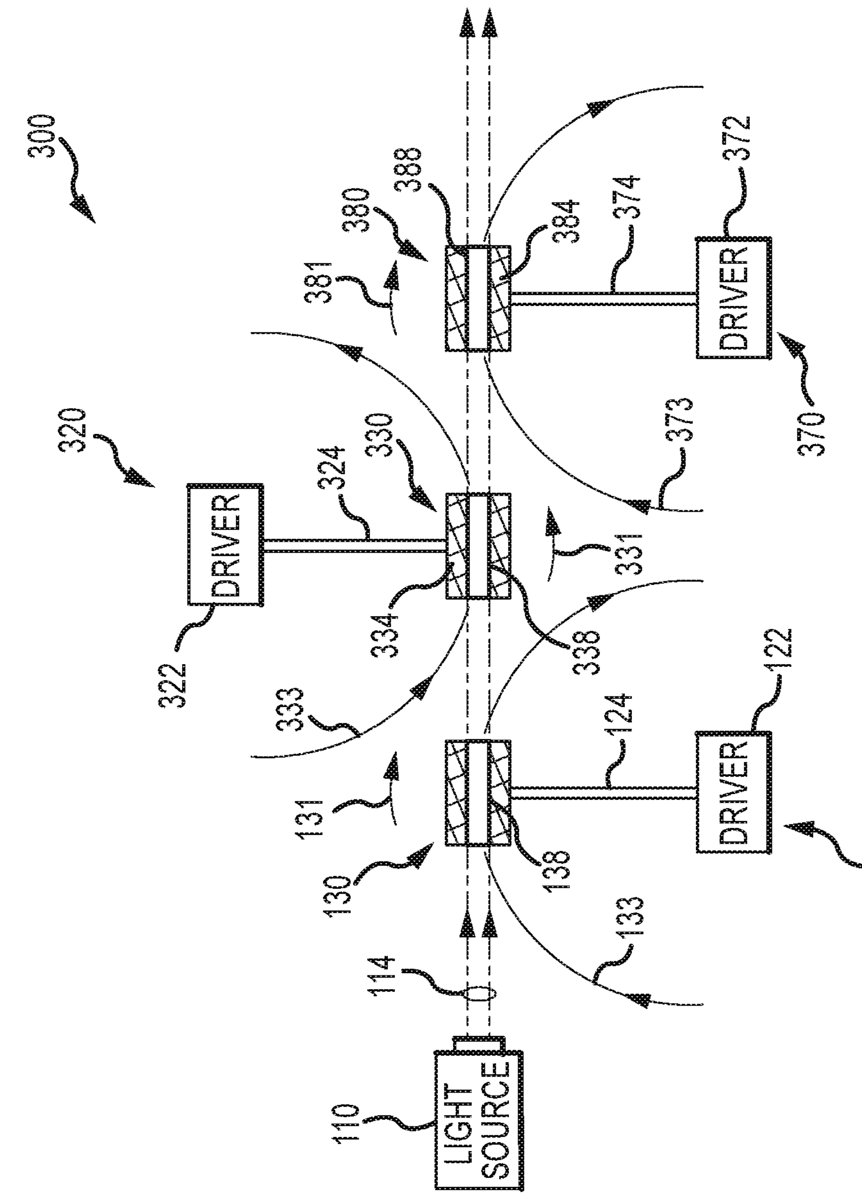
300
320
DRIVER
322
324
330
334
338
331
333
380
381
388
384
374
DRIVER
372
370
373
LIGHT
SOURCE
110
114
130
131
138
124
DRIVER
122
120
133

