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Hutton

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[54] **PROJECTION GATE APPARATUS HAVING AN AXIALLY-TRANSLATABLE MOUNT**

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[73] Assignee: **Vari-Lite, Inc.**, Dallas, Tex.

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[51] **Int. Cl.**[6] **F21V 21/28**

[52] **U.S. Cl.** **362/283**; 362/323

[58] **Field of Search** 362/281, 283, 362/293, 322, 323

[56] **References Cited**

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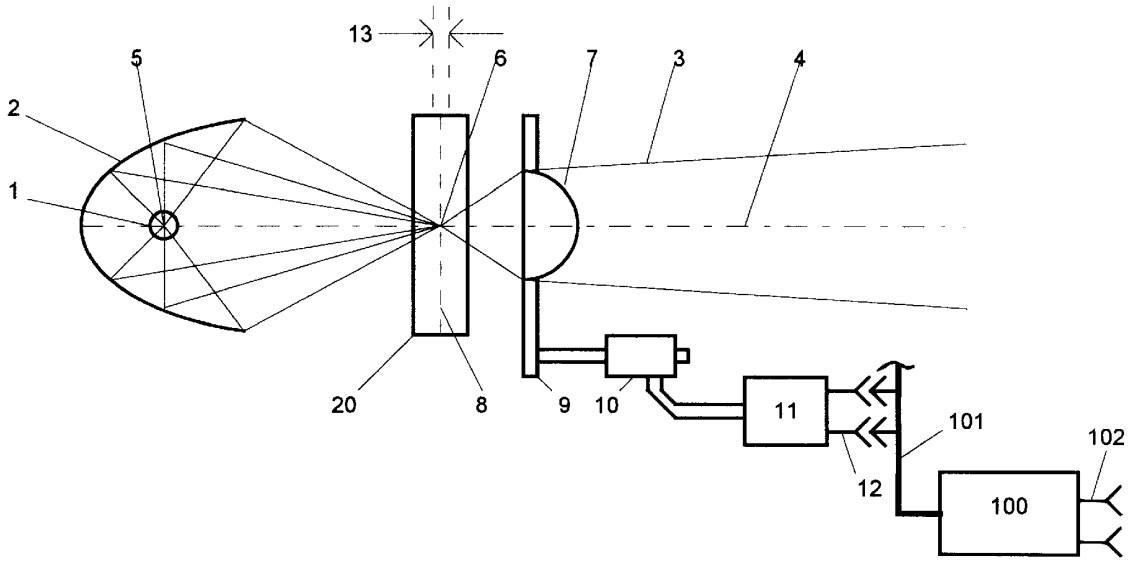
Assistant Examiner—Todd Reed Hopper
Attorney, Agent, or Firm—Hughes & Luce, L.L.P.

[57] **ABSTRACT**

An optical system for an image projector luminaire includes a variable-focus lens having a depth-of-field adjustable as to location along an optical axis, and two carriages each supporting at least one image pattern generator at separate locations along the optical axis, at least one of those carriages being adjustable as to location along the optical axis. The system is operable to bring either or both image pattern generators into focus. Each carriage may support pattern generator exchanger mechanisms for selecting one of a plurality of available patterns, and may also rotate the selected pattern. The movable carriage, the lens, and the pattern exchanger mechanisms may all be motorized and operable by remote or computer control.

