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[54] **RUNWAY ILLUMINATION SYSTEM**

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[52] **U.S. Cl.** ..... **240/1.2,** 240/41 R, 240/48, 350/6, 350/285

[51] **Int. Cl.** **B64f 1/20**

[58] **Field of Search** ..... 240/1.2, 3, 1 R, 41 R, 240/48; 350/285, 6, 7; 331/94.5 A, 94.5 X

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[57] **ABSTRACT**

An illumination system for providing center and edge stripes for an airport runway, in which six laser generating stations are respectively arranged in with relationship wit the ends of the proposed stripes. Each station includes a below-ground generator for producing a beam of coherent visible radiation, a housing supported above the level of the runway and an upstanding conduit for transmitting the beam to the housing. Within the housing the beam is expanded to the desired width of the stripes and is then collimated to prevent further increase in the beam diameter. The thus modified beam is projected either in a direction parallel to the runway or downwardly toward the runway surface and in a preferred embodiment is caused to oscillate at a frequency in excess of the persistency of vision to produce a continuous visible line on the runway.

15 Claims, 5 Drawing Figures

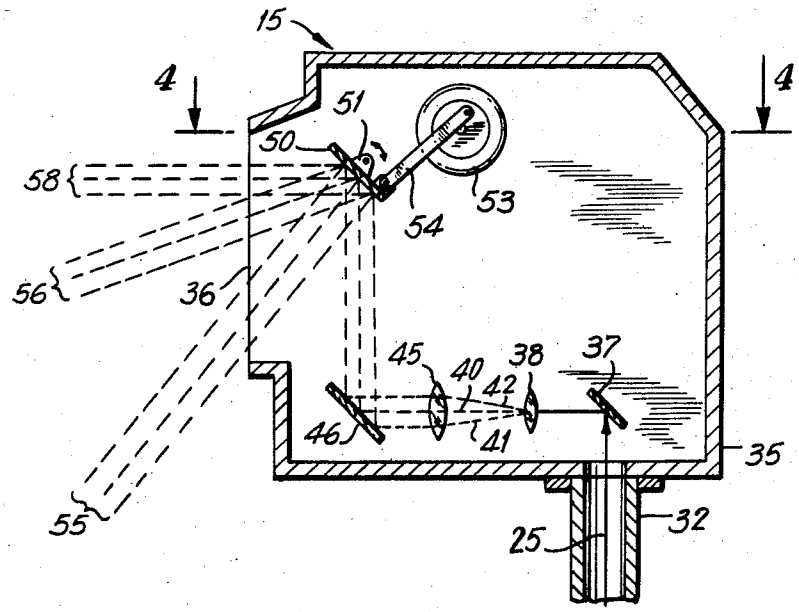


FIG. 1

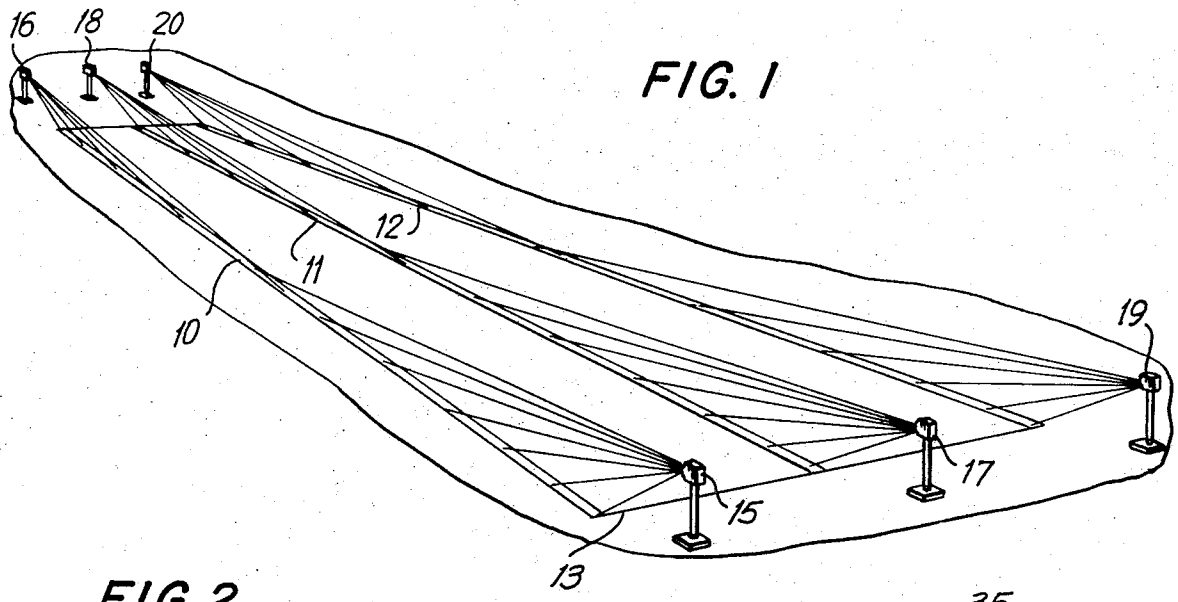


FIG. 2

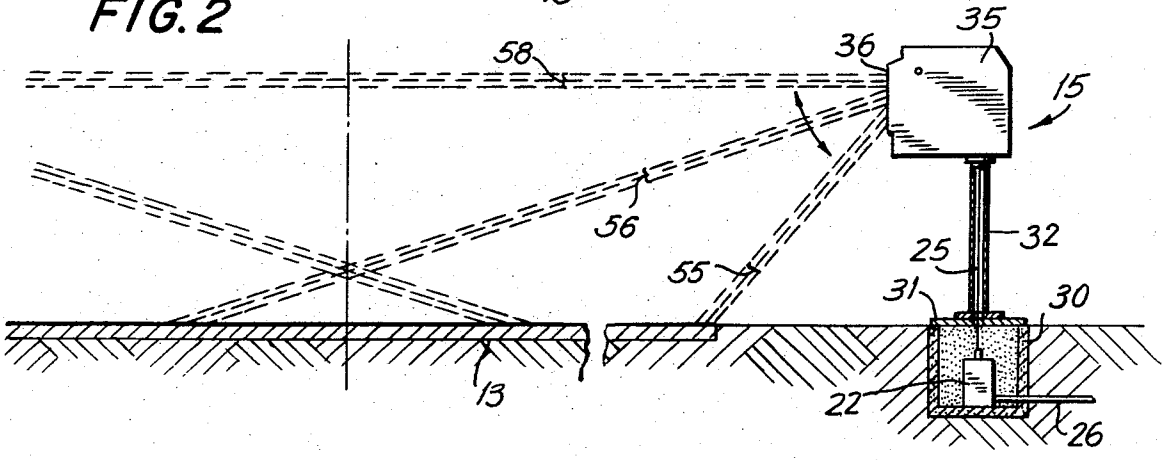
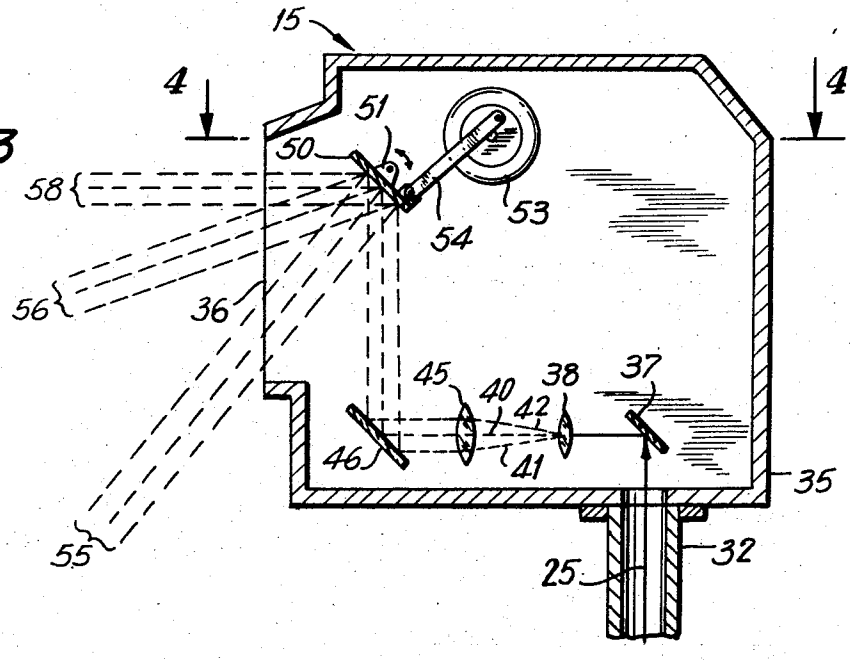


