July 16, 1968 S. A. HEENAN ETAL 3,392,639

PAVEMENT MARKER FOR DAY AND NIGHT VISIBILITY

Filed Oct. 12, 1966 2 Sheets-Sheet 1

FIG. 1

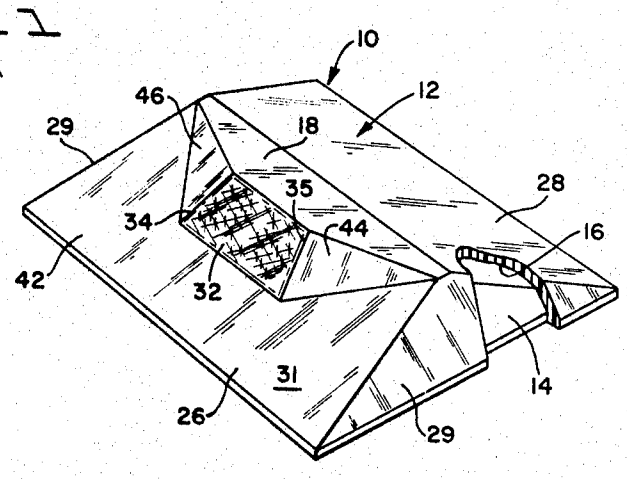


FIG. 2

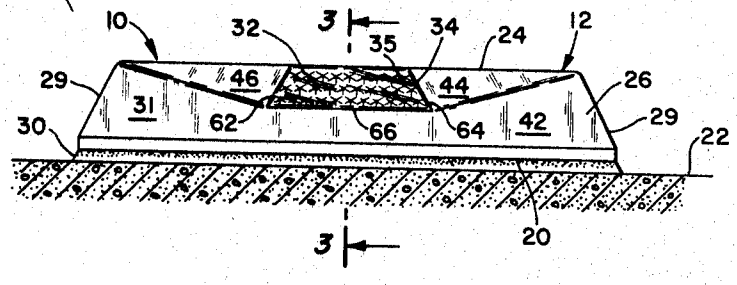
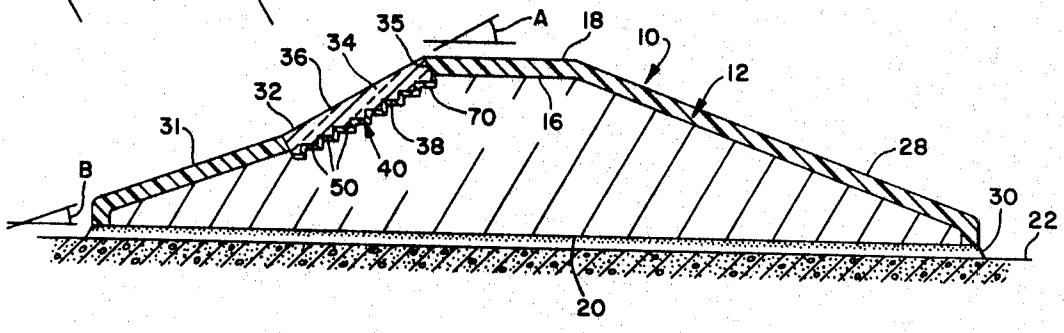


FIG. 3



INVENTORS
SIDNEY A. HEENAN
GLENN W. JOHNSON, JR.