16 Claims, 6 Drawing Sheets



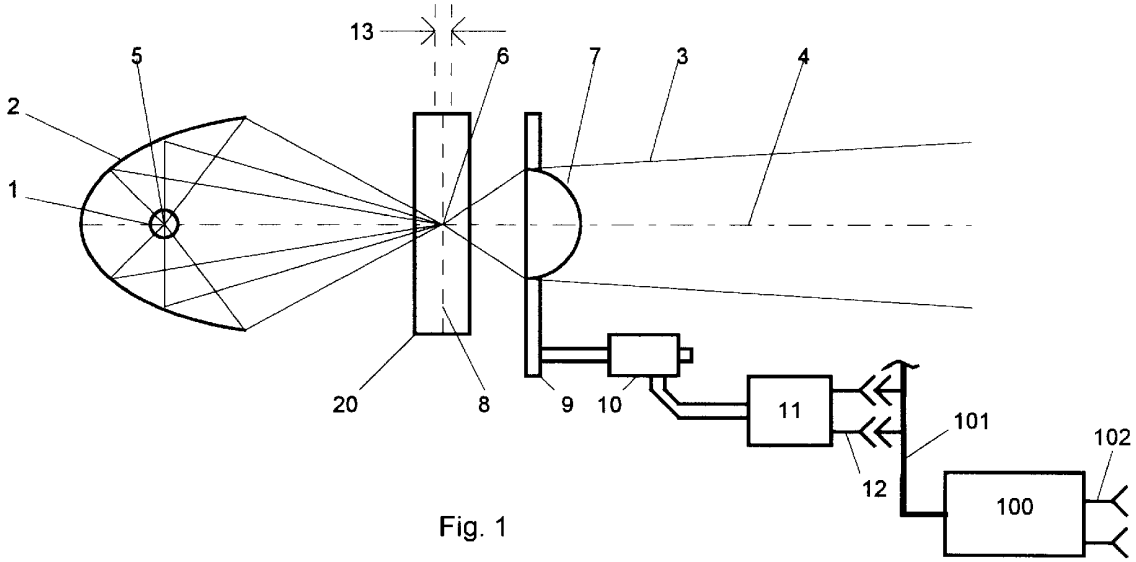

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Fig. 1

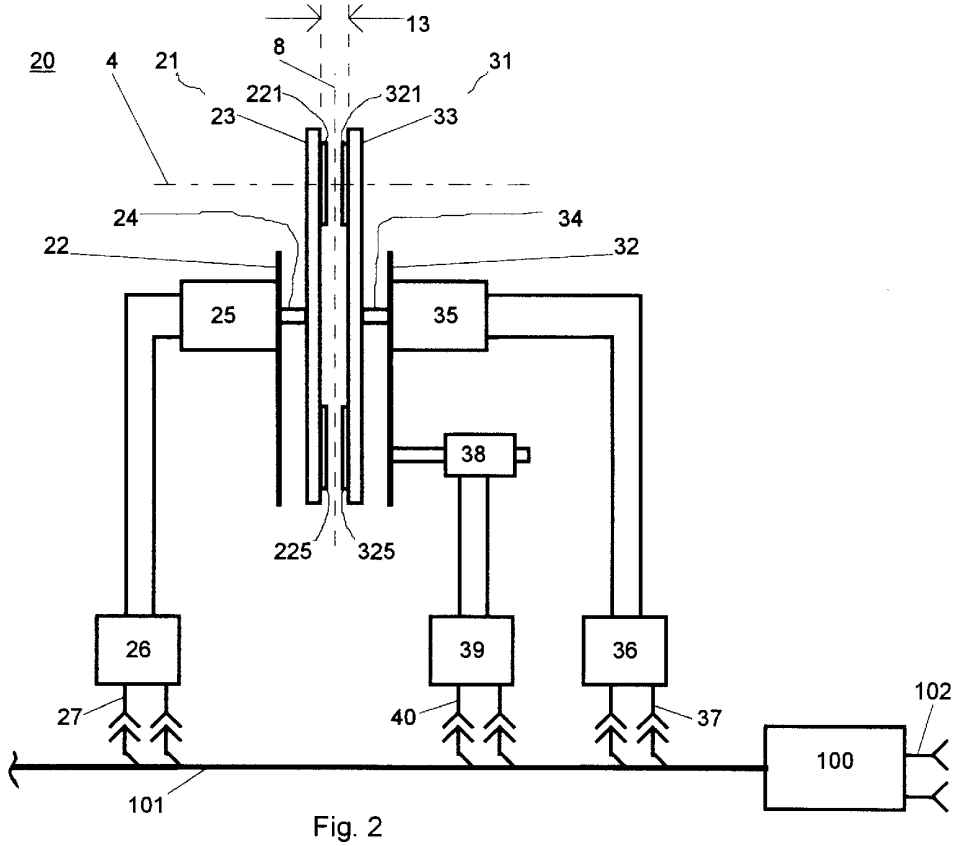
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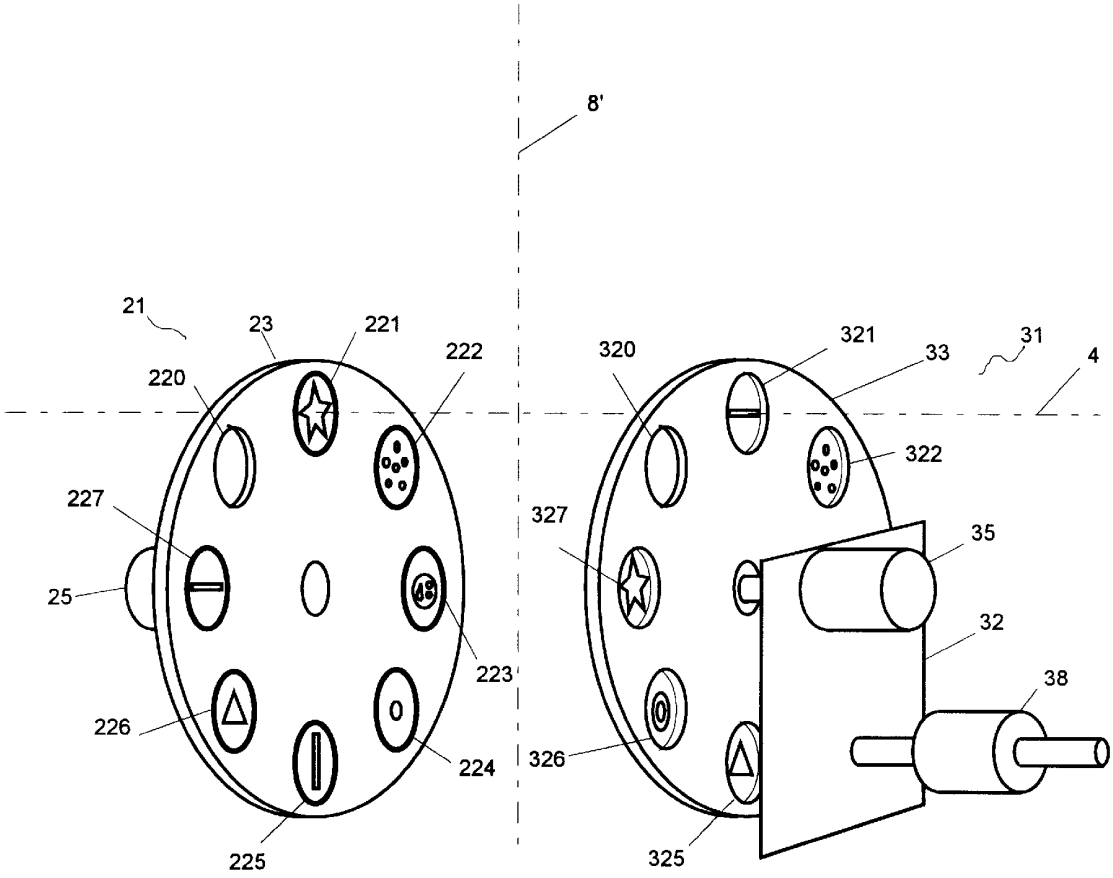
Fig. 2