FIG. 3

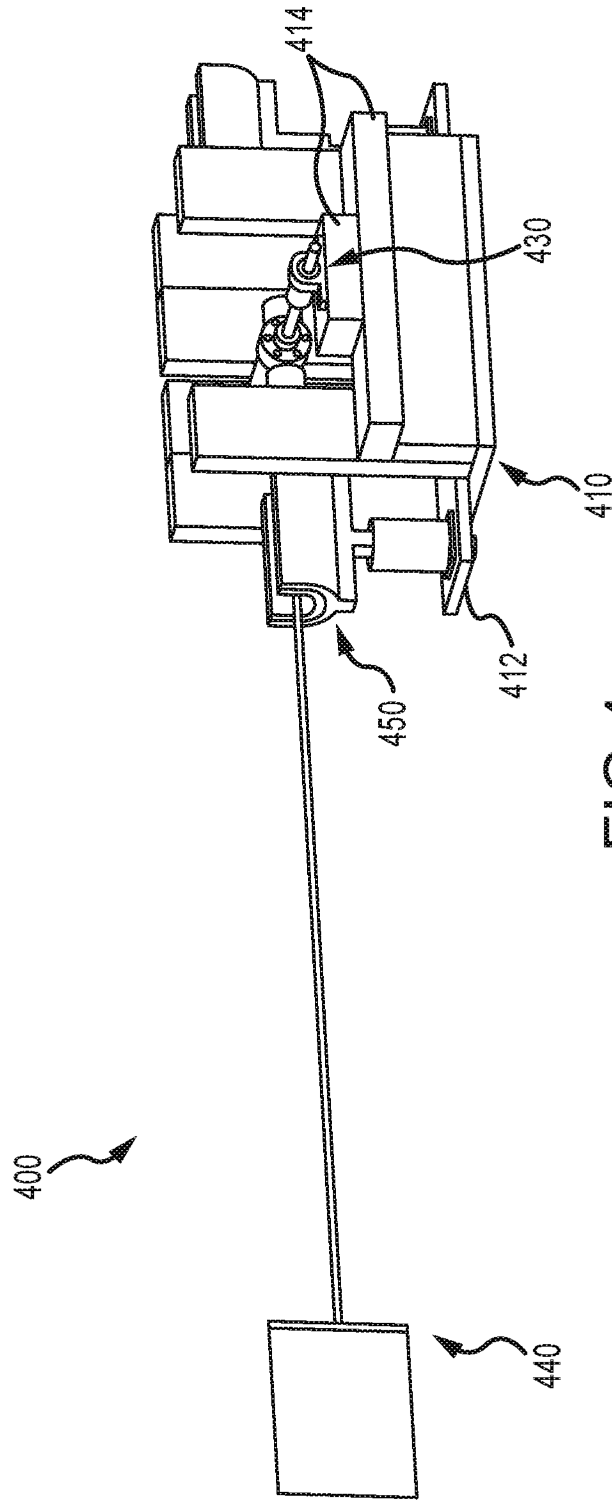


FIG.4

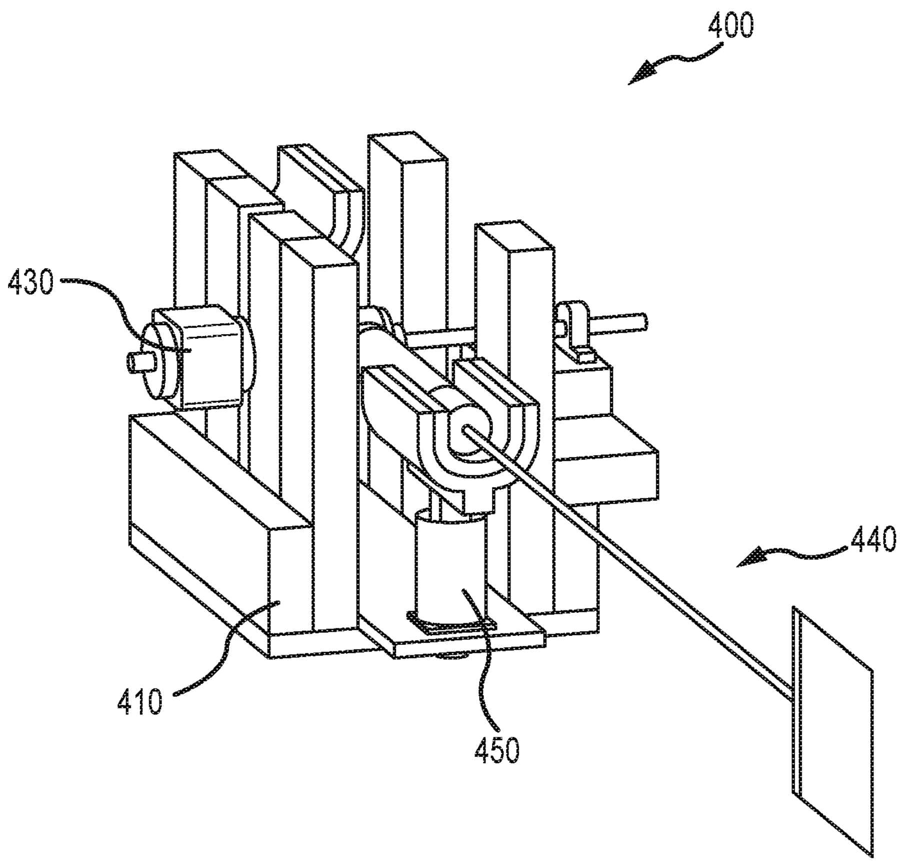


FIG.5

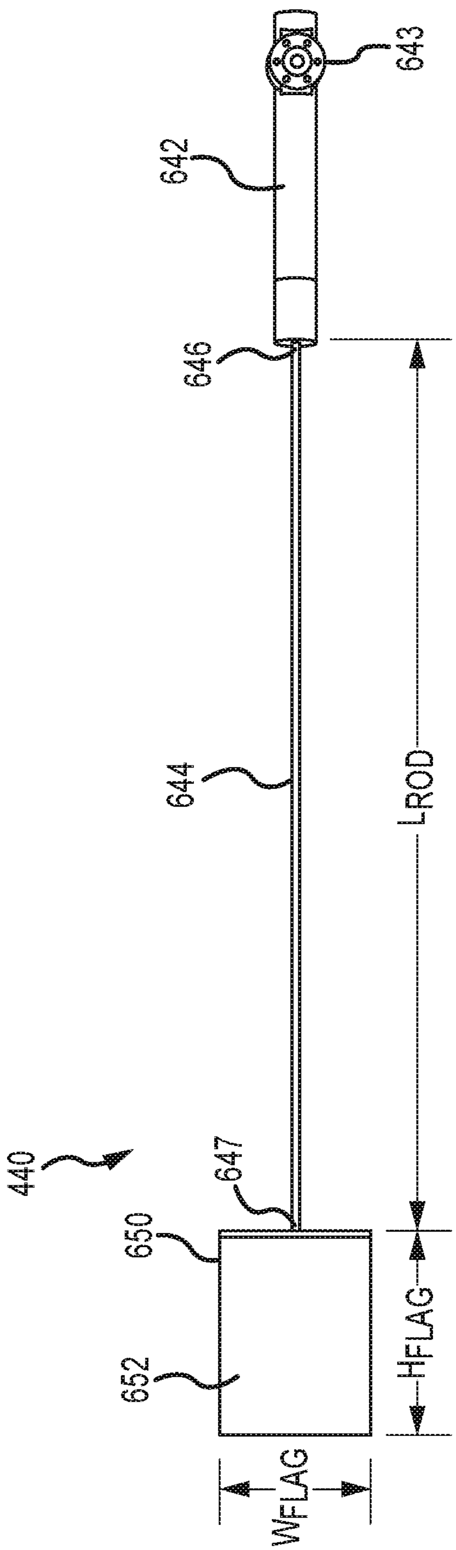


FIG.6

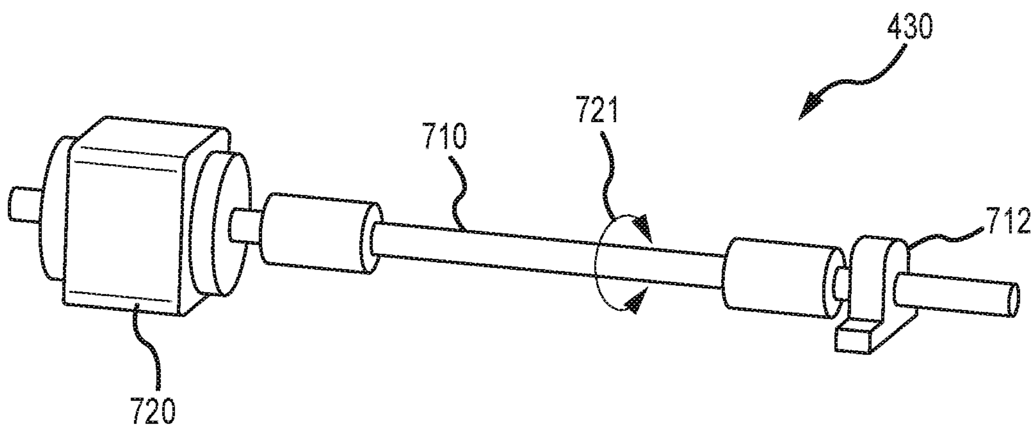


FIG.7

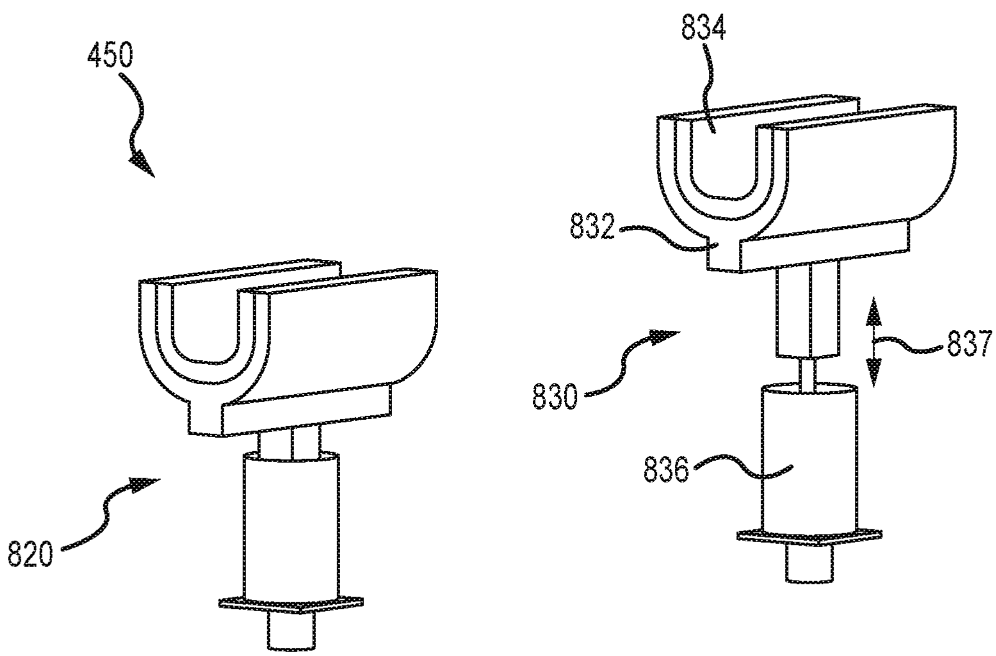


FIG.8

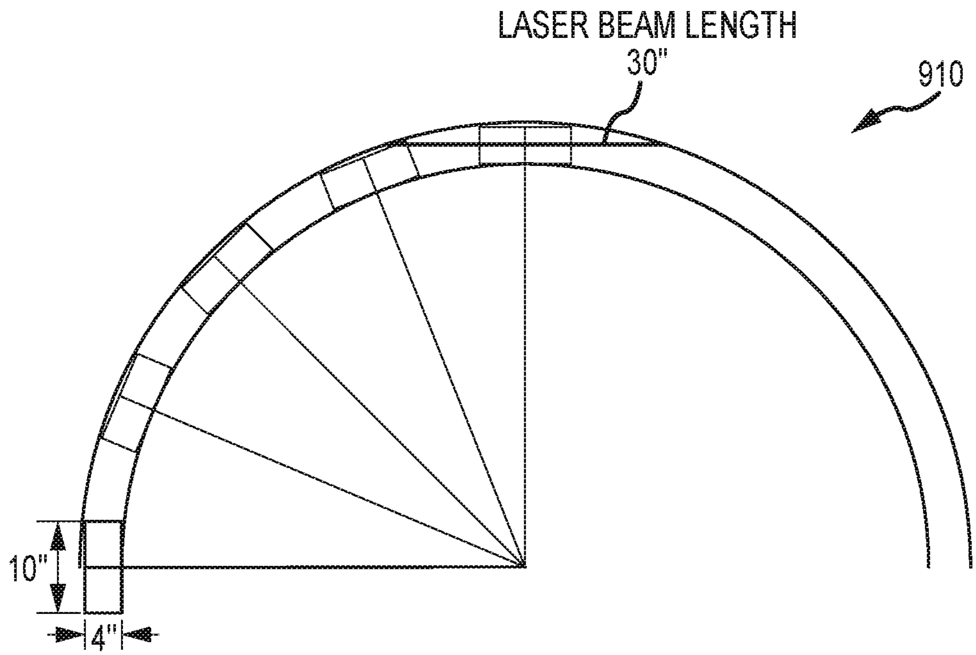


FIG.9

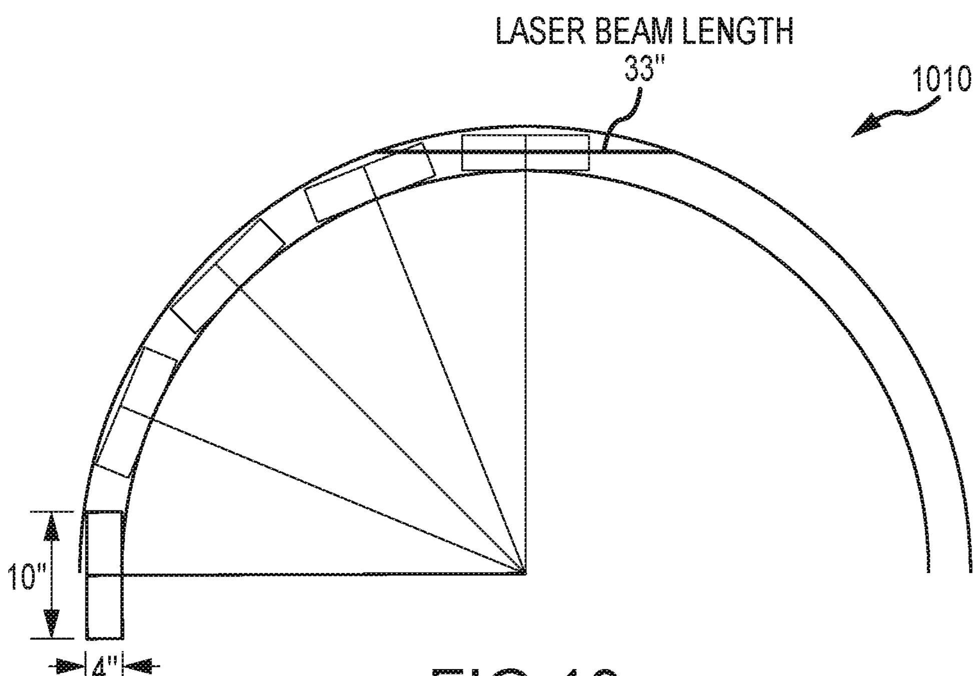