BY Shumaker & Jacob

ATTORNEYS

July 16, 1968 S. A. HEENAN ETAL 3,392,639

PAVEMENT MARKER FOR DAY AND NIGHT VISIBILITY

Filed Oct. 12, 1966 2 Sheets-Sheet 2

FIG. 4

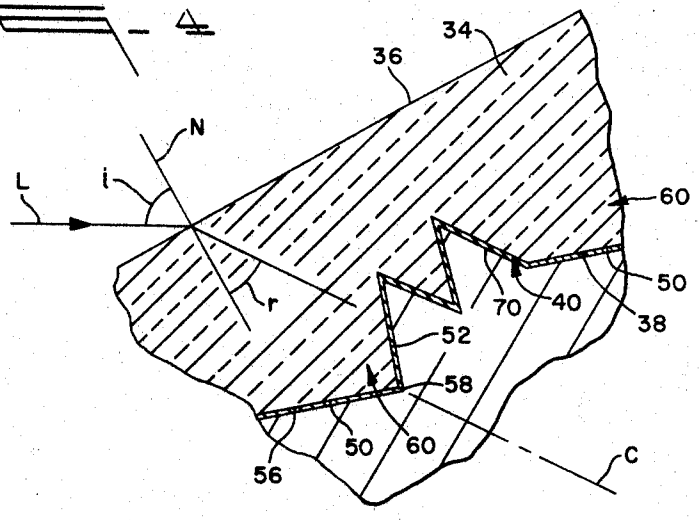
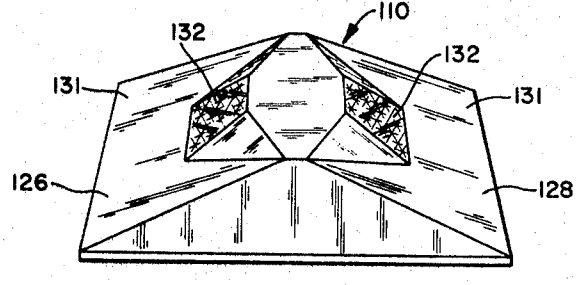


FIG. 5



INVENTORS
SIDNEY A. HEENAN
GLENN W. JOHNSON, JR.

BY Samuelson & Jacob

ATTORNEYS

United States Patent Office 3,392,639
Patented July 16, 1968

3,392,639

PAVEMENT MARKER FOR DAY AND NIGHT VISIBILITY

Sidney A. Heenan, Park Ridge, Ill., and Glenn W. Johnson, Jr., Summit, N.J., assignors to Elastic Stop Nut Corporation of America, Union, N.J., a corporation of New Jersey

Filed Oct. 12, 1966, Ser. No. 586,192
13 Claims. (Cl. 94—1.5)

The present invention relates generally to pavement markers and pertains more specifically to roadway traffic markers which are cleaned by the action of vehicular traffic on the roadway contacting the marker to maintain optimum visibility during service and which provide adequate visible markings during both the day and the night.

Pavement markers employing reflectors have enjoyed a high degree of acceptance in providing roadway markings visible from oncoming vehicles under nighttime conditions as a result of their ability to reflect light emanating from such vehicles. While it has been observed that the optical effectiveness of such reflectors will diminish rapidly during service as a result of the accumulation of dirt and other deposits which can form a film over the reflector system and inhibit the passage of light, it is now recognized that various means can be provided to clean the reflector surfaces in response to the contact of vehicular traffic with the marker structure and thus maintain their optical effectiveness. However, while effective reflector systems will provide adequate nighttime visibility in such markers, even clean reflectors of the relatively small sizes adequate for nighttime marking do not ordinarily provide a visible marking necessary for daytime use.

It is therefore an object of the invention to provide a pavement marker for establishing a marking which is adequately visible from an oncoming vehicle during both the day and the night and which will maintain its visible effectiveness during service.

Another object of the invention is to provide a pavement marker of the type described above and which can be installed readily and economically upon a roadway surface and which will withstand the constant contact with vehicular traffic inherent in such an installation.

Still another object of the invention is to provide a pavement marker employing a reflector system for nighttime visibility and an opaque facial area for daytime visibility, both of which will be wiped clean of accumulated dirt by contact with oncoming vehicular traffic and both of which will withstand mechanical abrasion arising out of such contact.

A further object of the invention is to provide a pavement marker of the type described which is self-cleaning with no moving component parts.

A still further object of the invention is to provide a pavement marker of the type described which is simple in construction, which is fabricated of relatively inexpensive materials and is capable of economical installation and maintenance.

