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(54) EMISSIVE HIGHWAY MARKERS

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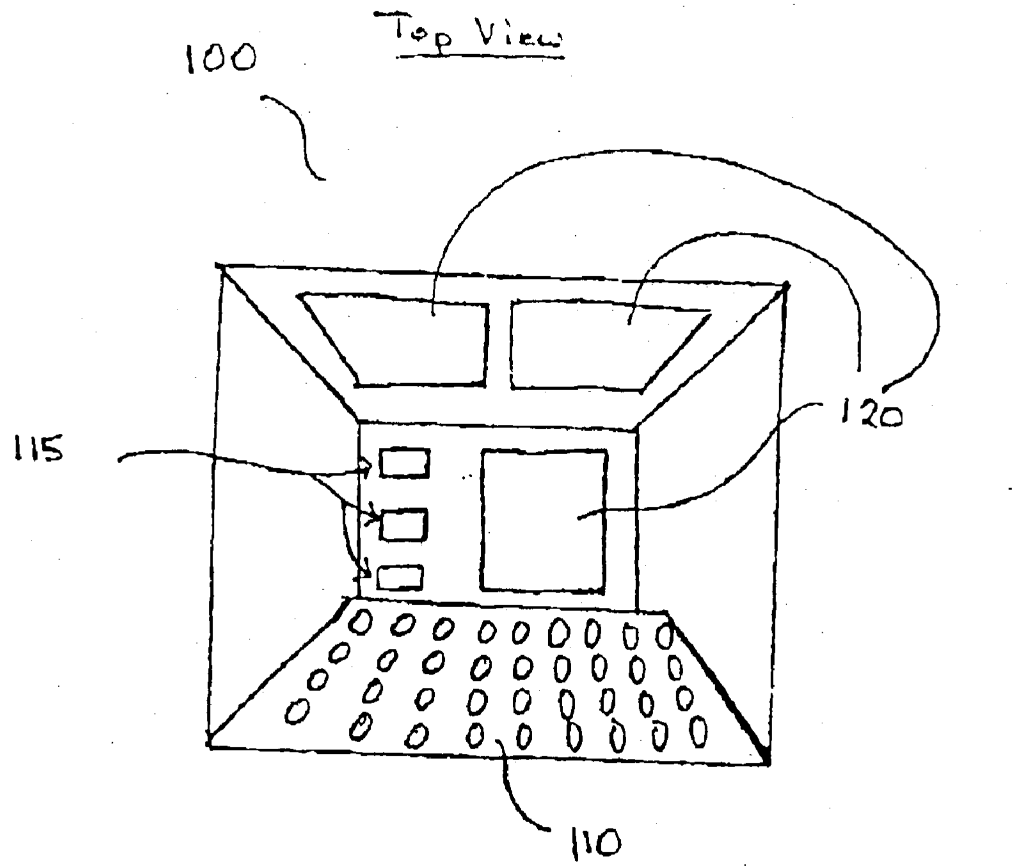
(57) **ABSTRACT**

A highway marker comprising an emissive device positioned on a highway, wherein said emissive device emits electromagnetic radiation.