8'
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221
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220
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38
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325

Fig. 3

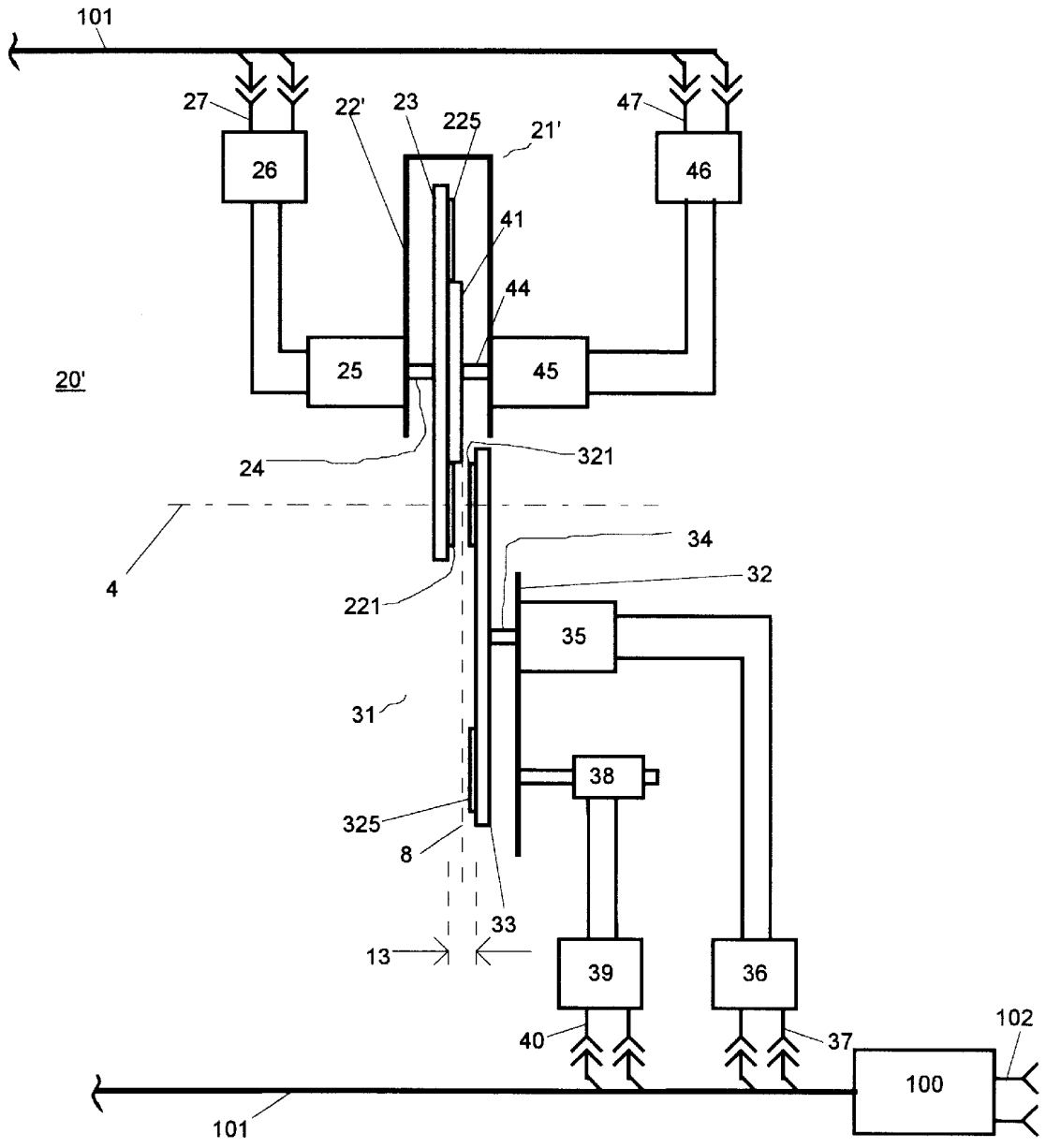
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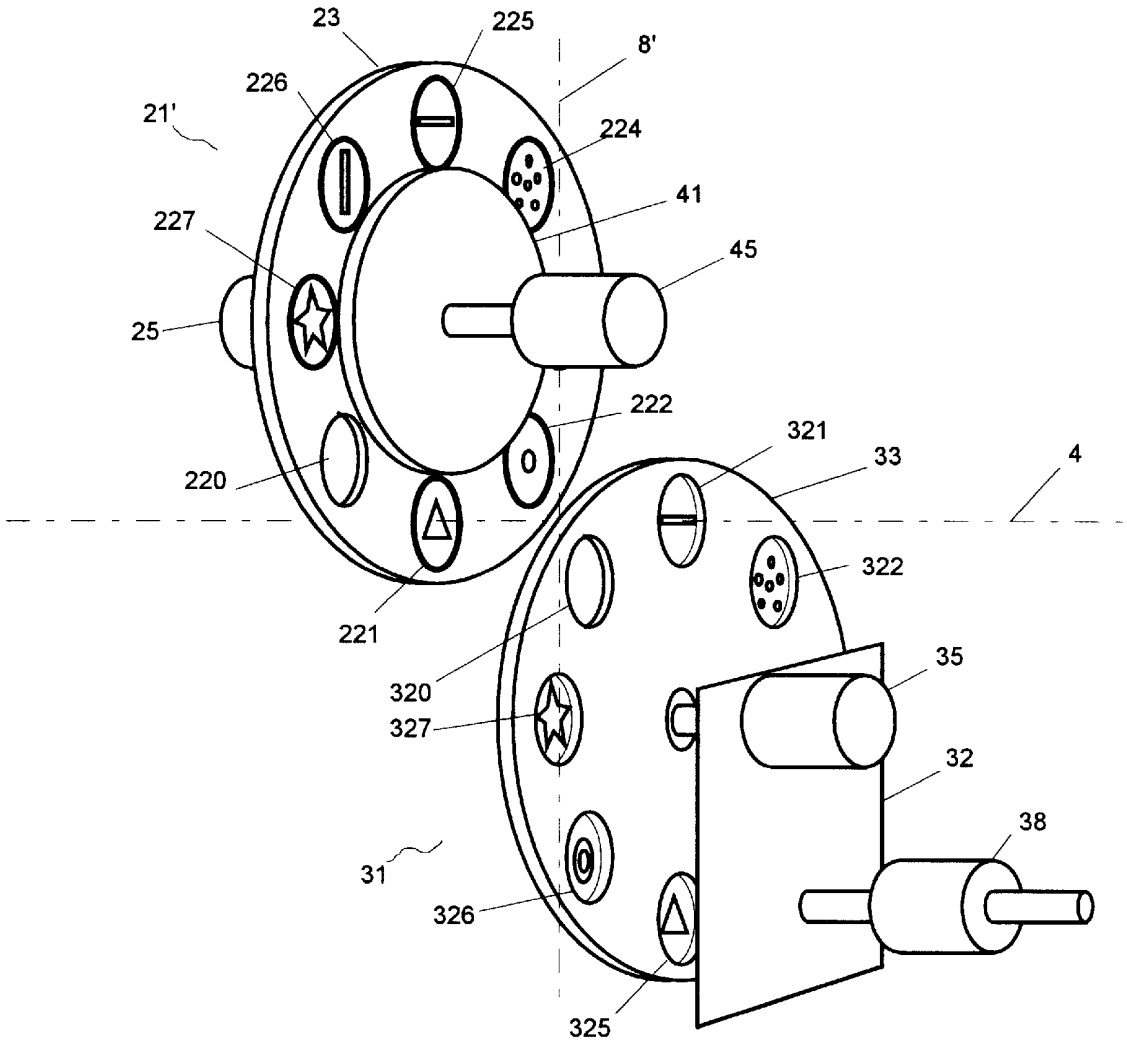
Fig. 4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325