The invention will be more fully understood and additional objects and advantages thereof will become apparent in the following detailed description of an embodiment of the invention illustrated in the accompanying drawing, in which:

FIGURE 1 is a partially sectional perspective view of a pavement marker constructed in accordance with the invention;

FIGURE 2 is a front elevational view of the pavement marker of FIGURE 1;

FIGURE 3 is an enlarged cross-sectional view taken along line 3—3 of FIGURE 2;

FIGURE 4 is an enlarged fragmentary view of a portion of FIGURE 3; and

FIGURE 5 is a perspective view of an alternative configuration of a pavement marker incorporating the invention.

Referring now to the drawing, a pavement marker constructed in accordance with the invention is shown in perspective at **10** in FIGURE 1 and has a body with a composite construction including a shell **12** of synthetic resin partially sectioned to show that it is filled, or "potted," with a relatively rigid filler material seen in the form of a cast solid core **14** which is contiguous with the inner surface **16** of the shell **12** and serves to reinforce the shell **12** and provide a solid, rugged structure capable of withstanding forces applied to the pavement marker when the outer surface **18** of the marker is struck by vehicular traffic during service.

The pavement marker is usually employed to provide a marking on a generally horizontal roadway surface, the marking being visible from an oncoming vehicle on the roadway to delineate traffic lanes, and, as best seen in FIGURES 2 and 3, is thus provided with a generally horizontal base **20** for cooperatively engaging the surface **22** of a roadway upon which the marker is to be installed. Shell **12** is further provided with a generally horizontal top **24**, which is raised vertically above the base **20**, opposite front and rear faces **26** and **28**, respectively, and opposite sides **29** which interconnect base **20** with top **24** to complete the shell **12**. The marker **10** is fixed in place upon the roadway surface **22** by an adhesive **30** which secures the marker at any desired location upon the pavement without requiring any recessing or other disruption of the pavement surface.

In order to render pavement marker **10** clearly visible during daylight hours, shell **12** is made opaque and is usually provided with a bright color. It is preferable, from the standpoint of durability, and especially for maximum abrasion and wear resistance, to fabricate shell **12** from a molded thermoplastic synthetic resin such as, for example, an acrylic like methyl methacrylate or a polycarbonate, some of which materials are known commercially as Lucite, Implex, or Lexan. The synthetic resin is pigmented to render shell **12** opaque and since the pigment runs completely through the resin, a certain amount of abrasion and wear will not affect the ability of the pavement marker to provide a clearly visible mark of desired color. Thus, front face **26** is located in a position to be viewed from oncoming vehicles and is provided with at least a first portion **31**, which is opaque and capable of being effectively viewed in daylight.

In order to render pavement marker **10** visible during night-time hours, a second portion **32** which is highly reflective is provided in the front face **26** which faces oncoming vehicular traffic so that light emanating from an oncoming vehicle will be reflected back toward the vehicle to establish a marking clearly visible in the surrounding darkness. Reflecting portion **32** is constructed to be initially optically efficient and the traffic marker is so designed as to maintain the optical effectiveness of the reflecting portion throughout the useful life of the marker. Thus, the body of the marker is provided with a window fabricated of a synthetic resin of the same, or similar, nature as the material of shell **12** with the exception that the window is light-transmitting rather than opaque. The window is shown in the form of an insert **34** fitted into a corresponding gap **35** in the front face **26** of the shell **12**.

As best seen in FIGURES 3 and 4, insert **34** has an outer, generally planar, obverse light receiving and retracting surface **36**. A retro-directive reflector system **40** in the reverse surface **38** receives light emanating from an oncoming vehicle and incident upon the obverse surface **36** and reflects such light generally parallel to the direction of incidence so that the insert **34** is rendered reflec-

tive and establishes the facial reflecting portion **32** which renders the pavement marker **10** capable of being effectively viewed at night.