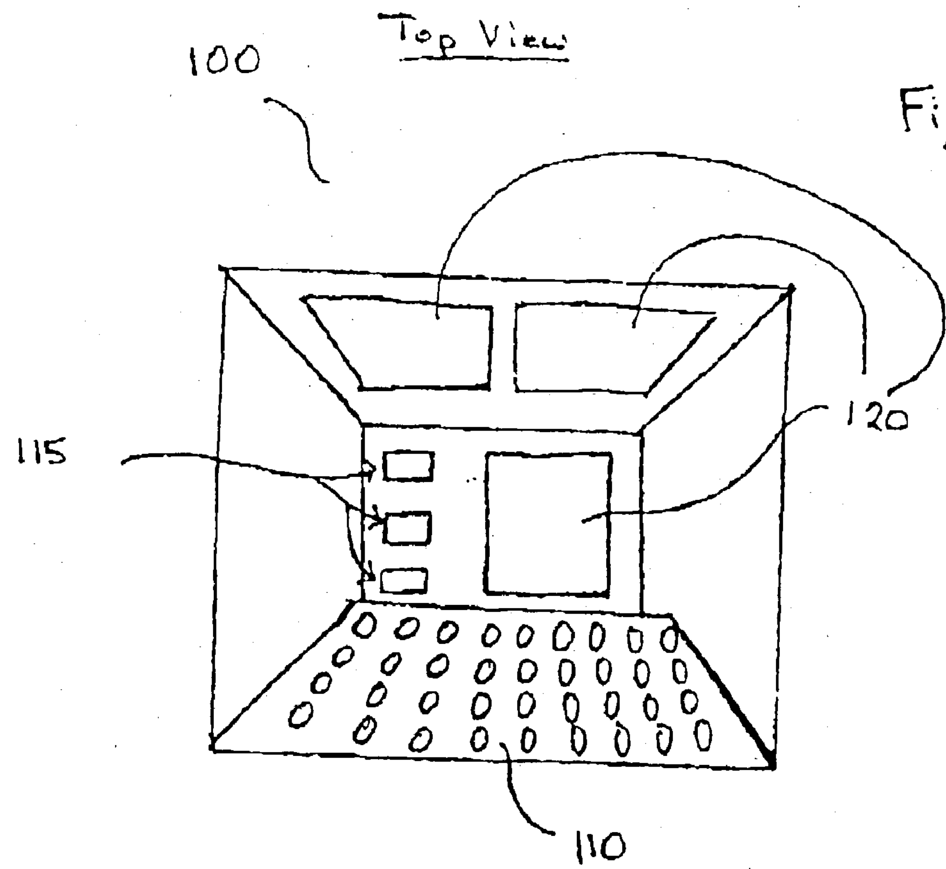


Fig. 1A

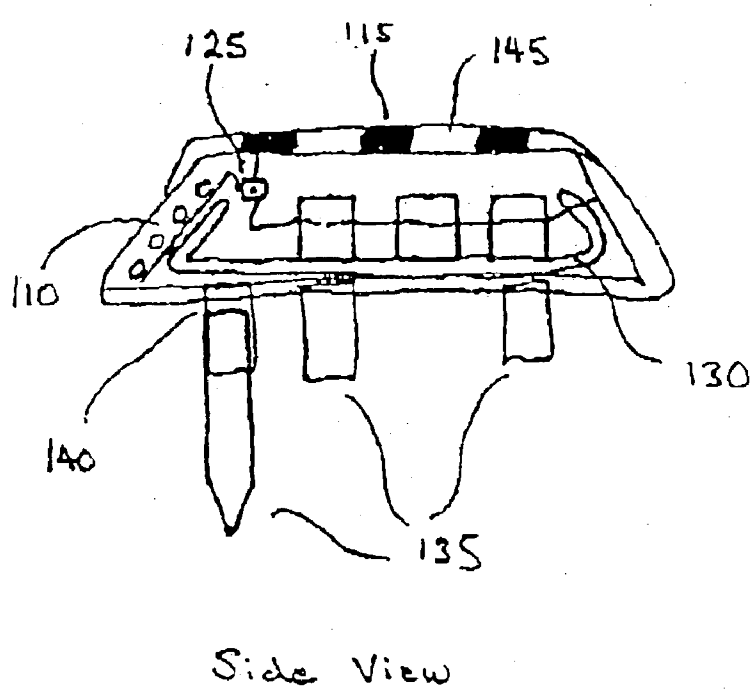
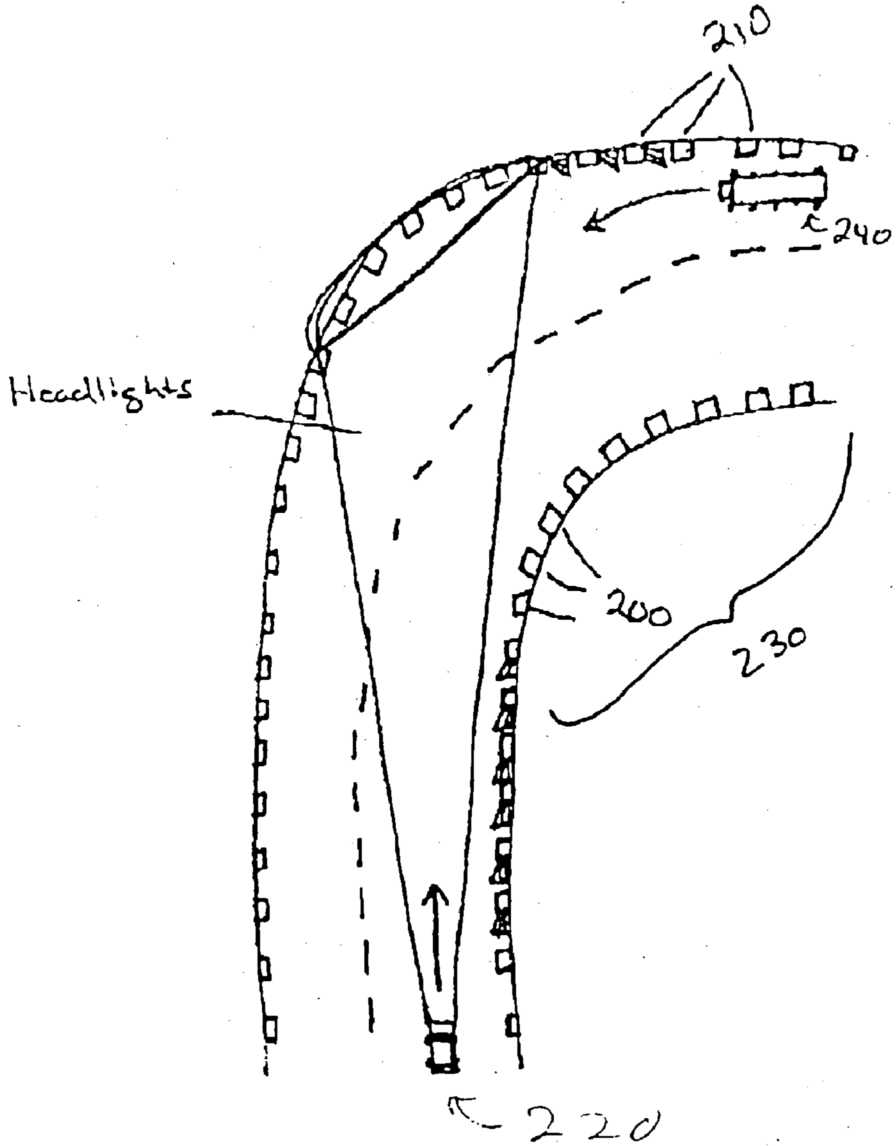


