

[54] REFRACTIVE SPHERICAL ROADWAY MARKER

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[51] Int. Cl.² E01F 9/06

[58] Field of Search..... 404/16; 264/346; 260/89.5 S, 89.5 A

[56] References Cited

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[57] ABSTRACT

A marker has a transparent spherical upper portion exposed above a surface and an inner conical reflecting surface divided into discrete sections of different colors so that reflected light from vehicle headlamps is passed, after refraction at the surface of the marker, back to the vehicle, to illuminate lane divisions and other road lines at night in which the marker and others like it are placed at intervals in such a manner as to vary the reflected signal as a function of the observer's vehicle's position vis-a-vis the marker, i.e. a color coded intelligence.

5 Claims, 4 Drawing Figures

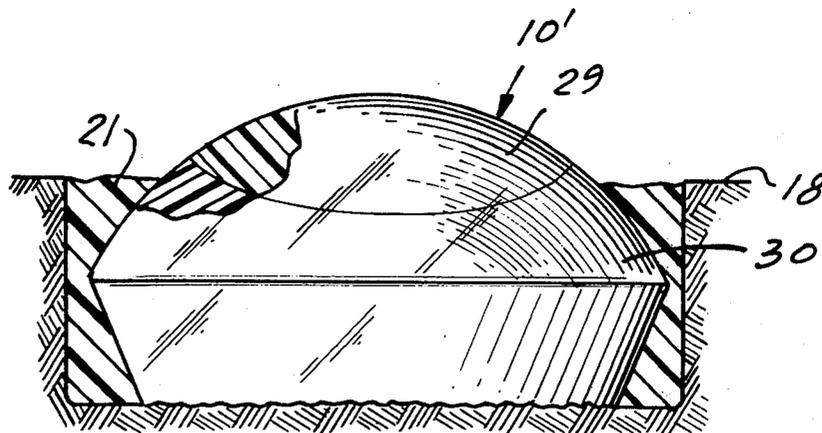


Fig-1

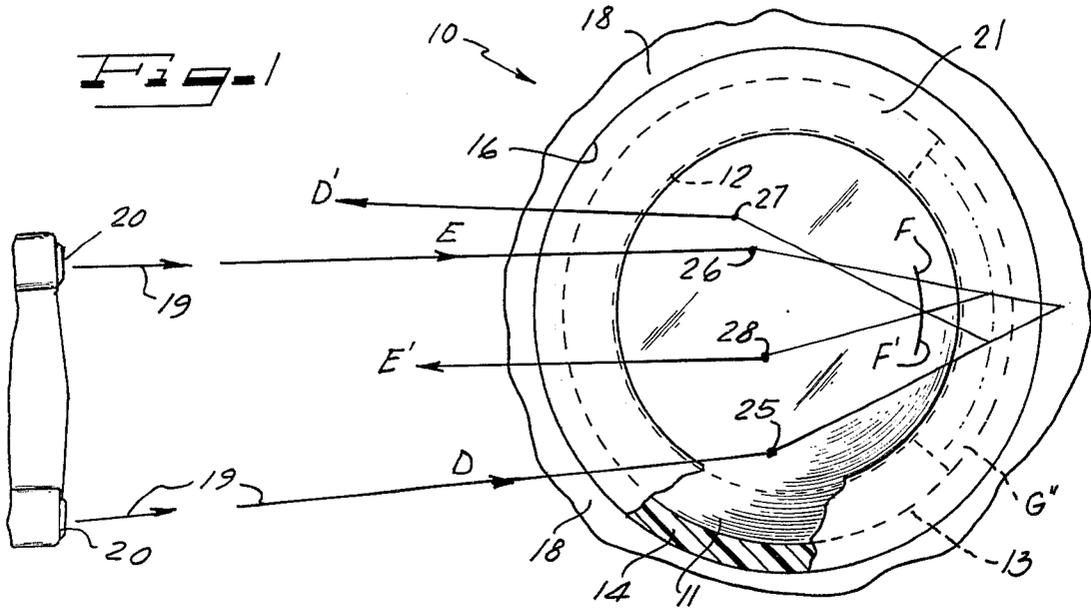


Fig-2

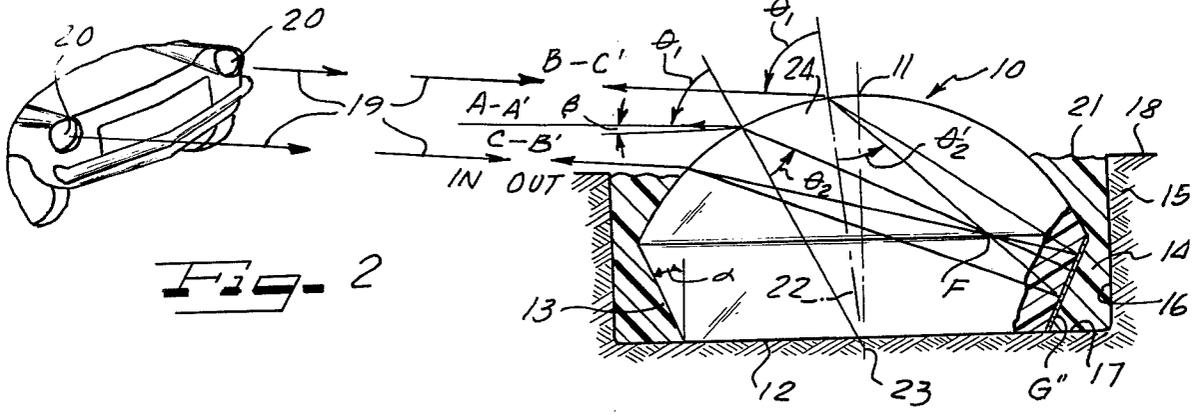


Fig-3

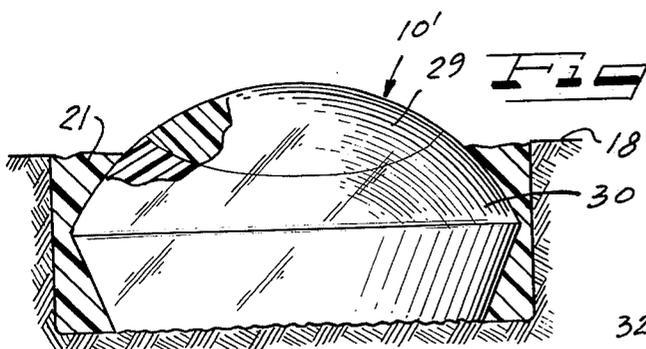
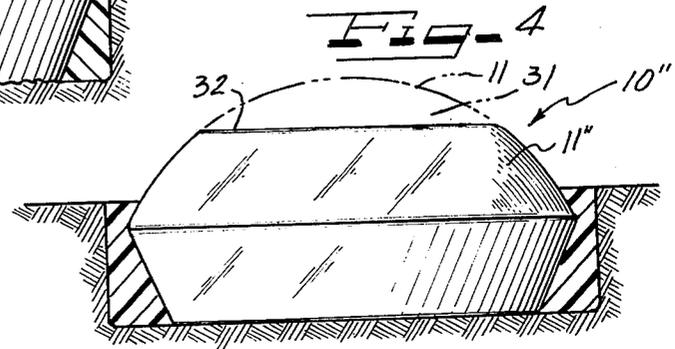


Fig-4



REFRACTIVE SPHERICAL ROADWAY MARKER

BACKGROUND OF THE INVENTION

1. Field of the Invention

This invention relates to raised reflective markers for delineating lanes and edges of roadways and other pathways under illumination by headlamps of vehicles on the path.

2. Description of the Prior Art

Raised roadway markers have been used in the United States for many years. The most popular nighttime reflectors are made of plastic material with either cube-corner reflex units or glass inserts of various shapes. The reflex units may be placed in special housings, such as steel ramp types or high-impact rubber/plastic housings where snowplows will damage other types of markers. Ceramic markers have been used extensively for daytime lane delineation but lack adequate nighttime reflectivity. Low-voltage