One of the most effective reflecting systems available employs the well-known triple-mirror reflex reflecting principle which is thoroughly explained in the Stimson U.S. Patent No. 1,905,655, issued May 2, 1933, wherein there is disclosed a reflex light reflector including an obverse light receiving face and a reverse light reflecting face consisting of a plurality of cube corners, each having three surfaces adapted for total internal reflection of light impinging thereon from the obverse face. Each of Stimson's cube corners has an axis, and the cube corner axes are parallel to one another. For maximum optical efficiency, it is usual for such reflectors to be oriented with the cube corner axes essentially aligned with the direction of the nominal incident light. Since the light emanating from oncoming vehicles is practically parallel to the roadway surface at distances where a pavement marker should provide a mark visible from the vehicle, it would at first appear that use of the above described reflecting system would necessitate having the obverse face of the reflector essentially perpendicular to the roadway surface. It has been observed, however, that such perpendicular surfaces will collect dirt and a light impeding film will appear, which film will very rapidly reduce the optical effectiveness of such a reflecting system. Thus, some means is required for periodically cleaning the obverse face of the reflector.

It has been discovered that if the obverse face of the reflector system is oriented horizontally, or parallel to the roadway surface, rather than vertically, the normal contact between the tires of passing vehicles and the obverse face will wipe the face clean and the reflector system can retain its optical effectiveness while in service. Unfortunately, however, such contact between oncoming vehicles and the obverse face will also give rise to abrasion of the surface of the obverse face which will rapidly deteriorate the optical quality of the face and reduce the optical effectiveness of the reflector. Such abrasion can be reduced by orienting the obverse face perpendicular to the roadway surface, or in a vertical plane. Thus, on one hand, the obverse face should be oriented toward the vertical to achieve initial optical efficiency and to reduce optical deterioration arising out of contact with oncoming vehicles but should, on the other hand, be oriented toward the horizontal to allow the face to be periodically wiped clean by such contact. Additionally, a planar face projecting vertically from the roadway surface could become a traffic hazard while a horizontal face would reduce such a hazard.

Pavement marker **10** provides an optically effective reflecting system which remains effective during service and still takes advantage of the wiping action arising out of contact with oncoming traffic. To this end, the generally planar obverse surface **36** of insert **34** is neither vertical nor horizontal, but is at an acute angle A to the roadway surface **22**. Acute angle A is chosen so as to be great enough to place the reflecting portion **32** near enough to the vertical to allow the reflecting system to be optically effective, but it is also small enough to allow adequate wiping of the obverse surface **36** by contact with the tires of oncoming vehicles. Acute angle A is also great enough to reduce optical deterioration of the obverse surface arising out of abrasion of the surface by such contact with oncoming vehicles. Additionally, angle A is small enough to prevent pavement marker **10** from becoming a traffic hazard.

Good results in maintaining optical effectiveness and in achieving adequate wiping action have been attained with an angle A of 30°. Theory indicates and experience has shown, however, that satisfactory results can be realized where angle A is varied within plus or minus 15° of the nominal angle of 30°.

Opaque portion **31** of front face **26** is also oriented so as to rise above the roadway surface **22** and makes an acute angle B with the horizontal roadway surface. Angle B must also be chosen so as to be great enough to place the opaque portion **31** near enough to the vertical to provide a sufficiently large area viewable from an oncoming vehicle to render the mark provided by marker **10** adequately visible in daylight. Thus, angle B must be great enough to establish a generally vertical projected area viewable along the horizontal direction of sufficiently large size to provide the requisite viewable surface area. Additionally, angle B must be great enough to reduce deterioration of the opaque portion **31** by wearing away of the surface of shell **12** through abrasive contact with the tires of oncoming vehicles. At the same time, however, angle B must be small enough to enable adequate wiping of opaque portion **31** by such contact with oncoming vehicles to maintain the surface portion clean. Additionally, angle B is small enough to prevent pavement marker **10** from becoming a traffic hazard.

An effective magnitude for angle B has been found to be 20°. Experience has shown, however, that satisfactory results can be realized where angle B is varied within plus or minus 10° of the nominal angle of 20°.