FIG.10

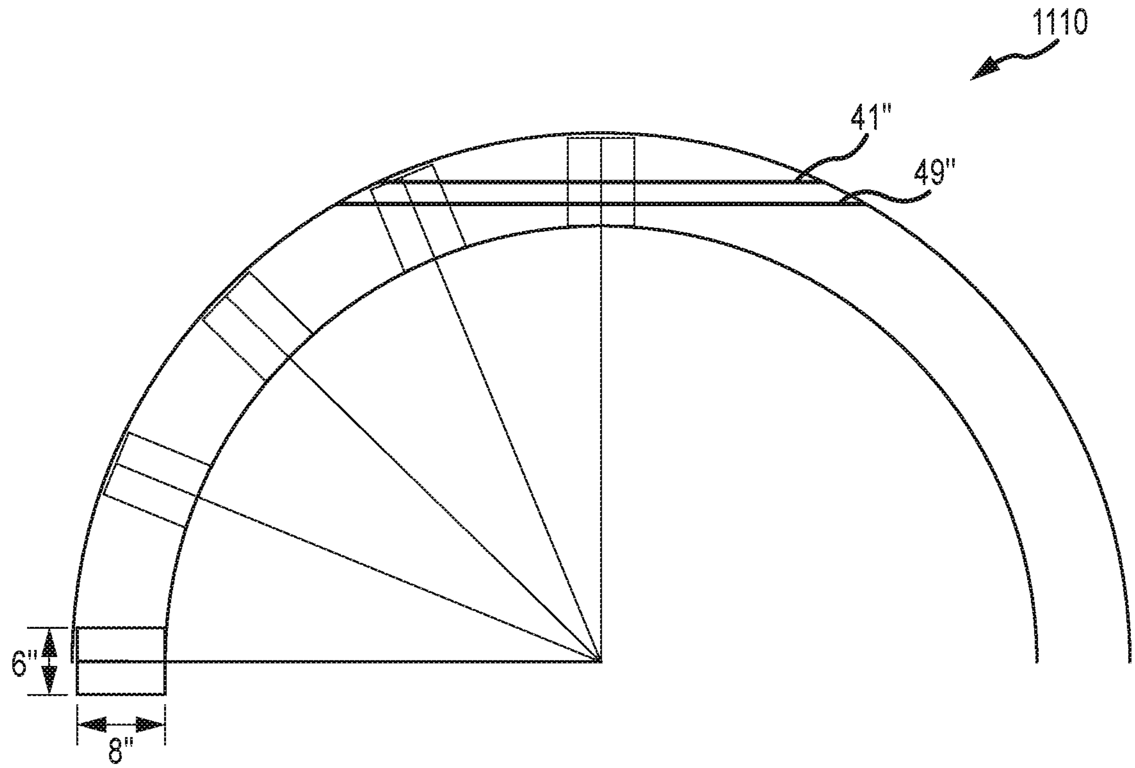


FIG.11

# SPECIAL EFFECTS SYSTEM FOR GENERATING A MIDAIR LASER BLAST ILLUSION

## CROSS REFERENCE TO RELATED APPLICATIONS

This application is a continuation of U.S. patent application Ser. No. 15/391,130, filed Dec. 27, 2016, which is incorporated herein by reference in its entirety.