electric light similar to lights used along airport runways have been employed where dense fog is encountered. Other markers use metallic reflecting strips, glass beads, convex reflective buttons, and tapered, hardened steel castings with plastic inserts. Some types of markers are set into holes drilled in the pavement, while others are bonded to the surface or are set into slots sawn into the roadway. See generally, Highway Research Board, *National Cooperative Highway Research Program Report 130, Roadway Delineation Systems*, 123-128, and Figure C-12, 1972. Reflective pavement markers are still in a developmental stage and the prior art has not satisfactorily solved problems of providing reflective pavement markers which withstand snowplowing without loss or breakage.

SUMMARY OF THE INVENTION

A marker is provided which may be inset into a shallow hole drilled in a pavement along a lane division or edge line. The marker has a spherical upper portion exposed above the roadway surface, while the lower portion of the marker is bonded and sealed below the roadway surface. Light from the headlamps of an approaching vehicle will be refracted by the exposed position of the marker and pass within the solid interior of the marker to a conical reflecting surface in the lower edge of the marker. The light will be reflected back out of the marker to the driver of the vehicle. The reflecting surface of the marker is on the interior of the marker and thus cannot be damaged by abrasion or impact. A series of markers will both illuminate lane divisions on the roadway at night and mark them during the day. The conical surface is divided into discrete zones and different colored reflecting surfaces may be used to provide information and warnings to vehicle drivers depending on their relative positions. The markers may be made visible from 400 feet by headlamps as low as one foot above the roadway surface.