FIG. 3



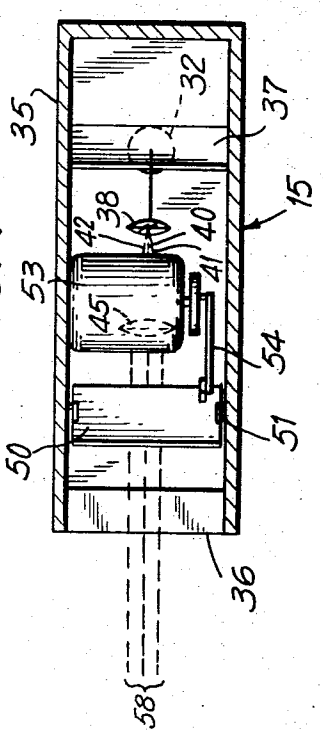


FIG. 4

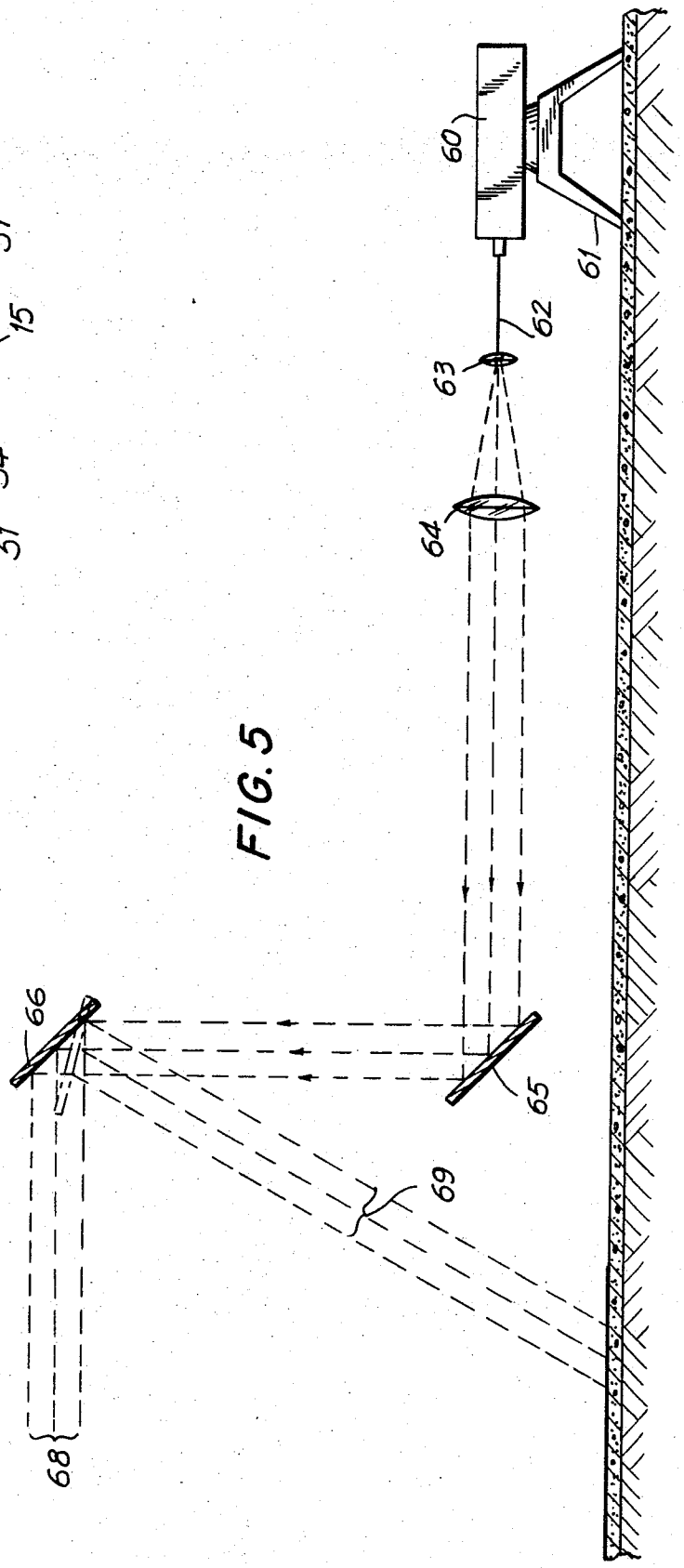


FIG. 5

RUNWAY ILLUMINATION SYSTEM

BACKGROUND OF THE INVENTION

This invention relates to the illumination of surfaces and more particularly to a system for providing illuminated striping for a longitudinally extending, substantially horizontal surface.

The present invention, while of general application, is particularly well suited for providing longitudinal striping on an airport runway, taxiway or other road surface. It is conventional practice to illuminate the edges and center lines of runways and taxiways with individual incandescent lamps of comparatively high candle power. The lamps are spaced apart by a fixed distance, commonly 50 feet for the center line and 200 feet for the runway edges. Modern jet runways at times approach 15,000 feet or more in length and require approximately 450 lamps for the edges and center lines. Although the major portion of each lamp is recessed below the runway surface, the lamp must protrude to some extent above the surface to provide adequate visibility for approaching aircraft.

Heretofore, difficulties were encountered in systems for providing illuminated striping on runways and other surfaces. As an illustration, the visibility of the stripes of such prior systems was impaired in situations in which the surface was in some way obstructed, such as during a snow storm or other inclement weather conditions. Snow plows and similar equipment used to remove the obstructions often tended to shear off the protruding portions of the lamps and thus necessitated their replacement. In addition, the type of illumination utilized in many previous systems exhibited a comparatively high installation cost, often running to several hundred dollars for each lamp. The power requirements for such prior systems also were excessive, and the systems were expensive to maintain.

SUMMARY

One general object of this invention, therefore, is to provide a new and improved illumination system for airport runways and other surfaces.

More specifically, it is an object of this invention to provide such a system which eliminates the need for installing individual lamps or other equipment on the surface being illuminated.

Another object of this invention is to provide a runway illumination system having substantially reduced power requirements.

A further object of the invention is to provide an illumination system utilizing comparatively simple mechanical and optical components which is economical to operate and maintain over extended periods of time.