## BACKGROUND

### 1. Field of the Description

The present description relates, in general, to theatrical and other visual special effect devices used to provide lighting-based illusions or displays and, more particularly, to a special effects system (or light-based display system) adapted to provide linear streaks, bolts, or elongated balls of light, e.g., an illusion that a theatrical prop such as a futuristic laser-based weapon has fired a laser blast or the like, and the output of the special effects system is 360-degree viewable.

### 2. Relevant Background

In the entertainment industry, there are many settings or venues where it is desirable to recreate scenes from popular movies often with live actors performing a scene from a movie. An often used lighting effect in movies is a streak or flash of light from various sources. For example, many futuristic movies include battles where the actors operate laser-based props, e.g., blaster gun props, which produce laser blasts. The laser blast beams in the movie travel through the air and may have the appearance of a volumetric ball or slug of light, which may be red, green, blue, or another color, that travels from the actor's weapon prop through the air in a line to its target.

To create such a scene in a movie, post-production computer graphics and other techniques are used to easily achieve the laser-blast effect inserting streaks of light after filming is completed. However, it has been problematic to create a similar effect in theatrical settings in real time or during a live production. This is especially troublesome because it is often desirable for the effect to be viewable in 360 degrees or from a wide range of viewing angles, such as both sides of a stage or set where actors are performing a movie-based scene. Further, the reproduced scene should look like the scene in the film.

Existing special effects and display systems have not been wholly successful at providing desired lighting-based illusions involving streaks, flashes, or balls of volumetric light appearing in air. One conventional technique is to project imagery onto a flat screen or wall positioned between the actor and their weapon prop and the target. Another special effects technique is to provide a Pepper's Ghost assembly on the set or in the display space. Neither of these solutions provides 360-degree viewing of the special effect, e.g., the use of a stationary projection screen or wall can only be viewed from one side. Also, projection on a wall appears flat and does not provide the desired volume to the "ball" or "slug" of light being fired from the prop weapon (or providing a similar effect). Pepper's Ghost assemblies are limited to use in corridors and enclosed spaces with a very limited viewing angle.



As will be understood, neither of these special effects approaches is useful for creating the desired streak of light that can be viewable from all directions, appears to be volumetric, and creates the illusion in midair. There remains a need for a new special effects system that overcomes the problems with prior devices and is useful in a wide variety of settings.

## SUMMARY

Briefly, a special effects system (or theatrical prop lighting assembly) is provided that is operable to generate a lighting effect that appears as a bolt or streak of light, such as a green cylinder of light that is several-to-many inches long (e.g., 6 inches to 18 inches in length or more length when two or more dynamic light receiving assemblies are used to provide "hand offs" of the bolt or streak of light) with no visually perceivable projection screen or surface. In this way, a volumetric slug or ball of light moves in midair through a viewer's field of vision for unique displays useful for recreating movie-like laser blasts that are 360-degree viewable, e.g., from the front or back as the light may pass between two sets of viewers.

The special effects system can be placed into nearly any show set space and be viewed from any direction. However, viewers typically will be blocked from certain viewpoints, such as looking directly at the outlet of the light source or being near the path of components providing the light bolt for safety reasons and to better conceal the effect. The special effects system can be implemented at a relatively low cost due to the design and nature of the mechanics and components used to create the laser blast or midair light streak (or bolt) effect. The special effects system is also useful in conditions or theatrical spaces/sets with higher ambient lighting levels in which prior devices are typically ineffective.

More particularly, a special effects apparatus or system is provided for generating an illusion of a moving beam of light in midair. The apparatus includes a light source generating a beam of light that is aimed along a linear light travel path, and the light source may take the form of a laser light source providing a colored laser beam or a collimated light emitting diode (LED) source providing red, green, or blue beams. The apparatus further includes a dynamic light receiving assembly, and this assembly includes: an elongated support rod (e.g., a pultruded carbon fiber or fiberglass rod that is 3 to 6 feet long); a light receiving element attached to a first end of the support rod; and a driver (or actuator) coupled to a second end of the support rod opposite the first end of the support rod.

To achieve the illusion of a midair laser blast or the like, the driver rotates the support rod about the second end at a high rotation rate (e.g., greater than about 100 RPM). During the rotation of the support rod by the driver, the light receiving element moves along an arcuate travel path that intersects the linear light travel path of the beam of light. Further, the arcuate travel path of the light receiving element and the linear light travel path are substantially coplanar (or the light receiving element is caused to travel in the plane of the light).

In some embodiments, the light receiving element includes a planar frame (e.g., a wire shaped into a rectangle affixed to the first end of the support rod) and a sheet of mesh fabric supported by the planar frame. The planar frame and arcuate travel path are coplanar, and the sheet of mesh fabric is not orthogonal to the light as in typical projection-based effects but is instead struck by the light along its thin

edge/end. A mesh fabric is used to provide a receiving surface that is not opaque but is able to receive (and reflect) light, and, in some cases, the mesh fabric is a black tulle fabric. The sheet of mesh fabric may be rectangular in shape with a width, as measured along a side proximate to the first end of the support rod, that is less than a height of the rectangular shape. In some particular implementations, the height may be in the range of 7 to 9 inches and the width is in the range of 5 to 7 inches (e.g., 8 inches by 6 inches). To provide a longer streak or bolt of light in midair (such as a streak in the range of 30 to 49 inches but typically in the range of 41 to 49 inches), when the support rod is fully deployed, the apparatus is designed such that the linear light travel path intersects the rectangular sheet of mesh fabric at a centerline or between the centerline and the side proximate to the first end of the support rod (e.g., at a distance below the centerline).

The rotation rate is in the range of 115 to 125 revolutions per minute (RPM) to disguise the presence of the light receiving element in the display space observed by a viewer (e.g., the viewer only sees the displayed streak or bolt of light and not the screen/flag of mesh fabric or the support rod). Further, to achieve a desired illusion, the support rod has a length in the range of 3 to 6 feet and has a black outer surface. In the same or other embodiments, the arcuate travel path may be a 180-degree arc or semi-circle, and the driver (e.g., a motor and a drive shaft with the support rod affixed near the second end to the drive shaft) includes a catcher assembly adapted to catch the support rod proximate to the second end and to absorb shock at opposite ends of the arcuate travel path (and to slow or reduce the rate of deceleration) to limit vibration or resonance of the support rod.

## BRIEF DESCRIPTION OF THE DRAWINGS

FIGS. **1**A and **1**B are functional block diagrams of a special effects system showing its operations at a first time and operating state with the light receiving screen retracted and at a second time and operating state with the light receiving screen being deployed (e.g., moved through an arcuate or semi-circular travel path) to display a volumetric bolt or streak of light in midair;

FIG. **2** illustrates the light receiving element in several positions (angular positions) about the fully deployed position (90 degrees rotation of the support rod) in which light from the source strikes the rapidly moving flag/screen;

FIG. **3** illustrates a special effects system that is provided through a modification of the system of FIGS. **1**A and **1**B to include additional dynamic light receiving assemblies so as to increase the length and/or quantity of light bolts/streaks produced with a light source;

FIGS. **4** and **5** are side and end perspective views, respectively, of a dynamic light receiving assembly of the present description such as may be used in the systems of FIGS. **1**A-**3**;

FIG. **6** is a side view of the whip assembly of the light receiving assembly of FIGS. **4** and **5**;

FIG. **7** is a side perspective view of the driver/actuator assembly of the light receiving assembly of FIGS. **4** and **5**;

FIG. **8** is a perspective end view of the braking assembly of the light receiving assembly of FIGS. **4** and **5**; and

FIGS. **9**-**11** are graphic illustrations of various tested or modeled flag/screen sizes and/or shapes and resulting light bolts or streak lengths.



## DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Briefly, a special effects system is described herein that is useful for producing bolts or linear streaks of light that appear to have volume and are 360-degree viewable, even in relatively high ambient light settings, in midair. The special effects system includes a light source (such as a laser beam source, a source providing bright collimated light, or other light source) that is static and targeted or aimed to provide a stream or beam of light along a path in a predefined plane. The special effects system further includes one or more dynamic light receiving assemblies, which are each configured to very rapidly (e.g., at a speed high enough to avoid detection by the viewer) move a light receiving flag or element through an arcuate path. The arcuate path is co-planar with the plane including the light stream/beam path such that the light receiving flag or element, which typically includes a planar screen, is moved through the light stream or beam such that an elongate bolt or linear streak of light is displayed on the rapidly moving screen.

In one exemplary embodiment, the dynamic light receiving assembly includes a carbon fiber rod with a small light receiving flag on one end. A driver or actuator (e.g., a 180-degree actuator or a 360-degree driver) is coupled to the other end of the rod. The driver or actuator is operated by a controller to move the rod (or flag support member) through the air at very high speeds (e.g., a rotation rate of 75 to 150 revolutions per minute (RPM) or the like with a rotation rate of about 120 RPM being used in one prototype), and the driver or actuator may include a "catcher" or brake assembly to slow the rod down very quickly (in 180-degree rotation embodiments) prior to rotating back in the other direction (e.g., the light-based special effect can be created with the light receiving flag moving in either direction (e.g., clockwise or counterclockwise or toward or away from the light source)). With the combination of the light source and the dynamic light receiving assembly (or assemblies), the laser blast or similar light effect can be generated in a repeatable and controlled (or timed/synchronized) manner.

In some embodiments, the dynamic light receiving assembly has the appearance of a device used to rapidly rotate (through a 180-degree, 360-degree, or other arcuate path) a large fly swatter. The "fly swatter" is provided by the flag support member or rod with a light receiving flag at one end that may be a frame (e.g., a wire rectangular frame) that holds or houses a screen. The screen is chosen to opaque enough to light to be able to receive the light from the light source but not so opaque that it is readily perceived by the viewer. Generally, the screen may be formed as a scrim from a mesh material, which, in some embodiments, takes the form of black tulle fabric (e.g., nylon tulle or the like).

The light source was chosen to provide bright collimated light or a fat beam laser that moves along a predefined linear path in a particular display plane. The arcuate path of the support rod is in a plane that is co-planar with this display plane and is chosen such that the light receiving screen (e.g., a planar rectangular swatch of black tulle fabric) is moved through the light stream/beam, which causes a linear portion of the light receiving screen to be illuminated. Through the workings of human vision (e.g., the human eye and persistence of vision), the viewer sees a traveling bolt or streak of light move through midair but no support rod and no light receiving screen. In brief, the viewer sees (or, more accurately, consciously perceives) nothing except the bolt or streak of light.

FIGS. **1**A and **1**B are functional block diagrams of a special effects system **100** showing its operations at a first time and operating state (screen retracted or pre-deployment) and at a second time and operating state (screen deployed) to display a volumetric bolt or streak of light in midair to a viewer **104**. As shown, the system **100** includes a light source **110** that operates in response to control signals **142** from a controller **140** (e.g., a computer with a processor running software/programs to provide the control functions described herein). Particularly, the light source **110** is shown to output or generate a light stream or beam **114** along a linear light path **115** in the display space observable by a viewer **104**. In the operating state shown in FIG. **1**A, there are no surfaces provided in the display space such that viewer **104** does not see or perceive the light stream/beam **114**.

The light source **110** may take many forms to practice the special effects system **100**. It is generally desirable that light **114** be relatively bright and be provided in a volumetric or "fat" stream or beam that can be aimed or targeted along a predefined travel path **115**. In some cases, the beam **114** is white while in other cases the source **110** is chosen to provide colored light (e.g., red, blue, green, or other colored light). Some embodiments use a light source **110** that outputs collimated light to provide the light stream/beam **114**. For example, the light source **110** may use a laser light source such as a laser light source projector (e.g., with a laser light engine to provide RGB color). In other cases, collimated light for the light stream/beam **114** is provided with a light source **110** in the form of a collimated light emitting diode (LED) source (e.g., an LED emitting red, green, or blue light or a combination of the three to create light **114** as a stream of any desired color). In still other cases, theatrical lighting is used for the source with its output focused into a relatively tight cylindrical beam to provide the stream/beam **114** along a travel path **115**. The light source **110** may be on continuously or may be only turned on by the controller **140** when the driver/actuator **122** is operated by the controller **140** to move the light receiving element **130** into the path of the output stream **114** from light source **110** so as to limit opportunities of viewers to detect the presence of the source **110**.

The special effects system **100** further includes a dynamic light receiving assembly **120**. This assembly **120** includes a driver or actuator **122** coupled to the first or lower end **125** of a support rod (or elongated screen support) **124**, and the driver or actuator **122** is selectively operable via control signals **144** from the controller **140**. In FIG. **1**A, the driver/actuator **122** is inactive or in a standby mode in which the support rod **124** is at a lowered position (e.g., at 0 degrees (or 180 degrees) when the travel path is a 180-degree arc or half circle).

The driver/actuator **122** may take a wide variety of forms to practice the system **100**, and it is generally selected to be capable of rotating the rod **124** through an arcuate or semi-circular (to circular) path at a rapid rate (such as in the range of 100 to 140 (or more) RPM or the like with 115 to 125 RPM being useful in some embodiments) to avoid or limit perception by the viewer **104** during deployment/movement of the rod **124**. For example, the driver/actuator **122** may be a pneumatic actuator with an inlet to cause movement in a first direction (e.g. clockwise) and then later in a second direction (e.g., counterclockwise) while other embodiments may use an electric motor/actuator. One prototyped embodiment used a pneumatic rotary actuator running at about 40 psi to rotate the whip assembly. A catcher or brake assembly (as explained in more detail below) may be included to assist the rapid stopping of the rod **124** at the ends of its travel path (unless a 360-degree path is used) and to limit vibration (which may be undesirable noisy or cause damage to the components of the assembly **120**).

The support rod **124** may also take a variety of forms to implement the system **100**. In some embodiments, the rod **124** is 3 to 6 feet or more in length, and it is provided as a cylindrical rod which may have a single diameter (same at each end **125** and **127**) or may be tapered similar to a fishing rod with a greater diameter at the inner end **125** than at the outer end **127**. In some cases, the rod has an outer diameter in the range of 0.15 to 0.5 inches (with one prototype using a 0.246-inch OD rod as measured at the base end **125**). The rod **124** in one useful embodiment was formed from a carbon fiber rod (e.g., a pultruded rod) while other embodiments utilized a fiberglass reinforced plastic rod (again, which may be formed using pultrusion or other techniques). To limit detection by the viewer **104**, the rod **124** is moved very rapidly through the display space, but it can also be designed with features that limit its perception such as a smaller diameter and choosing a color (e.g., a darker color such as black) and outer finish (matte or the like) that limits reflection of ambient light to the viewer **104**.