Fig. 1B

Fig. 2



EMISSIVE HIGHWAY MARKERS

CROSS REFERENCE TO RELATED APPLICATION

[0001] This application claims priority to U.S. Provisional Application Serial No. 60/352,551, filed Mar. 8, 2002, which is incorporated herein by reference in its entirety.

FIELD OF THE INVENTION

[0002] The invention relates to highway markers, more particularly to emissive highway markers that include light sources that emit electromagnetic radiation of desired wavelength(s) to enhance highway safety.

BACKGROUND

[0003] Thousands of people die on America's highway each year because of poor roadway markers. Many of these deaths occur in accidents that are attributable to low light conditions or an inability of the driver to adequately see curves and bends in the approaching roadway. Driving at night can be particularly difficult because many human beings have a lessened visual acuity in low light conditions. Conventional highway markers that are purely reflective do not adequately meet the needs of many people with such lessened visual acuity.

[0004] A fundamental problem with traditional reflective highway markers is that they reflect light in a straight path even though many roadways are not necessarily straight. Additionally, automotive headlights do not have consistent optical power across a wide viewing angle. As such, optional power declines at the outer edges of the headlight. This phenomenon is characteristic of all back-reflective headlights.

[0005] Still another problem with conventional highway markers commonly in use on highways today is that they reflect light of a wavelength that is not easily detected by the human eye in low ambient light conditions. Many reflective highway markers are yellow. However, yellow is not necessarily the optimal color for detection by the human eye in low light conditions. For example, the lighting of airport runways is typically done using blue lights because the human eye sees the wavelength of blue light better than it can see light of the yellow wavelength. What is needed are highway markers that can help reduce the number of injuries and fatalities that occur on highways due to accidents precipitated by inability to see highways, obstructions in the road, or other dangers that drivers can encounter while traveling in low light conditions.

SUMMARY

[0006] A highway marker system that comprises an emissive device positioned on a highway, wherein said emissive device emits electromagnetic radiation.

BRIEF DESCRIPTION OF THE DRAWINGS

[0007] **FIG. 1A** is a top view perspective of the emissive highway marker of the present invention.