In one illustrative embodiment of the invention, the system includes a plurality of radiation stations for forming one or more illuminated stripes on a longitudinally extending surface, and means for respectively supporting the stations in spaced relationship with the opposite ends of the surface. Each station is provided with a laser generator for producing a beam of coherent visible radiation. The beam is directed through a beam expanding lens which increases the diameter of the beam to the desired width of the stripe. The beam is then collimated and projected onto the surface to produce a visible line thereon.

In accordance with a particular feature of the invention, none of the equipment used to provide the desired striping needs to come in contact with the surface. As a result, the equipment is unaffected by snow plows or other vehicles on the surface.

In accordance with another feature of several important embodiments of the invention, even comparatively long surfaces such as airport runways do not require more than two radiation sources, one adjacent each end of the surface, to form a given stripe. The intensity of the resulting illumination is at least equal to and at times far greater than that provided by the multitude of light sources presently in use at most airports.

In accordance with still another feature of the invention, in some preferred embodiments, each laser beam extends for a substantial distance over the surface to be illuminated and advantageously is oscillated at a frequency in excess of the persistency of vision. As a result, there is produced a thin, continuous line which may be readily seen from the air.

The present invention, as well as further objects and features thereof, will be understood more clearly and fully when read with reference to the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a partially diagrammatic perspective view of an airport runway having an illumination system in accordance with one illustrative embodiment of the invention.

FIG. **2** is a schematic representation of one of the radiation stations in the system shown in FIG. **1**.

FIG. **3** is an enlarged vertical sectional view of a portion of the radiation station of FIG. **2**.

FIG. **4** is a sectional view taken along the line **4—4** in FIG. **3**.

FIG. **5** is a schematic representation of one of the radiation stations in an illumination system in accordance with another illustrative embodiment of the invention.