At the outer end **127**, the rod **124** supports a light receiving screen or element **130**. This element **130** is generally formed of an outer frame **132** (e.g., a black or other dark colored plastic or metal wire frame or the like) and a screen **134** supported by the frame **132** to be taut and planar. The screen **134** is fabricated from a material that is opaque enough to receive (and typically reflect) the light **114** from source **110** but not wholly opaque such that is easily seen or perceived by the viewer **104**. In general, the material for the screen **134** is mesh and a relatively dark color. In some embodiments, the screen **134** is formed of a black tulle fabric.

The shape and size of the screen **134** may be varied to practice the system **100**. For example, the screen **134** may be rectangular as shown or may be circular, square, triangular, hexagonal, or a combination shape (e.g., a rectangle with a triangular outer end). The inventors, however, performed numerous experiments and discovered that a rectangular shape works very well for the screen **134** with its base (side attached to supporting end **127**) being smaller than the height of the sides. It was also discovered that a larger screen **134** did not necessarily increase the size (e.g., length) of the achieved/displayed light bolt/streak with rectangles with bases in the range of 3 to 9 inches and sides in the range of 4 to 12 inches being useful (and with one optimized prototype using a screen that was 6 inches by 8 inches).

FIG. **1**B illustrates the special effects system **100** at a second time during a second operating state in which the control signals **144** from the controller **140** cause the driver/actuator **122** to deploy the light receiving element **130** into the display space. Specifically, the driver/actuator **122** acts to rotate the support rod **124** through a 180-degree arc or to rotate its base 180 degrees. This causes the light receiving element **130** and its screen **134** to travel along the arcuate or semi-circular screen travel path **133** shown in FIG. 1B, with the light receiving element **130** shown at the mid-way point in the path **133** (or with the rod **124** rotated to 90 degrees relative to the retracted position shown in FIG. **1**A).

The rotation shown with arrow **131** is a rapid rate/speed, V, such as in the range of 100 to 140 (or more) RPM, with some embodiments using a rotation rate of 115 to 125 (or about 120) RPM to avoid or limit perception or detection of the screen **134** and rod **124** by the viewer **104**. FIG. **1**B shows operation of the assembly **120** at a particular moment in time while it will be understood that at the high rotation rate, V, the screen **134** is only at the shown position for a very small amount of time during each rotation (during each travel of the screen **134** along the path **133**). However, the arcuate path **133** is in a plane that is chosen or set to coincide with or be coplanar with a plane containing the linear light travel path **115** (i.e., the linear path **115** is within the same plane containing the arcuate path **133** of the screen **134**).

As a result, the light beam/stream **114** output from the light source **110** illuminates a portion **138** of the mesh screen **134**, which causes light to be reflected or delivered as shown at **139** to the viewer **104**. Note, the light **114** is striking the thin portion or end of the planar screen **134** (i.e., the light **114** is "in-plane" with the flag/screen **134** and not orthogonal as is typical when projecting onto a surface). The viewer **104**, due to persistence of light, perceives this volumetric cylinder or rectangle (bolt/streak) of light **138**, along with illuminated portions of the screen **134** illuminated with the screen **134** at positions along the path **133** nearby (on either side) to the position shown in FIG. **1**B (e.g., the screen **134** is positioned in the path **115** of the light **114** over a range of angles of rotation near 90 degrees (such as 80 to 100 degrees)). The length of the bolt/streak of light **138** typically is some amount greater than the width of the base of the screen **134** (such as 1.5 to 8 times (or more) the size of the base as prototypes with a screen **134** with a base of 6 inches have been estimated to provide a bolt/streak of light **138** that is 18 to 40 or more inches long). Note, with reference to FIG. **11** and testing, a screen with a base of 6 inches (and a height of 8 inches) is estimated to produce a beam in the range of 41 and 49 inches. As shown, the assembly **120** is positioned relative to the light source **110** and the travel path **115** of the output beam **114** such that the light **114** strikes the middle of the screen **134** to provide the illuminated portion **138** (e.g., the linear travel path **115** bisects the rectangular area of the screen **134**), and this tends to provide a larger and/or longer streak or bolt when perceived **139** by the viewer **104**.

FIG. **2** illustrates the light receiving element **130** in several positions (angular positions) about the fully deployed position (90 degrees rotation of the support rod **124**). As discussed with reference to FIG. **1**B, the assembly **120** is oriented such that the flag/screen **134** is passed through an arcuate travel path **133** that is in a plane that also includes the linear travel path **115** of the output light beam **114** from the light source **110**. When the screen/flag **134** is fully deployed (or the rod **124** is at 90 degrees rotation from the retracted position in this example), the light path **115** bisects the rectangular area of the screen **134** to provide a first and relatively large portion of the viewable light bolt/streak **238**.

However, as shown in FIG. **2**, the light **114** also strikes the flag/screen **134** in numerous other positions of the flag/screen **134** on either side of this fully deployed position. The illumination of the screen **134** in these other positions causes the illuminated portions of the screen **134** to be seen by a viewer, and, due to the rapid rotation of the screen **134**, all of these portions are perceived as being concurrently illuminated to produce a larger (e.g., longer and larger volume) streak/bolt of light **238**. The angular rotation range where light **114** strikes at least a portion of the screen **134** may vary with the positioning of the assembly **120**, with the shape of the screen **134**, and with the size of the screen **134**. However, the rotation range may be a range of about 30 degrees such as 75 to 105 degrees when full deployment is identified as being 90 degrees of rotation.

In some cases, it may be desirable to provide a longer or larger streak or bolt of light in a space, and this may be achieved by combining two or more of the dynamic light receiving assemblies to place two or more of the light receiving elements (e.g., the flags/screens) into the light path of the light source. FIG. **3** illustrates a special effects system **300** that may be provided through a modification of the system **100** of FIGS. **1**A and **1**B to include additional dynamic light receiving assemblies **320** and **370** so as to increase the length and/or quantity of light bolts/streaks produced with a light source **110** with its output beam/stream **114** (of collimated light).

As shown, a second dynamic light receiving assembly **320** is provided in the system **300** to be "downstream" of the first assembly **120** relative to the light path **115** of the beam/stream of light **115** from the light source **110**. The first assembly **120** may be floor (or wall) mounted and the second assembly **320** may then be ceiling (or opposite wall) mounted. The second assembly **320** includes similar components as assembly **120** including a driver **322** for rotating **331** a support rod **324** upon which a light receiving element **330** is mounted. The second assembly **320** rotates the screen **334** through an arcuate travel path **333** that is in the same plane as the path **133** (and the two screens **134** and **334** are also coplanar to the plane containing these paths **133**, **333** and are coplanar to each other). The path **333** is spaced apart from first screen travel path **133** such that the screen **334** is illuminated along a later stretch or length of the light travel path **115** by the beam/stream of light **114**. This creates a second bolt/streak of light **338** visible by a viewer along the light travel path **115**, which is added to the streak bolt **138** in the perception of a viewer. The two streaks/bolts **138**, **338** may be nearly contiguous or may be separated by a small distance (e.g., to avoid collisions between the two rotated flags/screens **134**, **334**).

Similarly, a third assembly **370** is provided with a driver **372** that is floor (or wall) mounted similar to the driver **122** of assembly **120**. The assembly **370** includes a support rod **374** and a light receiving element **380**. The driver **372** operates to rotate **381** the screen **384** through an arcuate travel path **373** that passes through the light path **115** such that light **114** illuminates a portion **388** of the screen **384**, and this creates or displays an additional streak/bolt of light **388**. This bolt/streak **388** is perceived concurrently with the other bolts/streaks **138**, **338** due to the concurrent rotation of the three screens **134**, **334**, and **384** at high rates such that three bolts/streaks **138**, **338**, **388** may be perceived as a single "blast" from the light source **110** (or a prop weapon built up around or to include the source **110**). Hence, the overall length of this bolt/streak is the combined length of the three bolts/streaks **138**, **338**, **388** (each of which would include illuminated portions of the screens **134**, **334**, **384** over a range of rotation angles of the rods **124**, **324**, **374** that place the screens **134**, **334**, **384** into the path **115** of the light **114** so longer than shown in FIG. **3**). Additional (or fewer) assemblies may be used to increase (or reduce) the length of the displayed light bolt/streak provided by the system **300**.