[0008] **FIG. 1B** is a side view perspective of the emissive highway marker of the present invention.

[0009] **FIG. 2** is an illustration of a highway equipped with emissive highway markers.

DETAILED DESCRIPTION

[0010] Reference will now be made in detail to embodiments of the invention, examples of which are illustrated in the accompanying drawings. Whenever possible, the same reference numbers will be used throughout the drawings to refer to the same or like elements.

[0011] Emissive highway markers overcome the deficiencies of traditional reflective highway markers illuminated by back reflective automotive headlights because they give the driver better opportunity to see curves and bends in a highway. Emissive highway markers are capable of adjust the color of light emitted in response to ambient light conditions. Various colors of light can be used to convey information to the driver, such as the presence of an intersection, a road hazard, inclement weather or the need to be on a radio to receive regional or national emergency broadcast instructions. The disclosed markers may also be equipped to monitor the relative position and speed of passing vehicles and to communicate that information to a computer on board the vehicle.

[0012] Referring to **FIGS. 1A and 1B**, top and side views of an emissive highway marker **100** are shown. **FIG. 1A** illustrates an light-emitting diode (LED) array **110**, a plurality of photodetectors **115**, and a plurality of photovoltaic cells **120**. **FIG. 1** shows ASIC current drivers **125**, an aluminum cooling fin **130**, aluminum alloy cooling/positioning rods **135**, a stress absorbing spring **140**, and a plastic or metal shell **145** which contains the assemblage. The housing would also contain reflective materials to increase the overall visibility of the marker (not shown). As is discussed further below, marker **100** may further include a microprocessor and radio transmitter and receiver.

[0013] In an embodiment, LED array **110** can be constructed of one or more LED's that emit varying wavelengths of light. LED array **110** can include several types of LED's capable of emitting red, yellow, green, blue, white, or other colors of light. LED array **110** may also include LED's that emit light in the non-visible spectrum. Some examples of LED's that would be suitable for use in the present invention include, but are not limited to, LED's that emit light in the blue and green portion of the electromagnetic spectrum. These devices will, for example, typically be fabricated from indium gallium nitride and/or gallium nitride layers with or without suitable buffer layers on 6H or 4H silicon carbide substrates (where 6H is the polytype or atomic arrangement), aluminum oxide substrate, gallium nitride substrates or aluminum nitride substrates. Typically, LED's that are suitable for use in the present invention will be constructed from a substrate that allows high thermal conductivity and high optical transmissivity. While LED manufacturing techniques using aluminum nitride substrates are still evolving, there are other commercially available devices suitable for number **100**, such as nitride devices grown on both Al_2O_3 and silicon carbide substrates.

[0014] The basic function of traditional LED's is well known and need not be discussed in great detail. In summary, applying a voltage across the semi-conductive material of the LED induces an electron to move from the valence band to the conduction band. When the electron falls back down to the conduction band, it recombines with "holes" and causes the LED to emit a photon. One drawback to traditional LED technology is that optoelectronic devices degrade over time and lose power efficiency. As LED's degrade, the wavelength of the light emitted by the LED will change, causing a shift in the color of the light produced

[0015] Marker **100** may be constructed using LED's that are not as susceptible to degradation. For example, LED array **110** may employ LED's fabricated from gallium nitride grown on Al silicon carbide, gallium nitride or aluminum nitride. These devices emit electromagnetic radiation in the ultraviolet (UV) or blue portion of the spectrum and are coated with a phosphor. The UV emission striking the phosphor-coated diode creates a stimulated emission of white light that is not susceptible to color shift. The LED can in turn be placed inside a blue or green tinted material, such as plastic, that functions as a lens/filter to create blue or green light that is not subject to a color shift Alternatively, the phosphor-coated LED can itself emit light of a desired color, such as blue, green, yellow or red. Further, other LED's systems may be used as well.

[0016] In certain embodiments, the choice of light emitting semiconductor device may depend on the environment in which marker **100** is intended for use. In addition, embodiments of marker **100** are not limited by the type of LED used.