DESCRIPTION OF CERTAIN PREFERRED EMBODIMENTS

Referring to FIG. **1** of the drawings, there is shown a system for providing three illuminated stripes **10, 11** and **12** on an airport runway **13** or other longitudinally extending surface. The stripes extend from one end of the runway **13** to the other with the stripes **10** and **12** located at the edges of the runway and the stripe **11** along the center line. The stripes may be produced by projecting the illuminating radiation directly onto the runway surface, but in a preferred embodiment even greater illumination is provided by directing the radiation onto pre-existing stripes formed with paint containing glass beads or other reflectorizing material.

The radiation emanates from six radiation stations **15, 16, 17, 18, 19** and **20** in spaced relationship with the ends of the striping. The stations **15** and **16** are in line with the edge stripe **10**, the stations **17** and **18** are in line with the center stripe **11** and the stations **19** and **20** are in line with the edge stripe **12**. As best shown in FIG. **2**, each of the stations includes a laser generator **22**. The generator **22** is of conventional construction and illustratively comprises a mixed gas laser of the type available commercially from Coherent Radiation Corp., Palo Alto, Cal. The generator produces a beam **25** of coherent visible radiation having a diameter of the order of 1.5 millimeters. A service conduit **26** supplies the generator with three phase alternating current and with water or other suitable coolant.

The laser beam **25** preferably is green in color for maximum visibility. However, current regulations for many airports require amber edge stripes and a white center line, and under such conditions the generators for the radiation stations **15, 16, 19** and **20** produce amber beams and those for the radiation stations **17** and **18** produce white beams. Each of the generators is located below ground level and is housed in a weatherproof casing **30.** The casing **30** includes a cover **31** and serves to protect the generator from the elements.

An upstanding tubular conduit **32** is mounted on the cover **31.** The conduit **32** preferably is at least 3 feet in height and in some cases may be as high as 100 feet or even 200 feet. Particularly in these latter situations, the conduit and its associated generator are located a substantial distance from the end of the runway **13** to avoid interference from aircraft. Most runways are not completely flat but include a crown surface. The runways also vary in height because of variations in the terrain. The height of the conduit **32** is such that its upper portion is located well above the maximum height of the runway and also protrudes above any anticipated snowfall.

The tubular conduit **32** supports a housing **35.** The housing **35** is substantially enclosed but includes an aperture **36** on the side thereof facing the runway **13.** Mounted within the housing **35** is an optical system which comprises a fixed specular mirror **37** in position to receive the laser beam **25** from the conduit **32.** The beam **25** contacts the mirror **37** at an angle of incidence which illustratively is of the order of 45.0° and reflects it through a lens **38.** This lens expands the beam to a diameter equal to the desired width of the striping, illustratively eight inches. The diverging beam is represented schematically in FIG. **3** by a principal ray **40** and two side rays **41** and **42.**

When the beam **25** has reached the desired diameter, it is directed through a collimating lens **45.** The lens **45** functions in known manner to orient the beam rays **40, 41** and **42** in parallel relationship with one another. The beam is then reflected by a fixed specular mirror **46** at the same angle of incidence as that of the mirror **37.**

The mirror **46** directs the expanded beam **25** to an oscillating specular mirror **50.** The mirror **50** is supported by a bracket **51** which is pivotally affixed to the side wall of the housing **35** and is connected to the output shaft of a synchronous motor **53** by a linkage arm **54.** The motor **53** rotates continuously to oscillate the bracket **51** and the mirror **50** at a constant frequency about an axis parallel to the surface of the runway **13.** The mirror **50** moves through a predetermined angle which is determined by the height of the mirror and the lengths of the runway. In cases in which it is desired to produce continuous stripes on the runway surface, the frequency of oscillation is in excess of the persistency of vision and may be about 60 cycles per second, for example.

The laser beam **25** is reflected by the oscillating mirror **50** and is projected through the housing aperture **36** over a substantial portion of the surface of the runway **13.** The mirror **50** directs the beam at the oscillation frequency in a vertical plane which includes the corresponding stripe **10, 11** or **12** (FIG. **1**). The oscillating beam is represented schematically in FIG. **2** by the reference character **55** when in its lowermost position and by the reference character **56** when in its uppermost position. In the lower position the beam contacts the surface at the adjacent end of the runway, while in its upper position the beam meets the surface at a point which is slightly more than halfway down the length of the runway. The beam from the opposite end of the runway operates in a similar manner to produce a clearly visible stripe along the runway's entire length. The beams have a small overlap adjacent the center of the runway to insure that no gap exists in the stripe in cases in which the upper positions of the beams may be slightly misaligned.