With a general understanding of a special effect system of the present description understood, it may now be useful to describe a particular implementation of an assembly for rapidly deploying (and retracting) a light receiving element (e.g., a mesh screen or flag). FIGS. **4** and **5** are side and end perspective views, respectively, of a dynamic light receiving assembly **400** of the present description such as may be used in the special effects systems of FIGS. **1**A-**3** discussed above. In FIGS. **4** and **5**, the light receiving assembly **400** is shown in a first operating state with the whip assembly **440** retracted or in a retracted state (e.g., with the support rod of the whip assembly **440** at 0 degrees and the support rod resting in a first catcher and with the planar screen/flag oriented to being in a plane including the central axis of the support rod and being orthogonal to a plane containing the base member **412** (or a surface to which the base member **412** is affixed)).

As shown, the light receiving assembly **400** includes a base assembly **410**, a driver (or actuator) assembly **430**, a whip assembly **440**, and a brake assembly **450**. The base assembly **410** is configured for mounting the light receiving assembly **400** on a floor, on a ceiling, on a wall, within a prop body, or other surface, and the base assembly **410** is configured for physically supporting the components of the light receiving assembly **400** and may take a wide variety of forms to provide these functions. In the illustrated example, the base assembly **410** includes a base member or platform **412** for rigidly coupling with a mounting surface (not shown) and also for supporting the brake assembly **450**. The base assembly **410** also includes support members **414** for coupling the driver assembly **430** to the base member or platform **412** (while allowing the shaft of the driver assembly **430** to rotate and providing slots/gaps for the shaft/rod of the whip assembly **440** to rotate through a desired amount of rotation (e.g., 180 degrees) between brake assembly components).

FIG. **6** is a side view of the whip assembly **440** of the light receiving assembly of FIGS. **4** and **5**. As shown, the whip assembly **440** includes a mounting sleeve **642** with a shaft coupler **643** for rigidly attaching the sleeve **642** to the drive shaft of the driver assembly **430** (i.e., the drive shaft passes through the coupler **643** as can be seen in FIG. **4** and one or more set screws or other fasteners may lock the coupler **643** to the shaft) such that the sleeve **642** rotates with rotation of the drive shaft.

The whip assembly **440** further includes a support rod **644** that is constrained at a first or inner end **646** inside the sleeve **642** to move with the sleeve **642**. At the opposite second or outer end **647** of the rod **644**, a flag or screen **652** is mounted to a frame **650**, which is rigidly attached to the rod **644**. The rod **644** may have a length, $L_{Rod}$, of 3 to 6 feet or more, and it may be provided as a tube such as a pultruded carbon fiber tube (hollow) with an OD in the range of 0.15 to 0.3 inches such as 0.22 inches. The rod's length, $L_{Rod}$, defines the length of the arc through which the flag/screen **652** travels.

The flag or screen **652** is contained within a frame **650**, which in one embodiment was provided as a length of 0.055-inch diameter spring wire bent into a rectangle (e.g., a 6-inch by 8-inch rectangle) that sits within the end **647** of the rod **644**. The flag or screen **652** in one embodiment was provided as a swatch or piece of tulle fabric that spans the wire frame **650**. The flag/screen **652** is the part of the assembly **400** that travels in the plane of the light beam/stream (e.g., a laser beam, a collimated light stream/beam from a collimated light source, or the like), and the light striking the rapidly rotating flag/screen **652** creates the illusion of a moving light beam.

FIG. **7** is a side perspective view of the driver/actuator assembly **430** of the light receiving assembly **400** of FIGS. **4** and **5**. As shown, the assembly **430** includes a drive shaft **710** that is rotated, e.g., through 180 degrees, by a drive motor **720**. The drive motor **720** is chosen to be able to provide the rotation **721** at a high rate such as 100 to 140 RPM (with one prototype using a rotation rate of approximately 120 RPM). The drive motor **720** is attached to one or more of the base supports **414**. A shaft collar/support (or bearing) **712** is included for pivotally supporting (e.g., with bearing surfaces) the end of the shaft **710** opposite the motor **720**, and the collar **712** is affixed to one of the base supports **414**. As shown in FIGS. **4** and **5**, the sleeve of the whip assembly **440** is connected to the shaft **710** to move with the rotation **721** of the shaft **710**.

FIG. **8** is a perspective end view of the braking assembly **450** of the light receiving assembly **400** of FIGS. **4** and **5**. The braking assembly **450** includes left and right (or first and second) brake members or elements **820**, **830**, with similar configuration such that the description below of member/element **830** is applicable to member/element **820**. As shown, the brake element **830** includes a catcher or rod-receiving channel **832** that is mounted onto a shock absorber **836** (e.g., an air snubber). In use, at the end of the rotation of the whip assembly **440**, the whip sleeve **642** is caught by the catcher of these two brake members/elements **820**, **830** and is slowed to a more gradual stop (e.g., to limit vibration associated with hard stop).

The catcher or rod-receiving element **832** is a part designed, such as a partial cylinder or open-topped tube, to specifically accommodate the whip sleeve **642** (e.g., with an ID greater than the OD of the sleeve **642** by some predefined amount) as it completes its arc of movement. The dimensions, including length, height, and width, of the catcher **832** were chosen or, in some cases, maximized or optimized for this purpose. As shown, a pad **834** is provided upon the inner or contact surfaces of the catcher **832** to soften the impact of the whip sleeve **642** on the catcher **832**. In one embodiment, the pad **834** takes the form of a layer of memory foam that coats the inside of the catcher **832**. The catcher **832** is coupled with a piston of a shock absorber **836** to allow at least some movement **837** of the catcher **832** upon receipt of a whip sleeve **642**. For example, the shock absorber **836** may be an adjustable pneumatic shock absorber that acts to help decelerate the whip assembly **440** at the ends of its travel path/arc. The shock absorber **836** can be adjusted so as to allow minimum resonance of the carbon fiber rod **644** of the whip assembly **440** upon impact with the catcher **830** and its pad **832**.

FIGS. **9-11** are graphs **910**, **1010**, and **1110** or graphic illustrations of various tested or modeled flag/screen sizes and/or shapes and resulting light bolts or streak lengths. The inventors performed a study to determine ways to optimize the shape of the light receiving screen or flag in order to produce the longest possible visible light streak or bolt (or laser "blast" or beam) in midair. In this study, the support rod was assumed to have a constant length of 4 feet, and, as shown in FIGS. **9-11** with graphs **910**, **1010**, and **1110**, the radial paths for flags/screens of varying dimensions were drawn.