Fig. 5

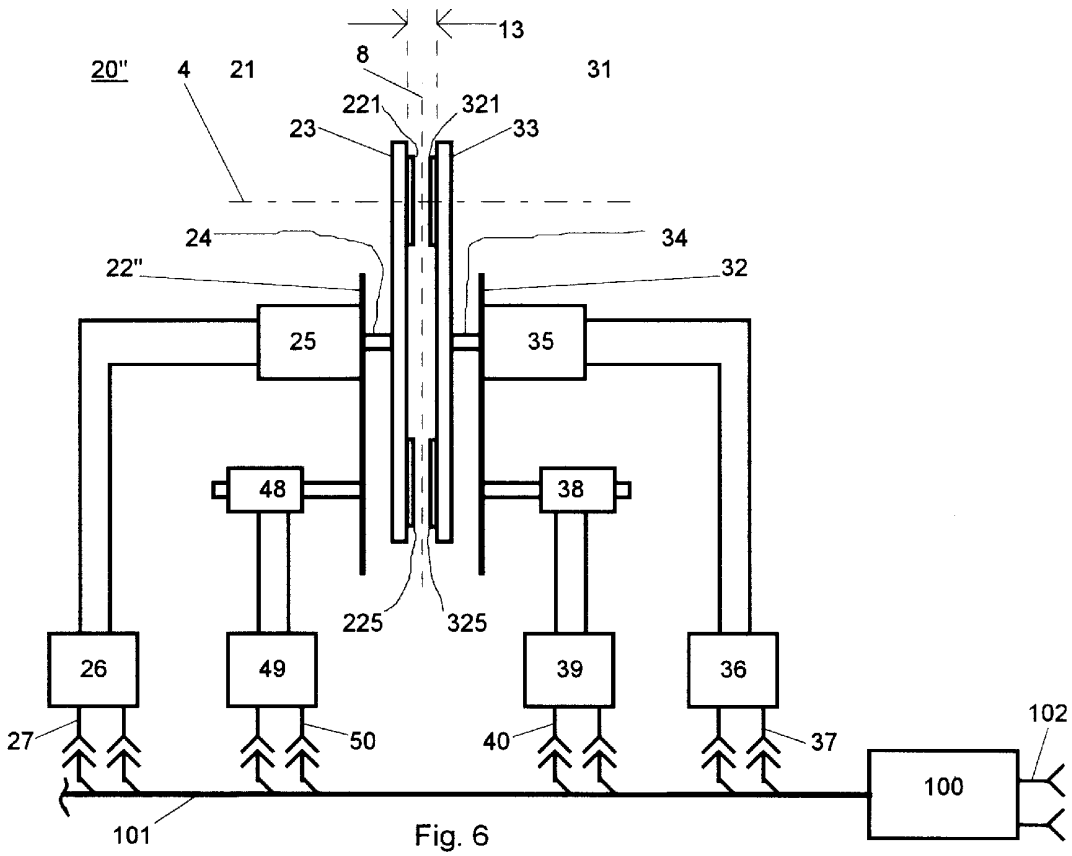
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Fig. 6