In some arrangements, each of the beams for a given stripe oscillates from one end of the runway to the other. Thus, the beams from the radiation stations **15** and **16,** for example, may each traverse the entire length of the runway **13** to produce the edge stripe **10.** This arrangement further increases the intensity of the illumination and serves to maintain the striping in cases in which one of the radiation stations is temporarily obstructed or out of operation.

In certain advantageous embodiments of the invention, the reflecting mirror **50** is stationary and serves to project the laser beam horizontally from one end of the runway to the other. In these latter embodiments the position of the horizontal beam is illustrated at **58** in FIG. **3.** The beam is reflected by dust or other particles in the atmosphere to provide a continuous illuminated stripe a fixed distance above the runway surface. One advantage of this arrangement is that the intensity of the illumination is not affected by variations in the reflectivity of the runway surface such as might be caused by rain, snow, etc.

In the embodiment of FIGS. **1–4,** the housing **30** for the laser generator **22** at each of the radiation stations is located below ground level adjacent one side of the plane of the runway surface, while the housing **35** for the generator's optical system is disposed above the ground adjacent the opposite side of the plane of the surface. In other advantageous arrangements, both the laser generator and the associated optics are disposed on the same side of the surface. Referring to FIG. **5,** for example, there is shown a laser generator **60** which is mounted above the surface of the runway on a leg assembly **61.** The generator **60** is similar to the generator **22** (FIG. **2**) described heretofore and produces a beam **62** of coherent visible radiation. The beam **62** is directed horizontally from the generator through a beam expander lens **63** and a collimating lens **64** to provide a beam of the desired diameter. The expanded beam is reflected vertically upward by a fixed specular mirror **65** to an oscillating mirror **66.** This latter mirror is oscillated about a horizontal axis at a frequency in excess of the persistency of vision such that the reflected beam moves back and forth through an angle of approximately sixty degrees. The upper position of the reflected beam is substantially horizontal and is shown schematically at **68,** while the lower beam position, indicated at **69,** is such that the beam strikes the adjacent end of the runway. The system of FIG. **5** operates in a manner similar to that described heretofore to produce continuous edge and center line stripes on the runway surface.

Illumination systems in accordance with the invention also may be employed to produce broken or intermittent stripes on the runway surface. To comply with various regulations or for other purposes, optical choppers and similar devices may be used to provide a stro-

boscopic effect and thus closely duplicate the appearance of spaced lamps along each stripe.

Although the invention has been illustrated and described with particular reference to the provision of longitudinal striping for airport runways, it also may be employed for the illumination of highways and many other types of surfaces. The individual radiation stations are oriented with respect to the surface in accordance with the location of the desired illumination and the particular application. To provide edge and center stripes on the flight deck of an aircraft carrier, for example, one convenient arrangement is to utilize three radiation stations mounted one above the other on the superstructure of the vessel. Each station produces a beam of coherent visible radiation which oscillates back and forth from one end of the landing portion of the flight deck to the other. Various other uses for the invention will become aparent to those skilled in the art upon a perusal of the present specification.

The terms and expressions which have been employed are used as terms of description and not of limitation, and there is no intention in the use of such terms and expressions of excluding any equivalents of the features shown and described or portions thereof, but it is recognized that various modifications are possible within the scope of the invention claimed.

What is claimed is:

1. A system for providing illuminated striping for a surface, the system comprising:
- at least one radiation station; and
- means for supporting the radiation station in spaced relationship with one end of the surface, the radiation station including
- laser means for producing a beam of coherent visible radiation,
- an optical system for projecting the beam so that it lies in a plane which includes the striping, and
- means for oscillating the beam at a constant frequency, to produce a visible line along said surface.

2. A system for providing illuminated striping for a surface, the system comprising:
- at least one radiation station; and
- means for supporting the radiation station in spaced relationship with one end of the surface, the radiation station including
- laser means for producing a beam of coherent visible radiation,
- means for expanding the beam to a diameter equal to the width of the striping, and
- means for projecting the expanded beam so that it lies in a plane which includes the striping, to produce a visible line along said surface.

3. A system as defined in claim **2**, which further includes reflective means along the striping for reflecting said beam.