As best seen in FIGURES 1 and 2, opaque portion **31** may be comprised of smaller areas lying at various acute angles to the horizontal in order to provide a relatively smooth transition between the insert **34**, which lies at the nominal angle A with respect to horizontal, and the major area **42** of the opaque portion **31**, which major area lies at the nominal angle B which is ordinarily less than angle A. Thus, minor areas **44** and **46** of opaque portion **31** will lie at acute angles having a magnitude between angles A and B.

Referring now to FIGURES 3 and 4, the reflecting system **40** is a triple-mirror reflex reflector system in principle, the reverse surface **38** containing a plurality of light reflecting elements **50** each of which is adapted for total internal reflection of light impinging on the reverse surface **38**.

Each reflector element **50** has three substantially square planar surfaces **52**, **54** and **56** arranged mutually at right angles and meeting at a common point **58** thus forming a cube corner **60**. Each cube corner **60** has an axis (the diagonal of the cube passing through the cube corner), one of which is illustrated at C in FIGURE 4. The axes of all cube corners **60** are parallel to one another, although they need not necessarily be parallel.

Light emanating from the headlamps of an oncoming vehicle on the roadway is represented by ray L in FIGURE 4 and is essentially parallel to the horizontal surface of the road. In actuality, ray L will vary from the horizontal by about only 6° while the vehicle passes through the zone where the reflecting system is required to provide a mark visible from the vehicle. Because obverse surface **36** makes an acute angle A with the horizontal roadway surface, ray L will be incident upon obverse surface **36** at an angle of incidence i with the normal N to the obverse surface and will be refracted upon passage into the material of insert **32** at an angle of refraction r as the light proceeds toward reverse surface **38**. Where the index of refraction of the material of insert **32** is u, light ray L will be refracted in accordance with the following formula:

$$u=\frac{\sin i}{\sin r}$$

and the angle of refraction r can be expressed as:

$$r=\sin^{-1}\left(\frac{\sin i}{u}\right)$$

In ordinary triple-mirror reflector structures the axes of the cube corners are aligned with the normal to the obverse face and the obverse face is generally located in a plane which is perpendicular or very nearly perpendicular to the nominal incident light so that any refraction

which may take place at the obverse face is generally of a negligible magnitude. Since maximum efficiency of such a reflector is realized when the light impinging upon the reverse surface is parallel to the axes of the cube corners, maximum efficiency is easily attained in ordinary reflector structures. However, in pavement marker **10**, obverse surface **36** lies in a plane making a nominal angle of 30° with the horizontal and angle of incidence *i* is approximately 60°. The angle of refraction *r* then becomes substantial. For example, where insert **32** is molded of methyl methacrylate, *u* is 1.5 and the angle of refraction *r* will be 35°16′. If the cube corner axes were aligned with the normal N to the obverse face as in ordinary reflex reflector structures, the optical efficiency of the reflector system would suffer severely from the large angle of incidence. However, by aligning the cube corner axes of reflector elements **50** with the direction of the refracted light rays, that is, at an angle *r* to normal N, maximum efficiency of the reflector is maintained despite the rather large angle of incidence.

It is noted that while ideally the cube corner axes should be aligned exactly parallel with the direction of the refracted light rays as computed above for maximum efficiency, in practice it has been found that adequate performance can be attained when the alignment of the cube corner axes is within about 13° of the computed direction of the refracted rays. Hence, general alignment of the cube corner axes with the refracted light within the above tolerances will give rise to satisfactory operation of the pavement marker.

It will be apparent that the angle of incidence will increase with a decrease in angle A and the greater the angle of incidence, the greater the transmission losses at surface **36**, both entering and leaving the surface, and the greater the angular error of the return ray caused by small error in the reflecting cube. For optical reasons, then, as well as for the reduction of abrasion arising out of contact with oncoming traffic, it has been determined that angle A should not be decreased below 15°.