The ability of the marker to withstand snowplow impacts may be increased by making the lower portion of the marker more flexible than the upper part, for example by using plastic molding and curing processes. Further, the upper surface of the marker may be truncated to reduce the profile of the marker, and reduce its susceptibility to snowplow damage, with some reduction in reflectivity.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a top view of the marker set in a roadway, partially cut-away, and showing the paths of horizontally-offset light rays.

FIG. 2 is a cross sectional view through the marker and road surface, and shows the paths of vertically offset light rays through the spherical portion of the marker and reflections off the conical surface provided.

FIG. 3 shows an alternative construction of the marker, in cross section,

FIG. 4 shows a marker with its spherical upper portion truncated to reduce its profile.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A solid body 10 is shown with a convex spherical upper surface 11 and a lower horizontal part 12 with both parts bounded by a conical surface 13 around the peripheries thereof and the cone being of greater diameter at its top than at its bottom. The sides of the conical surface 13 form an angle α with the vertical. The marker body 10 is set in a hole 14 drilled into the pavement 15 and having a cylindrical wall 16 and a flat bottom 17 beneath the road surface 18. The upper spherical surface 11 extends above the road surface 18 where it may intercept light rays 19 emanating from vehicle headlamps 20. A bonding and sealing compound 21 such as epoxy locks the marker 10 into the hole 14. The conical surface 13 may be provided with any of several reflective coatings or treatments "G", such as cube corners, reflective paint, or metallic surfaces, either formed in the surface 13 or bonded thereto. The surface 13 may be divided or partitioned into a plurality of separate discrete zones each of a different selected color such as four separate quadrants colored yellow, red, green and white.

In operation, light rays A, B, and C produced by the headlamps 20 will strike the marker 10 at an angle β above the horizontal. Each light ray A will also strike the surface 11 at an angle ϕ_1 from a radial line 22 drawn from the center 23 of the spherical segment 11. The ray A will be refracted upon passing from the air into the denser material 24 of the body 10, through an angle ϕ_2 from the line 22 which may be found from the well known formula,

$$n_1 \sin \phi_1 = n_2 \sin \phi_2,$$

where n_1 and n_2 are the indices of refraction here of air and of the material 24, respectively. The bent ray A will pass through the material 24 and the focal point F of the spherical section 11 and strike the reflective coating G at the conical surface 13. The ray will then be reflected back as ray A'. If the incident ray A was perpendicular to the conical surface 13 as shown, the returning ray A' will also pass through the focal point F and retrace the path of the incoming ray A, back to the vehicle having the headlamp 20 for viewing by the driver thereof. Other rays B and C will follow similar paths but will be refracted through different angles ϕ_2' because of their different incident angles to the radial lines 22 from the center 23 of the spherical segment 11. These other rays B and C will pass through the focal point F only on passing into the material 24 and will exit the material 24 after being reflected by the surface G as shown at B' and C'.

FIG. 1 shows the paths of rays D and E which are horizontally offset from one another. Ray D will strike the spherical surface 11 at a point 25 and be refracted into the interior of the body 10. After it is refracted at the surface of the body, it passes through the focal plane F-F' and is reflected from the reflecting coating G at the conical surface 13. The reflected ray D' then passes out of the spherical surface 11 at point 27 and back to the vehicle with headlamps 20. Ray E follows a similar path, entering at 26 and reflected as ray E', emerging from the surface 11 at point 28.

The angle β may be from one minute of arc, corresponding to a headlamp one foot from the ground at a distance of 400 feet, to approximately 25°, corresponding to a truck headlamp 4 feet off the ground and a distance of 20 feet to the marker. Then the angle θ and the width conical surface 13 may readily be derived once the index of refraction n_2 of the material 24, the radius of the spherical surface 11, and the distance which the spherical surface 11 extends above the road surface 18 are known.

By virtue of the discrete color zones, the reflecting surface G may produce one or more colors in the reflected light, according to the choice of reflective coating or of colors for glass cubes used in a reflex type surface. Different colors may be provided around different portions of the conical surface 13 to provide different information to drivers approaching the marker from different directions. Thus the edge of an acceleration lane may be marked in yellow or red as seen by drivers in the acceleration lane, while it could be seen as white by drivers in the through lanes. On two-lane roads, passing and no-passing zones may be marked in yellow and red, respectively, and different information provided to drivers traveling in opposite directions. Red or white indications could also be given to drivers entering from side streets onto a thoroughfare by the same lane markers as are provided down the center of the two-lane thoroughfare. Thus, by reflecting different colors of light from separate zones into corresponding discrete directions, appropriate color coded intelligence is transmitted to the observer.