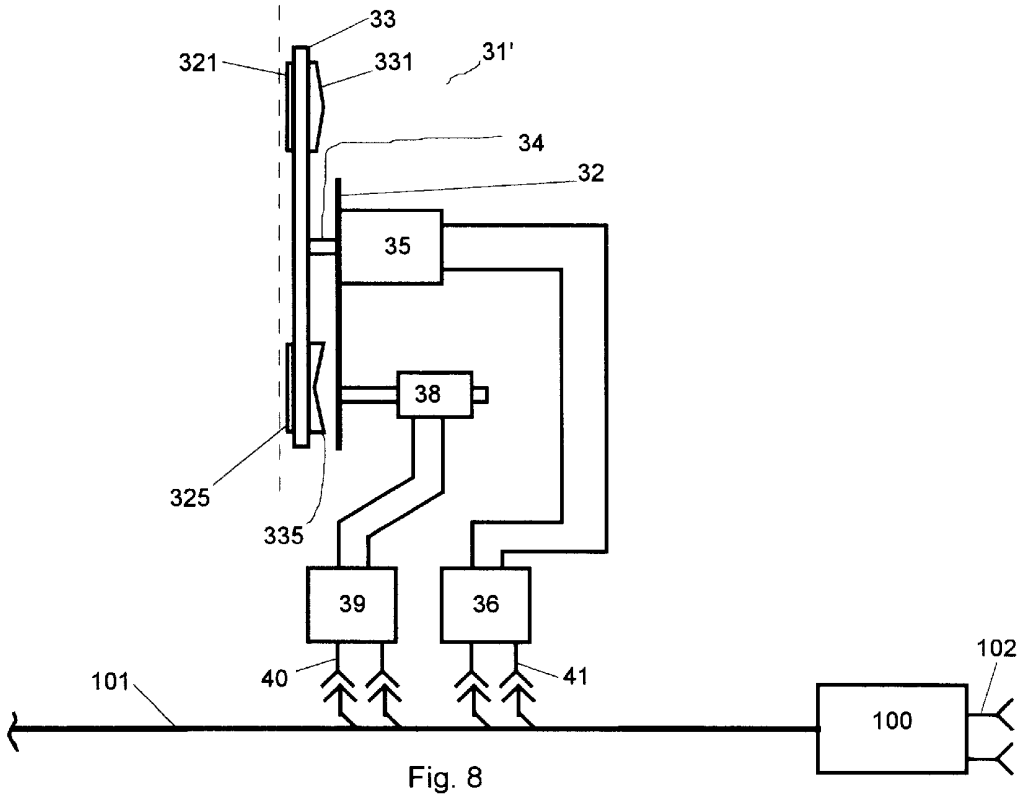
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Fig. 8

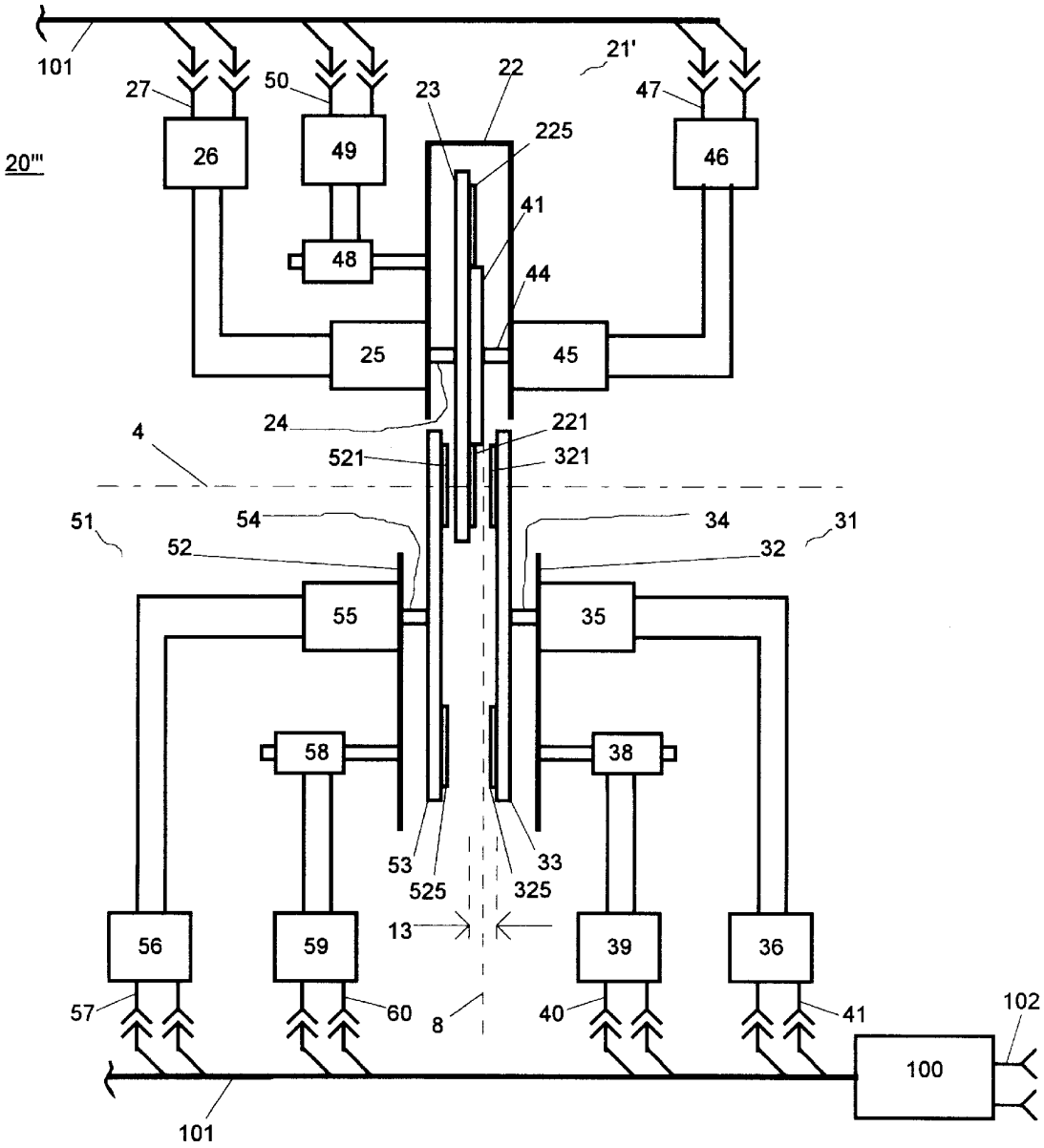
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Fig. 7