The effectiveness of the reflector system **40** allows the reflecting portion **32** of front face **26** to occupy a relatively small portion of the area of front face **26**, leaving the larger area for opaque portion **31**. In general, the opaque portion **31** should provide a significantly larger projected viewable area than the corresponding area of reflective portion **32**. It has been found that satisfactory results are attained where the projected viewable area of opaque portion **31** is in the order of magnitude of five times that of reflective portion **32**.

It is noted that the trapezoidal configuration of insert **34** enables sides **62** and **64** (see FIGURE 2) of the insert to each follow a line of cube corners **60** so that the entire insert is effective in providing a reflective portion in the front face **26**. Thus, sides **62** and **64** each make an angle of 75° with the base **66** of the trapezoidal configuration.

Shell **12** is readily fabricated by molding an opaque portion of pigmented thermoplastic synthetic resin utilizing well-known techniques and providing the gap in the pigmented molded portion into which the light-transmitting insert, which is also molded of a thermoplastic resin, is placed. Pavement marker **10** is then completed by filling the molded and assembled shell with a material which will adhere to inner surface **16** and harden to form solid core **14**. Such materials as epoxy compounds have been found suitable for the formation of core **14**, although other suitable cast synthetic resins will become apparent to those skilled in the material arts. Since it is desirable from a structural standpoint that core **14** be contiguous with shell **12** and no voids exist between the shell and the core, reverse surface **38** is coated with a light-reflecting material **70**, such as by metallizing the reverse surface in a now well-known manner, to assure that the reflecting elements **50** will perform their assigned function. Since the insert **34** is molded separately from the remainder of the shell, the color and properties of the insert are independent of the color and properties of the remainder of the shell and each may be fabricated with any desired color or properties.

It will be noted that the overall appearance of the marker is pleasing as well as functional. The device presents no hazard to passing traffic since both sides **29** as well as both faces **26** and **28** are at an angle to the vertical which will reduce the shock imparted to the tires of contacting vehicles.

Although the pavement marker depicted in FIGURES 1 through 4 is monodirectional in that only front face **26** is provided with a reflective portion **32**, it will be apparent that a similar reflective portion could be provided in the rear face **28** to render the marker bidirectional. Thus, traffic marker **110**, illustrated in FIGURE 5, is provided with front and rear faces **126** and **128**, respectively, each having an opaque portion **131** and a reflective portion **132** to render traffic marker **110** bidirectional.

It will be apparent that the illustrated pavement markers are well suited to the attainment of the stated objects and advantages. The markers are self-cleaning without requiring moving component parts and will exhibit exemplary performance over a relatively long useful life.

The above detailed description is provided by way of example only. Various details of design and construction may be modified without departing from the true spirit and scope of the invention as defined in the appended claims.

The embodiments of the invention in which an exclusive property or privilege is claimed are defined as follows:

1. A pavement marker for providing a marking on a generally horizontal roadway surface, the marking being visible from an oncoming vehicle on the roadway both during the day and during the night, said pavement marker comprising:

a body of synthetic resin having at least one portion providing a face located in position to be viewed from the oncoming vehicle, said body portion having;

a first part which is opaque, said first part providing a first facial portion capable of being effectively viewed in daylight; and

a second part which is light transmitting and has an outer, obverse light receiving and refracting surface, an inner, reverse light receiving and reflecting surface, and a retro-directive reflecting system in said reverse surface for receiving light emanating from the oncoming vehicle and incident upon said obverse face and reflecting such light generally parallel to the direction of incidence for rendering said second part reflective and providing a second facial portion capable of being effectively viewed at night;

each of said first and second facial portions being so oriented as to make an acute angle with the horizontal and to rise above the roadway surface upon which the pavement marker is to be installed, each said acute angle being great enough to reduce deterioration of said first and second facial portions arising out of contact with the oncoming vehicle while being small enough to allow adequate wiping of said first and second facial portions by such contact;

the acute angle of the first facial portion being great enough to provide a sufficiently large projected viewable area; and

the acute angle of the second facial portion being great enough to maintain adequate optical effectiveness of said retro-directive reflecting system during service.