4. A system as defined in claim **2**, in which the laser means and the projecting means are located on opposite sides of the plane of said surface.

5. A system as defined in claim **2**, in which the laser means and the projecting means are located on the same side of the plane of said surface.

6. A system for providing illuminated striping for a longitudinally extending surface, the system comprising:
- a plurality of radiation stations; and
- means for respectively supporting the radiation stations in spaced relationship with the opposite ends of the surface, each of the radiation stations including
- laser generating means for producing a beam of coherent visible radiation,
- an optical system including means for collimating said beam, and
- projecting means for directing the collimated beam over a substantial portion of the length of said surface to produce a visible stripe thereon.

7. A system for providing illuminated striping for a surface, the system comprising:
- a plurality of radiation stations; and
- means for respectively supporting the radiation stations in spaced relationship with opposite ends of the surface, each of the radiation stations including
- laser generating means for producing a beam of coherent visible radiation,
- housing means for substantially enclosing the laser generating means,
- an optical system for receiving said beam from the housing means, the optical system including means for expanding said beam and means for collimating the expanded beam, and
- projecting means for directing the expanded and collimated beam over said surface to produce a visible stripe thereon.

8. A system as defined in claim **7**, in which the projecting means directs the expanded and collimated beam at an angle toward said surface.

9. A system as defined in claim **7**, in which the path of the expanded and collimated beam is substantially parallel to said surface.

10. A system for providing illuminated striping for a surface, the system comprising:
- a plurality of radiation stations; and
- means for respectively supporting the radiation stations in spaced relationship with apparatus ends of the surface, each of the radiation stations including
- laser generating means for producing a beam of coherent visible radiation,
- housing means for substantially enclosing the laser generating means,
- an optical system for receiving said beam from the housing means, and
- projecting means for directing the beam over a substantial portion of said surface to produce a visible stripe thereon, the projecting means including means for oscillating the beam in a plane which includes said stripe at a frequency in excess of the persistency of vision.

11. A system for providing illuminated striping for a longitudinally extending surface, the system comprising:
- a plurality of radiation stations; and
- means for respectively supporting the radiation stations in spaced relationship with the opposite ends of the striping, each of the radiation stations including
- laser generating means for producing a beam of coherent visible radiation,
- housing means for substantially enclosing the laser generating means,
- a conduit communicating with the housing means in alignment with the generated beam,
- an optical system for receiving said beam from the conduit, and

projecting means for directing the received beam over a substantial portion of the length of said surface to produce a visible stripe thereon, the projecting means including means for oscillating the beam in a plane which includes said stripe at a frequency in excess of the persistency of vision.

12. A system for providing illuminated striping for a longitudinally extending surface, the system comprising:

a plurality of radiation stations; and

means for respectively supporting the radiation stations in spaced relationship with the opposite ends of the striping, each of the radiation stations including

laser generating means for producing a beam of coherent visible radiation,

housing means for locating the laser generating means adjacent one side of the plane of said surface,

means for transmitting the generated beam to a point adjacent the opposite side of the plane of said surface,

an optical system for receiving said beam, and

projecting means for directing the received beam over a substantial portion of the length of said surface to produce a visible stripe thereon, the projecting means including means for oscillating the beam in a plane which includes said stripe at a frequency in excess of the persistency of vision.

13. A system for providing illluminated striping for a longitudinally extending surface, the system comprising:

a plurality of radiation stations; and

means for respectively supporting the radiation stations in spaced relationship with the opposite ends of the striping, each of the radiation stations including

laser generating means for producing a beam of coherent visible radiation,

housing means for locating the laser generating means adjacent one side of the plane of said surface,

means for transmitting the generated beam to a point adjacent the opposite side of the plane of said surface,

on optical system for receiving said beam, the optical system including means for expanding said beam and means for collimating the expanded beam, and

projecting means for directing the expanded and collimated beam over a substantial portion of the length of said surface to produce a visible stripe thereon, the projecting means including means for oscillating the beam in a plane which includes said stripe at a frequency in excess of the persistency of vision.

14. A system as defined in claim **13**, in which the projecting means directs the expanded and collimated beam over at least one-half the length of said surface.

15. A system as defined in claim **13**, in which the expanded and collimated beam oscillates from one end of the surface to the other.

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