PROJECTION GATE APPARATUS HAVING AN AXIALLY-TRANSLATABLE MOUNT

FIELD OF THE INVENTION

The present invention relates generally to stage lighting instruments, and particularly to an image-projector luminaire having an axially-translatable mount for moving an image pattern generator along the optical axis of the luminaire.

DESCRIPTION OF RELATED ART

Prior art image pattern projector luminaires have evolved from the ellipsoidal spot luminaire with a stamped steel stencil-like pattern inserted in a projection gate, to motorized pattern exchangers such as those shown in U.S. Pat. Nos. 4,392,187; 4,779,176; 5,537,303; 4,891,738; and 5,113,332. These pattern exchangers provide simple and durable means for inserting one of a selection of image pattern generators or "gobos" into a projection optical system and for removing the generator therefrom. Certain of these pattern exchangers provide various means for rotating the pattern generator within the beam to provide for rotating or controlling the orientation of the projected image.

Motorized means for adjusting a projection lens are shown in U.S. Pat. Nos. 4,709,311; and 5,029,992 which are incorporated herein by reference. These provide means for controlling the quality of a projected image, which means can be operated by remote control to bring a projected image into or out of focus. In projection luminaires having plural sequential image pattern generators, adjustment of the lens can bring either of two image pattern generators into focus while the other goes out of focus, thereby "morphing" from one image to the other.

While it is known that two image pattern generators can be brought into focus at the same time if both pattern generators lie within a depth of field of the projection lens, both pattern generators will always be in focus whenever either one is in focus so that morphing between them is not possible. Further, the depth of field of a high-performance projection lens may be small, preventing or making difficult the operation of two adjacent motorized pattern exchangers.

SUMMARY OF THE INVENTION

It is an object of the invention to provide a motorized mechanism for exchanging image pattern generators or "gobos" within a projection optical system that provides a carriage for at least two gobos in the system at the same time and provides means for bringing either or both gobos into focus.

In accordance with the present invention, a projection optical system includes a lamp coupled with a reflector projecting a light beam along an optical axis, a projection gate apparatus, and a projection lens. The projection gate apparatus includes a fixed gobo carriage and a movable gobo carriage, the movable gobo carriage being movable along the axis of the light beam. The projection lens is adjustable as to the location of its object plane along the optical axis; the lens and the movable gobo carriage being operable to bring either or both gobos into focus.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic side elevation of an optical system for an image projector luminaire;

FIG. **2** is a schematic side elevation of a projection gate apparatus according to one aspect of the present invention;

FIG. **3** is a perspective view of a projection gate apparatus according to one aspect of the present invention;

FIG. **4** is a schematic side elevation of a projection gate apparatus according to a second aspect of the present invention;

FIG. **5** is a perspective view of a projection gate apparatus according to a second aspect of the present invention;

FIG. **6** is a schematic side elevation of a projection gate apparatus according to a third aspect of the present invention;

FIG. **7** is a schematic side elevation of a projection gate apparatus according to a fourth aspect of the present invention;

FIG. **8** is a schematic side elevation of a projection gate apparatus according to a fifth aspect of the present invention.

DETAILED DESCRIPTION

FIG. **1** shows a typical optical system for a projector luminaire. A lamp **1** coupled with an elliptical reflector **2** projects a light beam **3** along an optical axis **4**. The lamp is located at a first focal point **5** of the reflector, the lamp and reflector comprising an illumination system for illuminating a projection gate. Alternatively, the illumination system may include a lamp coupled with a spherical or other reflector and a condenser lens. A projection gate apparatus **20** located along the optical axis near a minimal focus **6** of the reflector controls the shape of the beam, including the forming of images by the projected beam. A lens **7** located along the optical axis projects an image of an object at the object plane **8** located at a certain distance behind the lens and within the projection gate apparatus.

The lens is supported by a movable carriage **9**, the carriage being movable along the optical axis so as to form a focused image of the object within the projection gate apparatus. The object plane, located a certain distance behind the lens, possesses a certain depth-of-field characteristic **13**, the distance to the object plane and the extent of the depth-of-field being dependent upon the design of the lens. The location of the object plane is adjusted by moving the lens. A motorized mechanism **10** coupled to the lens carriage can be operated by remote control or by computer control via a motor drive circuit **11** having control input terminals **12**.

The projection gate apparatus **20**, according to one aspect of the present invention as shown in FIG. **2**, includes a first gobo carriage **21** and a second gobo carriage **31** disposed on either side of object plane **8**. As shown in FIG. **3** with the first and second gobo carriages separated for clarity and the location of the object plane represented by a center line **8'**, first gobo carriage **21** has a plurality of gobos **221–227** mounted about the periphery of a wheel **23**, the wheel being mounted on the shaft **24** of a reversible electric motor **25** mounted to a support **22**(see also FIG. **2**). The motor can be energized in a forward or reverse direction via a motor drive

circuit **26** having control input terminals **27** to position a selected one the plurality of gobos in the beam path. The wheel preferably includes an open position **220** comprising a clear aperture in which no image is formed.