2. The pavement marker of claim **1** wherein the acute angle of the first facial portion is within 10° of a nominal angle 20° and the acute angle of the second facial portion is within 15° of a nominal angle of 30°.

3. The pavement marker of claim **1** wherein the acute

angle of the major part of the first facial portion is 20° and the acute angle of the second facial portion is 30°.

4. The pavement marker of claim 1 wherein the projected viewable area of the first facial portion is greater than the projected viewable area of the second facial portion.

5. The pavement marker of claim 1 wherein the projected viewable area of the first facial portion is in the order of magnitude of five times the projected viewable area of the second facial portion.

6. The pavement marker of claim 1 wherein the body has a gap therein contiguous with the first part thereof and the second part is in the form of an insert placed within the gap.

7. The pavement marker of claim 1 wherein said retrodirective reflecting system is a triple-mirror reflex reflecting system in said reverse surface.

8. The pavement marker of claim 1 wherein the body of synthetic resin comprises:

a shell of thermoplastic synthetic resin of given thickness;

a filler material of cast synthetic resin filling said shell and reinforcing the shell against forces applied externally by the contact with the oncoming vehicles;

said shell having at least a portion which is pigmented throughout the thickness thereof to render said portion opaque, said portion including said first part of said body portion,

a gap in said shell in the facial portion of said body; and

a light transmitting insert in said shell within the gap thereof and including the second part of said body portion.

9. The pavement marker of claim 8 wherein said retrodirective reflecting system is a triple-mirror reflex reflecting system including a plurality of light reflecting elements in said reverse surface for effecting reflection of light impinging thereon from said obverse surface, each said element having three planar surfaces arranged mutually at right angles and meeting at a common point remote from said obverse surface to form a cube corner, the axis through the cube corner of each said reflecting element being at an angle with the normal to said obverse surface for allowing said reflecting elements to receive light emanating in a generally horizontal direction from the oncoming vehicle and retracted by said obverse surface as a result of the acute angle of the second facial portion and to reflect said light generally parallel to the direction of incidence of the light incident upon said obverse surface.

10. The pavement marker of claim 9 wherein the acute angle of the first facial portion is within 10° of a nominal angle 20° and the acute angle of the second facial portion is within 15° of a nominal angle of 30°.

11. The pavement marker of claim 9 wherein the acute angle of the major part of the first facial portion is 20° and the acute angle of the second facial portion is 30°.

12. The pavement marker of claim 9 wherein the projected viewable area of the first facial portion is greater than the projected viewable area of the second facial portion.

13. The pavement marker of claim 9 wherein the projected viewable area of the first facial portion is in the order of magnitude of five times the projected viewable area of the second facial portion.

References Cited

UNITED STATES PATENTS

2,666,373	1/1954	Mattson	94—1.5
2,991,698	7/1961	Leubaz	94—1.5
3,093,038	6/1963	McRobbie	94—1.5
3,240,132	3/1966	Wiswell	94—1.5
3,319,542	5/1967	Hansen	94—1.5
3,332,327	7/1967	Heenan	94—1.5
3,343,467	9/1967	Bonvallet	94—1.5

NILE C. BYERS, JR., *Primary Examiner.*

UNITED STATES PATENT OFFICE

CERTIFICATE OF CORRECTION

Patent No. 3,392,639 July 16, 1968

Sidney A. Heenan et al.

It is certified that error appears in the above identified patent and that said Letters Patent are hereby corrected as shown below:

Column 2, lines 67 and 68, "retracting" should read -- refracting --. Column 8, line 7, "retracted" should read -- refracted --.

Signed and sealed this 30th day of December 1969.

(SEAL)
Attest:

Edward M. Fletcher, Jr.
Attesting Officer

WILLIAM E. SCHUYLER, JR.
Commissioner of Patents