The markers 10 may also be constructed specifically to withstand impact shocks from vehicle tires and snowplows. Although some new materials such as XT Acrylic may be able without special treatment to withstand the shock of impact by a steel snowplow blade, an alternative configuration shown in FIG. 3 provides a resilient base integral with the marker together with a hard and abrasion-resistant upper surface.

FIG. 3 shows a cross section of a marker body 10' corresponding with the body 10 of FIG. 2. In this embodiment, the uniform material 24 of FIG. 2 is replaced by a hard material 29 comprising the upper part of the body and a flexible material 30 which forms the base of the body. The two materials 29 and 30 should have the same molecular structures and indices of refraction so that the joint between them is optically clear, as may be provided by a high-impact strength clear plastic such as acrylic, molded or cured under different conditions to obtain the different hardness characteristics. The flexible material 30 remains below the surface of the road, so that only the hard material 29 is subject to abrasion and impact. The flexible material 30 will allow the hard material 29 to move downwardly somewhat under the force of an impact such as from a snowplow blade.

Alternatively, the body 10 of the marker may be made resilient by curing the acrylic plastic of the basic (FIG. 2) configuration with a temperature gradient from top to bottom so that material near the spherical surface 11 in the upper part of the body is hard while the material near the bottom is comparatively soft and resilient. Under the force of an impact, the hard upper material could recoil downwardly as before.

Another alternative embodiment 10'' for a reflective marker is shown in FIG. 4. Here the upper part 31 of the spherical segment 11 is removed and a flat surface 32 forms the upper surface of the marker. The surface 32 may be horizontal, or slanted downwardly to the rear or downstream side (the direction of traffic using the markers). The remainder 11'' of the spherical surface of the marker 10'' above the surface 18 of the road refracts light to the reflecting surface G as previously, but the amount of light reflected is reduced because of the decrease in light gathering area. Studies have shown that too bright a reflection from a marker is undesirable, so it is possible that with proper choice of reflective material G both optimum nighttime delineation of pavement lines and minimum interference with or damage from snowplowing operations is achieved.

Although various other modifications might be suggested by those versed in the art, it should be understood that I wish to embody within the scope of the patent warranted hereon all such modifications as reasonably and properly come within the scope of my contribution to the art.

I claim as my invention:

1. A roadway marker comprising a device of transparent material having a front and a back side and comprising:

a convex upper refracting surface having a spherical radius over at least part of its front side;

a substantially horizontal lower surface of smaller radius than the spherical radius of the upper surface; a surface bounding the refracting and the lower surfaces which is conical on at least the side opposite the side having a spherical radius;

the conical surface having a light-reflecting treatment;

the conical surface having an angle from the vertical and being of a width such that the treatment of its surface will reflect light refracted through the upper surface from a light source located between one minute of arc and approximately 25° of arc from the horizontal back to said source; and said transparent material being characterized by having decreasing hardness from its upper surface to its lower surface, thereby to provide a resilient base an impact-resistant top portion.

2. A roadway marker as defined in claim 1, and further characterized by said transparent material being a high-impact acrylic plastic.

3. A roadway marker as defined in claim 1, the focal plane of the refracting surface being between that surface and the opposite conical reflecting surface.

4. A roadway marker comprising a device of transparent material having a front and a front and a back side and comprising:

a convex upper refracting surface having a spherical radius over at least part of its front side;

a substantially horizontal lower surface of smaller radius than the spherical radius of the upper surface;

5

a surface bounding the refracting and the lower surfaces which is conical on at least the side opposite the side having a spherical radius;
 the conical surface having a light reflecting treatment;
 the conical surface having an angle from the vertical and being of a width such that the treatment on its surface will reflect light refracted through the upper surface from a light source located between one minute of arc and approximately 25° of arc from the horizontal back to said source; and
 said transparent material characterized by: an upper portion of high-impact clear plastic having a molecular structure and index of refraction, and a lower portion of flexible clear plastic having the

6

same molecular structure and index of refraction as said upper part,
 thereby to provide a resilient base.

5. A roadway marker comprising a device of transparent material having a refracting surface extending above the roadway surface and a reflecting surface opposite said refracting surface and beneath the surface of the roadway, characterized by:

said device having an integral resilient base portion through which incident and reflected light passes to absorb shocks of impact, as from snowplows; and said device having a hard, impact-resistant upper surface portion to resist abrasion and cracking from traffic loads thereon.

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