As shown in FIG. **2** and FIG. **3**, second gobo carriage **31** has a plurality of gobos **321–327** mounted about the periphery of a wheel **33**, the wheel being mounted on the shaft **34** of a reversible electric motor **35** driven by a motor drive circuit **36** having control input terminals **37**. The second gobo carriage is supported by a movable support carriage **32**, the support carriage being movable along the optical axis so as to position a selected gobo close enough to a selected gobo of the first gobo carriage such that both gobos lie within the depth of field of the lens when focused on the first gobo carriage. A motorized mechanism or linear translator **38** comprising, for example, a motor and a lead screw coupled to support carriage **32**, can be operated by remote control or by computer control via a motor drive circuit **39** having control input terminals **40**. All of the motor drive circuits, such as **11**, **26**, **36**, and **39**, may be connected via their respective input terminals to a motor control bus **101**, which is energized by a controller **100** having input terminals **102** for connection to remote control means. The controller **100** may comprise a local de-multiplexer circuit such as that shown in U.S. Pat. No. 4,392,187 (incorporated herein by reference). Alternatively, controller **100** may comprise a local processor-based circuit such as that shown in U.S. Pat. No. 4,980,806 (incorporated herein by reference).

In operation, first gobo carriage **21** is operated to position a first selected gobo **221** in the beam path, second gobo carriage **31** is operated to position a second selected gobo **321** in the beam path, and lens carriage **9** is operated to focus the lens upon one or the other images formed by the selected gobos. The lens carriage can be operated in one direction to bring the first image, formed by gobo **221**, into focus and can then be operated in an opposite direction to bring the second image, formed by gobo **321**, into focus while the first image goes out of focus, thereby morphing from the first image to the second image.

Alternatively, support carriage **32** can be operated simultaneously with lens carriage **9** to move the second gobo **321** adjacent to the first gobo **221**, within the depth-of-field of the lens, while the lens is moved concomitantly to keep the second image in focus. Note that the depth-of-field of the lens can be as small as 0.050 inches (1.27 mm). When the first gobo and the second gobo are located within the depth-of-field of the lens, and the lens is focused on either gobo, then both images formed thereby are in focus. A compound image is formed comprising elements of the first image and the second image.

Thereafter, support carriage **32** can be operated simultaneously with lens carriage **9** to move the second gobo **321** away from the first gobo **221**, while the lens is moved concomitantly to keep the second image in focus. As the lens **7** moves, the object plane **8** of the lens is moved away from first gobo so that the first image formed thereby goes out of focus, while the second gobo is moved concomitantly to keep the second gobo in the object plane. The compound image dissolves into the second image as elements of the first image go out of focus. Alternatively, the lens may be initially focused on both gobos, and the lens held stationary while support carriage **32** moves second gobo **321** away from first gobo **221**, thereby dissolving the image of the second gobo so that only the first gobo remains to form a projected image. A preferred embodiment of the present invention provides that the image-forming planes of the two gobos lie on or about adjacent faces of their respective gobo carriages, rather than being on opposing faces thereof, so that the imaging-forming planes might be positioned as closely as possible longitudinally within the depth-of-field of the lens. This enables the two images to be brought into sharp focus both at the same time, as desired.

The above-described apparatus provides motorized means for focusing a projection lens on a selected one or both of two image pattern generators (gobos) placed in a light beam, and enables a method for gradually introducing an image into a light beam or removing the image from the beam, for gradually transitioning from one image to another, and for gradually transitioning from a compound image to a single image or vice versa.

An alternate arrangement of the first and second gobo carriages shown in FIG. **4** and FIG. **5**, provides for accommodation of a gobo rotator mechanism such as disclosed in U.S. Pat. No. 5,537,303 said patent being incorporated by reference herein. In this alternate arrangement, first gobo carriage **21'** is disposed on an opposite side of optical axis **4** from gobo carriage **31** to provide clearance for a gobo rotator mechanism, including gobos **221–227** rotatably mounted to wheel **23** and engaged by a sun gear **41** coupled to a shaft **44** of motor **45** under the control of motor drive circuit **46** having control input terminals **47**. Sun gear **41** engages each gobo **221–227** such that as sun gear **4** rotates so does each gobo. A similar gobo rotator mechanism may also be provided for second gobo carriage **31**.

According to another aspect of the present invention shown in FIG. **6**, projection gate apparatus **20"** includes a movable support carriage **22"** provided for first gobo carriage **21"** such that the longitudinal position of a gobo supported by the first gobo carriage is also adjustable along the optical axis, thereby providing for a variety of optical effects as the position of the two gobos and the position of the object plane of the projection lens are varied.

According to another aspect of the present invention shown in FIG. **7**, projection gate apparatus **20"'** includes a third gobo carriage **51** comprising a plurality of gobos **521–527** mounted about the periphery of a wheel **53** mounted on a shaft **54** of a motor **55** under control of motor drive circuit **56** having control input terminals **57**, which may also be supported by a movable support carriage **52** having a motorized mechanism **58** coupled to the support carriage and operated via a motor drive circuit **59** having control input terminals **60**, thereby providing for a variety of optical effects involving combinations of up to three images. Two images might be in sharp focus while a third image provides soft or diffuse effects, the third image being out of focus. Alternatively, one image might be in sharp focus while two other images provide soft or diffuse effects, the other two images being out of focus. Further, a dissolve can be accomplished by spacing three images along the optical axis such that no two images can lie within the depth-of-field of the projection lens, and then sweeping the lens throughout a range of travel which brings each of the three images

successively into focus and then out of focus, thereby morphing from one image to another image to yet another image. Alternatively, the lens might remain stationary while three movable support carriages in concomitant motion sweep their respective gobos through the depth-of-field of the projection lens. Gobo carriage support **22** can be made movable with the addition of a motorized mechanism **48** coupled thereto, the mechanism operated via motor drive circuit **49** having control input terminals **50**.