[0017] The number of LED's or other light emitting semi-conductive devices used in the construction of marker **100** may also vary according the environment. In addition to degradation over time, the lifetime of an optoelectronic device is a function of the drive current supplied to the device and the ambient temperature of the environment in which the LED operates. For example, highway surfaces can become very hot, and driving an optoelectronic device at its rated current in such a hot environment may cause rapid degradation in the device. An embodiment of marker **100** may be constructed using a plurality LED's or other optoelectronic devices. In this case, each emissive highway marker may be operated at a low drive current while still providing sufficient emission of light from the marker to be visible to the human eye in low light conditions.

[0018] In one embodiment photodetectors **115** can be used to control the emissions of the optoelectronic devices in response to changes in ambient light conditions. Photodetectors **115** interface with a microprocessor or an ASIC (not shown). Photodetectors **115** measure ambient light conditions and provide a signal that is a function of how many photons of light are impinging on the detector. The signal from photodetector **115** can cause marker **100** to alter the color of light emitted by LED array **110** in varying conditions. For example, the human eye has a much higher responsivity to green light in high ambient light conditions than it does to blue light, while in low light the human eye has a higher responsivity to blue light. So in high ambient light conditions, marker **100** may emit green light, while in low ambient light conditions, blue light can be produced by LED array **110**. Each marker can be equipped with the necessary optoelectronic devices for producing each different color. Markers can also be controlled to emit other colors to signal the driver that he is approaching a stop sign or an intersection.

[0019] Marker **100** can be controlled by a plurality of different mechanisms. For example, marker **100** can be given a manual setting at the time the marker is installed. Alternatively, the marker could be controlled by an optically-activated device equipped with a microprocessor or an ASIC that is responsive to non-visible radiation such as IR or RF to permit remote control of the marker in a manner similar to a TV remote control. Marker **100** may also use a temperature measurement device that causes the marker to emit a particular color of light in response to changes in the ambient temperature. This embodiment would allow the motorist to be warned that the roadway surface, in particular bridges, may have an unusual condition, such as being icy. Similarly, detection mechanisms for moisture on the roadway surface can be used in conjunction with the markers, which allows the motorist to be warned that the road surface may be wet or slippery. The color of the markers may also change to indicate that the motorist should tune in to an Emergency Management System radio broadcast, such as in the event of a severe weather or other emergency.

[0020] LED arrays **110** can emit both visible and non-visible electromagnetic radiation. The non-visible radiation can be used to signal an enunciator device inside a vehicle to track the position of the vehicle relative to the boundaries of the highway, such as the median or the shoulder.

[0021] In another embodiment, optoelectronic devices such as laser diodes in combination with a light emitting diode having a narrow viewing angle, that emit IR or UV can be used to produce the signal. The diodes can broadcast a multidirectional signal that is unique to the marker. This signal can carry information regarding the position of the individual marker and other traffic information.

[0022] A detector system on the vehicle would receive the signal from the marker. A computer within the vehicle will be able to determine the exact position of the vehicle relative to the markers by "listening" to multiple markers. This could be accomplished in two ways. First, the marker could send information in predetermined intervals. Second, information regarding the interval could be incorporated in the signal. With the time interval emitted and the time interval received, the computer would be able to determine the vehicle's magnitude of velocity with respect to one marker. Thus based on multiple markers, the computer could triangulate the vehicle's position relative to the markers.

[0023] The detector system could be composed of one photodetector, several photodetectors, or in a preferred embodiment, an array of photodetectors. The array of photodetectors would contain a plurality of devices tuned to specific wavelengths outside the visible spectrum. Certain photodetectors could have bandpass filters. These devices integrated into an array would cover large portions of the spectrum, thereby creating a solid state spectrographer. This would vastly increase the amount of information that could be transmitted from the markers to the detector system.

[0024] An enunciator in the vehicle can warn the driver and passengers of the vehicle in the event the vehicle is traveling too close to the shoulder or median or is traveling too fast for road conditions, or is approaching an intersection or stop sign or some other warning. The speed and position data gathered by a vehicle's computer from the markers may also be used to automatically print speeding tickets. In addition, discreet marker locations can work in conjunction with a global positioning system (GPS) to provide exact street and highway location, confirmation or annunciation.

[0025] Markers **100** can also detect the presence of a stopped vehicle or other obstruction in the roadway. The presence of a stopped vehicle or other obstruction can cause the marker detecting the obstruction to signal other highway markers in the proximity of the obstruction to emit, for example, a yellow light indicating the potential hazard. The signal may be sent between markers via any medium, including IR and RF.