The first investigation of the study involved determining whether increasing the horizontal width of the flag/screen (as measured perpendicular to the support rod) would increase the size (i.e., length) of the visible volumetric light bolt/streak. The images or graphs **910** and **1010** of FIGS. **9** and **10** represent two examples of different flag widths while keeping the height of the flag/screen constant at 4 inches. Specifically, graph **910** shows results of the investigation by illustrating the flag envelope and light bolt/streak (or laser beam) length for a 4-inch by 10-inch flag. As can be seen in FIG. **9**, this generates a light bolt/streak (or laser beam) with a length of 30 inches. Graph **1010** shows the effect of increasing the width form 10 inches to 14 inches. This increases the length of the light streak/bolt (or laser beam) from 30 inches up to 33 inches. As seen, the increase in flag/screen width from 10 to 14 inches produced a relatively small increase in light bolt/streak length such that the inventors determined that there is only a small benefit to increasing the width of a flag/screen.

The second investigation involved increasing the vertical height of the flag/screen (as measured parallel to the support rod). FIG. **11** shows with graph **1110** the results of increasing a flag with a width of 6 inches and a larger height of 8 inches as compared to 4 inches in the tests of FIGS. **9** and **10**. This shows a resulting light streak/bolt (or laser beam) length of 41 inches, which is significantly larger than obtained with the wide but short vertical height flags used in the tests of FIGS. **9** and **10**. The images of FIGS. **9-11** make it clear that increasing the height of the flag/screen allows the flag/screen to cover more area in the linear path of the output light from the light source (e.g., cover or touch more of the beam/stream of collimated light, laser light, or other light from the source). Physical testing of various flag/screen shapes led to the non-intuitive discovery of an optimal flag shape of 8 inches (in height) by 6 inches (in width) based on weight, rigidity, and other factors and not to a larger flag/screen.

Additionally, the examples above indicated it may be desirable in some cases to have the linear light path bisect the rectangular screen/flag when it is fully deployed (support rod at 90 degrees). However, the inventors also made the surprising discovery that there is a noticeable change in the length of the light bolt/streak (or laser beam) displayed based on where the light path (the laser beam or the like) passes through the flag/screen.

In the image **1110** of FIG. **11**, a streak/bolt with a length of 41 inches is achieved with the light path passing through the center of the flag/screen at full deployment. In contrast, a full 8 inches of length were added to the displayed light bolt/streak (or laser beam) to obtain a length of 49 inches by moving the laser slightly lower than the center of the flag/screen (such as to have the light path pass through a location that is located between 20 and 40 percent of the height of the flag when the flag/screen is fully deployed). Overall, the maximum light bolt/streak (or laser beam) length that is used or achieved for a special effects system will likely depend on each individual assembly and where the light source is located.

Although the invention has been described and illustrated with a certain degree of particularity, it is understood that the present disclosure has been made only by way of example, and that numerous changes in the combination and arrangement of parts can be resorted to by those skilled in the art without departing from the spirit and scope of the invention, as hereinafter claimed.

The dynamic light receiving assemblies described herein may be floor mounted as shown in FIGS. **1**A and **1**B. However, they may also be wall or ceiling mounted and/or at an angle relative to a support surface. The dynamic light receiving assemblies may also be "prop mounted" in a theatrical set with a slot provided in the surface of the prop through which the support rod and light receiving element (with the flag/screen) may pass during rotation by the driver/actuator into the display space adjacent the prop.

Many embodiments will be configured for 180-degree rotation as this facilitates hiding or disguising the presence of the driver/actuator and rod and screen when these are not being rapidly rotated. The 180-degree rotation embodiments also require relatively small amounts of space. However, other angular ranges may be used in some cases (such as 30 to 150 degrees, 45 to 135 degrees, and the like). In other cases, full rotation in a circle (360-degree rotation) is utilized with a servo actuated motor or the like being used as the driver for the support rod.

We claim:

**1**. A special effects apparatus for generating an illusion of a moving beam of light in midair comprising:



a light delivery element; and

a dynamic light delivery assembly comprising:

a support rod, wherein the light delivery element is attached to a first end of the support rod; and

a driver coupled to a second end of the support rod opposite the first end of the support rod,

wherein the driver rotates the support rod about the second end at a rotation rate;

wherein, during the rotation of the support rod by the driver, the light delivery element moves along an arcuate travel path and delivers light to a viewer such that the delivered light is along a linear light travel path; and

wherein the arcuate travel path of the light delivery element and the linear light travel path are substantially coplanar.

**2**. The apparatus of claim **1**, wherein the rotation rate is in the range of 100 to 140 revolutions per minute (RPM).

**3**. The apparatus of claim **2**, wherein the rotation rate is in the range of 115 to 125 RPM.

**4**. The apparatus of claim **1**, wherein the support rod has a black outer surface.

**5**. The apparatus of claim **4**, wherein the black outer surface has a matte finish.

**6**. The apparatus of claim **1**, wherein the light delivery element only delivers the light to the viewer during a portion of travel along the arcuate travel path such that the delivered light appears to the viewer to be along the linear light travel path.

**7**. The apparatus of claim **1**, wherein the delivered light is red, green, or blue or a combination thereof.

**8**. The apparatus of claim **1**, wherein the support rod has a length in the range of 3 to 6 feet.

**9**. The apparatus of claim **1**, wherein the arcuate travel path is a 30-degree to 180-degree arc and wherein the driver comprises a catcher assembly adapted to catch the support rod proximate to the second end and to decelerate the support rod to absorb shock at opposite ends of travel of the arcuate travel path.

**10**. A special effects apparatus for generating an illusion of a moving beam of light in midair comprising:

a dynamic light delivery assembly comprising:

an elongated support rod;

a light delivery element attached proximate to a first end of the support rod; and

a driver coupled to a second end of the support rod opposite the first end of the support rod,

wherein the driver rotates the support rod about the second end at a rotation rate;

wherein, during the rotation of the support rod by the driver, the light delivery element moves along an arcuate travel path and delivers light to a viewer during a portion of travel along the arcuate travel path such that the delivered light is along a linear light travel path; and

wherein the arcuate travel path of the light delivery element and the linear light travel path are substantially coplanar.

**11**. The apparatus of claim **10**, wherein the rotation rate is in the range of 100 to 140 revolutions per minute (RPM).

**12**. The apparatus of claim **11**, wherein the rotation rate is in the range of 115 to 125 RPM.

**13**. The apparatus of claim **11**, wherein the support rod has a length in the range of 3 to 6 feet.

**14**. The apparatus of claim **11**, wherein the support rod has a black outer surface.

**15**. The apparatus of claim **11**, wherein the arcuate travel path is a 30-degree to 180-degree arc and wherein the driver comprises a catcher assembly adapted to catch the support rod proximate to the second end and to decelerate the support rod to absorb shock at opposite ends of travel of the arcuate travel path.

**16**. A special effects apparatus for displaying midair beams of light in a repeatable manner, comprising:

a light providing assembly;

a rod, wherein the light providing assembly is attached to a first end of the rod; and

a drive assembly coupled to a second end of the rod, wherein the drive assembly rotates the rod at a rotation rate greater than 100 RPM to move the first end of the rod along an arcuate path;

wherein the arcuate path is in a plane,

wherein the light providing assembly provides light while in the plane and over a range of angular positions of the rod,

wherein the provided light is 360-degree perceivable as a substantially linear streak or beam of light in the plane,

wherein the arcuate travel path is a 30-degree to 180-degree arc, and

wherein the driver comprises a catcher assembly adapted to catch the support rod proximate to the second end and to decelerate the support rod to absorb shock at opposite ends of travel of the arcuate travel path.

**17**. The apparatus of claim **16**, wherein the linear streak or beam of light has a length of at least 30 inches.

**18**. The apparatus of claim **16**, wherein the support rod has a length in the range of 3 to 6 feet.

**19**. The apparatus of claim **16**, wherein the support rod has a black outer surface.

* * * * *