According to another aspect of the present invention shown in FIG. **8**, a gobo carriage **31'** supports an image-forming gobo **321** on one surface of the carriage and supports another light modifying device such as a prism **331** or other refractive element **335** on an opposite surface of the carriage. When the prism or other refractive element is positioned coaxially with the optical axis, the longitudinal position of the object plane relative to the gobo and the prism can be varied to provide for a variety of optical effect as the lens is focused upon either the gobo or the prism, both, or neither; dynamic effects also being possible as the relative longitudinal positions of the optical elements are varied while the lamp is energized and a light beam is consequently projected.

It should be recognized that static or dynamic optical effects can be produced by the invention in any of its aspects, providing that any movable support carriages are motorized and are operable by manual or preprogrammed, local or remote control; a variety of suitable control arrangements being well-known. For example, three or more gobo exchanger wheels can be mounted in close proximity and supported by a single movable support carriage operable to position any one gobo or two adjacent gobos within the depth of field of the object plane. It should also be recognized that the invention is practicable by locating the disclosed projection gate apparatus adjacent to a focal point of a focused-beam optical system as shown herein, or by locating the apparatus of the present invention in any collimated portion of a light beam wherein the image-forming elements are illuminated and can be brought within a depth-of-field of a projection lens.

I claim:

1. A projection optical system, comprising:

a lamp coupled with a reflector for projecting a light beam along an optical axis, a projection gate apparatus, and a projection lens having an object plane;

said projection lens being movable so as to adjust the location of said object plane along said optical axis;

said projection gate apparatus including a first gobo carriage having a first image pattern generator and a second gobo carriage having a second image pattern generator:

said second gobo carriage being movable along said optical axis;

said lens and said second gobo carriage being operable to place either or both of said first and second image pattern generators within a depth-of-field of said object plane.

2. The projection optical system according to claim **1** further including a third gobo carriage movable along said optical axis, said third gobo carriage having a third image pattern generator.

3. The projection optical system according to claim **2** wherein said first gobo carriage is movable along said optical axis.

4. A method for controlling images to be projected by a projection optical system, comprising the steps of:

moving a lens along an optical axis of said projection optical system to focus upon a first gobo;

moving a second gobo along said optical axis so that both gobos are in focus.

5. The method of claim **4**, further comprising the step of moving said second gobo and said lens so that said first gobo goes out of focus and said second gobo remains in focus.

6. The method of claim **4**, further comprising the step of moving said second gobo along said optical axis so that only the first gobo is still in focus.

7. A method for controlling images to be projected by a projection optical system, comprising the steps of:

moving a first gobo along an optical axis of said projection optical system to place said first gobo within a depth of field of an object plane of a projection lens.

8. The method of claim **7**, further comprising the step of moving a second gobo along said optical axis of said projection optical system to place said second gobo within a depth of field of an object plane of a projection lens.

9. The method of claim **8**, further comprising the step of moving either said first gobo or said second gobo along said optical axis to remove either of said gobos out of said depth of field.

10. In a stage lighting instrument including an image projection optical system having plural axial locations along an optical axis thereof, a method of controlling the focus of plural sequential image pattern generators coincident with said optical axis in a projection gate apparatus, comprising the steps of:

controlling the axial location of at least one element of a projection lens system to locate an object plane of said lens system within said projection gate apparatus, and

controlling the axial location of at least one of said image pattern generators to vary the axial separation of at least two of said image pattern generators within said projection gate apparatus.

11. A projection gate apparatus for use in a projection optical system having a lamp coupled with a reflector for projecting a light beam along an optical axis and a projection lens movable along said optical axis, said projection lens defining an object plane, said projection gate comprising:

a first carriage for supporting a first image pattern generator;

a second carriage for supporting a second image pattern generator, and

a translator for moving said second carriage along said optical axis such that either or both of said first and image pattern generators can be disposed within a depth of field of said object plane.

12. A projection gate apparatus according to claim **11** further comprising a third carriage supporting a third image pattern generator and a translator for moving said third carriage along said optical axis.

13. A projection gate apparatus according to claim **11** wherein said first and second carriages are disposed on opposite sides of said optical axis.

14. A projection gate apparatus according to claim **12** further comprising a translator for moving said first carriage along said optical axis.

15. A method for controlling images to be projected by a projection optical system having a lamp coupled with a

reflector for projecting a light beam along an optical axis, and a projection lens having a depth of field, said method comprising the steps of

providing a first image pattern generator along said optical axis,

providing a second image generator along said optical axis, and

locating said second image pattern generator and said projection lens along said optical axis so as to place either or both of said image pattern generators within the depth of field of said lens.

16. A projection optical system comprising:

a lamp for projecting a light beam along an optical axis;

a projection lens disposed along said optical axis said projection lens having a depth of field;

a first linear translator associated with said projection lens and capable of moving said lens along said optical axis;

first and second image pattern generators disposed along said optical axis;

a second linear translator associated with said second image pattern generator capable of moving said second image pattern along said optical axis;

a controller associated with said first and second linear translators for coordinating the movement of said projection lens and said second image pattern generator to place either or both of said image pattern generators in the depth of field of said projection lens.

* * * * *