[0026] **FIG. 2** shows a section of a highway equipped with markers as described above. Markers **200** emit light according to the ambient conditions to delineate a curve **230** in the highway. For example, markers **200** may emit blue light at night. Alternatively, markers **2000** may emit green light during daylight hours.

[0027] In another embodiment, as a vehicle **200** approaches the inner portion of a curve **230**, the curve markers **220** and **210** clearly delineate for the driver the curve even though markers **200** and **210** may not be directly illuminated by the headlights of vehicle **220**. In addition, as vehicle **220** rounds curve **230** and approaches a stalled vehicle **240**, markers **210** alert the driver of vehicle **220** to the impending hazard posed by stalled vehicle **240** by emitting, for example, yellow light. Similarly, markers **200** and **210** can detect light from headlights of vehicle **220** and alert people around curve **230** of the approach of vehicle **220**. In addition to changing colors in response to ambient light or highway conditions, marker **200** or **210** may be directed to change the color of emitted light upon receipt of an RF, IR, or other signal, where the signal originates from a central station or from another marker. While performing the above described functions, markers **200** or **210** may simultaneously emit signals to a computer on board vehicle **220** to indicate the relative speed and position of vehicle **220**. These signals can typically be IR or RF.

[0028] In one embodiment, the shell would be fabricated from metal. The metal would provide flexibility and impact strength. In another embodiment, the housing would be injection molded from a glass or carbon reinforced plastic such as polycarbonate. This plastic is sold under the trade names Lexan by the GE Plastics of Pittsfield, Mass. Lexan 141 or 503 as well as several other grades would be suitable for this application. Other plastics that would be appropriate include Acrylonitrile Butadiene Styrene (ABS) and Acrylic Styrene Acrylonitrile (ASA).

[0029] Other embodiments of the invention will be apparent to those skilled in the art from consideration of the specification and practice of the invention disclosed herein. It is intended that the specification and examples be considered as exemplary only, with a true scope and spirit of the invention being indicated by the following claims.

What is claimed is:

1. A highway marker comprising:

a housing;

a plurality of LED's mounted in the housing, emitting electromagnetic radiation;

a photodetector generating a signal responsive to an ambient light condition surrounding the housing; and

a control circuit responsive to the photodetector signal to control the electromagnetic radiation from at east one LED to emit radiation of a predetermined color as perceived by the human eye according to the spectral sensitivity of the human eye for the ambient light condition.

2. A highway marker according to claim 1, further comprising a power source integral with the housing for powering the plurality of LED's.

3. A highway marker according to claim 1, further comprising a cooling fin in thermal communication with at least one LED, wherein the cooling fin dissipates LED generated heat.

4. A highway marker according to claim 1, further comprising a thermally conductive member for mounting the housing to a surface, wherein the thermally conductive member transfers heat between a surface and the marker.

5. A highway marker according to claim 1, wherein at least one LED emits electromagnetic radiation in the range of 10^{-2} m to 10^{-8} m.

6. A highway marker according to claim 1, wherein at least one LED emits electromagnetic radiation that is filtered with tinted material.

7. A highway marker according to claim 1, wherein at least one LED has a substrate selected from silicon, gallium nitride, aluminum nitride, aluminum oxide, silicon carbide, diamond, silicon germanium, and germanium.

8. A highway marker according to claim 1, further comprising a photovoltaic cell for generating power.

9. A highway marker according to claim 2, wherein the power source is a battery.

10. A highway marker according to claim 2, wherein the power source is a line power source.

11. A highway marker according to claim 1 further comprising a power source and wherein the plurality of LED's and the power source has a plurality of redundancies.

12. A highway marker according to claim 1 further comprising a battery to heat the housing.

13. A highway marker according to claim 1, wherein the photodetector is responsive to electromagnetic radiation in the range of 10^{-2} m to 10^{-8} m.

14. A highway marker according to claim 1, wherein the LED's transmit information regarding the location or traffic to vehicle-mounted detection systems that receive and process the signals.

15. A highway marker according to claim 1, including an internal feedback providing a constant brightness of the LED's.

16. A highway marker comprising:

a plurality of LED's;

a photodetector generating a signal responsive to ambient light condition; and

means for adjusting the wavelength of emitted electromagnetic radiation of at least one LED to maintain a predetermined color as perceived by the human eye according to the spectral sensitivity of the human eye for the ambient light condition.

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