We hereby apply for the grant of a Patent for an invention entitled: "RETROREFLECTIVE ELEMENTS, THEIR UTILIZATION AND METHOD OF MANUFACTURE", which is described in the accompanying complete specification. This application is a Convention application and is based on the applications numbered 564,412 and 534,817, for a patent or similar protection made in UNITED STATES OF AMERICA, on 2nd April, 1975 and 20th December, 1974.

Our address for service is Messrs. Edwd. Waters & Sons, Patent Attorneys, 50 Queen Street, Melbourne, Victoria, Australia.

DATED this 11th day of December, 1975.

ROBERT B. BAGSHAW.

BY: J. A. Barker.

To: THE COMMISSIONER OF PATENTS.
COMMONWEALTH OF AUSTRALIA
Patents Act 1952-1960
DECLARATION IN SUPPORT OF A CONVENTION
APPLICATION FOR A PATENT OR PATENT OF ADDITION

In support of the Convention Application made by

Robert B. Bagshaw

for a patent for an invention entitled:

Retroreflective Elements, Their Utilization and Method of Manufacture

I, Robert B. Bagshaw

of 2024 North Oak Lane
State College, Centre County
Pennsylvania, U.S.A. 16801

do solemnly and sincerely declare as follows:

1. I am the applicant for the patent.

2. The basic applications as defined by Section 141 of the Act were

made in the United States on the 20th day of December 1974, by
Robert B. Bagshaw, Serial No. 534,817 (Abandoned)
on the 2nd day of April 1975, by
Robert B. Bagshaw, Serial No. 564,412

3. I am the actual inventor of the invention referred to in the basic applications.

4. The basic application referred to in paragraph 2 of this Declaration was the first application made in a Convention country in respect of the invention the subject of the application.

DECLARED at Philadelphia, Pennsylvania U.S.A.
this 3rd day of December 1975

Robert B. Bagshaw

To: THE COMMISSIONER OF PATENTS.
Complete Specification for the invention entitled:

"Retroreflective Elements, Their Utilization and Method of Manufacture".

The following statement is a full description of this invention, including the best method of performing it known to: US.
Background of the Invention.

In the prior art, it has become commonplace to utilize retroreflective elements and markers of various types, on streets and highways to provide nighttime delineation of center lines, edge lines, medians, obstacles, obstructions, signs, etc. In fact, it has become commonplace for retroreflective material to be used in large quantities for traffic control, especially on signs.
Retroreflective material is a material that requires no power of its own, but reflects light back to or towards its source. It has become especially important as a safety aid on highways that functions such that light from an automobile headlight striking a retroreflective material is reflected back towards the driver's eyes, creating the appearance of illumination of the retroreflective material.

Examples of prior art developments utilizing retroreflective characteristics for signs, traffic control devices, etc. are U. S. Patents #1,902,440; 2,251,386; and 2,294,930. In these patents there is contained a teaching of using minute glass spheres, because of the inherent retroreflective capabilities of the glass spheres. Originally, traffic signs were produced by applying a coating of paint or binder to the surface and then applying a uniform layer of glass spheres to the binder while wet, permitting the spheres to become partially imbedded in the paint with approximately 50% of the sphere diameters left exposed. These spheres are ordinarily half silvered, placed on a silvered surface, or partially covered with a metallic paint, in order to provide the desired reflective qualities. Signs made according to the techniques of prior developments, such as of the three above-mentioned patents were effective except under adverse weather conditions. When the signs would become wet, due to rain falling on the sign surfaces, the lenticular surface of the sign, comprised of a plurality of glass beads, would be destroyed, thereby destroying the ability of the spheres to act as retroreflectors.
The solution to that problem, while taking the form of various methods, basically involved the use of a flat overlay on the spherical surfaces, to prevent destruction of the spherical shapes that comprised the overall surface. Examples of various methods that are used to prevent the destruction of the lenticular surfaces of the beads that include the use of flat overlays are included in U. S. Patents #2,326,634; 2,543,800; 2,592,882; and 2,713,286. The sheet materials disclosed therein are in each instance retro-reflective materials in the form of planar sheets, each having a plurality of minute retroreflective components, preferably in the form of glass beads.

In that phase of highway safety that is addressed to delineating streets and highways by painted lines, it has become accepted as a method, and commonplace throughout the world that glass beads are applied to the highway by applying a paint or binder to the highway surface and then to drop or embed minute glass spheres into the wet paint or binder. An example of this technique is present in U. S. Patent #2,267,995. The retroreflective capability of the glass beads so imbedded works rather well during dry weather but is totally non-effective during wet weather, as in rain, due to the destruction (from a lenticular standpoint) of the retroreflective surfaces of the beads by the presence of rain water thereon. Further disadvantage inherent in this technique for delineating streets and highways resides in, for all practical purposes, a limitation of the color of the light returned to the
source, to either white or yellow; the colors normally applied to the highway by the paint or binder.

While retroreflective materials of the type employing a flat overlay, as discussed above with respect to U. S. Patents 2,326,634; 2,543,800; 2,592,882; and 2,713,286, while working well in the vertical plane as applied to stop signs and the like, would not work well when applied to a horizontal surface such as a roadway or the like, and in fact would be completely non-effective due to basic and well-known optical principles.

The optical principle involved is that the angle of incidence of light approaching a retroreflective surface cannot exceed 40° or 45° if it desired to have any light reflection back to the light source. By angle of incidence, it is meant the angular measurement of the path of light toward the surface, as measured from a perpendicular to the surface. Automotive head lamps of course direct light onto road surfaces at incident angles that are effectively generally greater than 80° and that often approach 90° incident angles, whereby the light beam is parallel to the horizontal surface.

It has been known in the art to use various elevated markers having retroreflective qualities, and with some success. The most common of such markers are molded-plastic units that extend sufficiently high above the highway surface to prevent water from destroying the lenticular surfaces of the beads employed, and hence from destroying their retroreflective qualities. Such markers are generally expensive, time consuming upon installation, and are subject to
accidental removal by snowplows. Examples of such raised constructions are present in the following U. S. Patents: 3,043,196; 3,171,827; 3,175,935; 3,252,376; 3,254,563; 3,255,282; and 3,418,896.

While all of these teachings present improvements under dry weather conditions, none are really effective under adverse conditions; specifically, under wet weather conditions, because of lenticular destruction of surfaces of beads, cylinders, aggregates or the like when wet.

The Present Invention

The present invention is addressed to providing novel three-dimensional retroreflective elements, capable of providing visible light retroreflection when applied to a surface, even when the angle of incidence of the light relative to the surface exceeds 45°, and even when the exterior of the element is water-wet. The elements are provided in the form of three dimensional shapes that may be included in, or applied to paint, binder or the like, to be applied to road surfaces, or any other desired surfaces wherein wide angles of light incidence will be encountered, and wherein retroreflection of light to its source is desired. The elements are constructed to have more than one surface, the surfaces being at angular dispositions relative to each other, and with more than one surface having a great number of minute retroreflective components, with the minute retroreflective components having exteriors that are protected from lenticular destruction by water. The elements may be
constructed from existing planar retroreflective sheet material, or may be constructed by employing existing retroreflective glass beads or other glass shapes having the desired retroreflective characteristics, as desired.

It is the primary object of the present invention to provide novel retroreflective elements adapted for use in providing retroreflective capabilities when subjected to use that involves a wide angle of incidence of light.

It is a further object of the present invention to provide techniques for making retroreflective elements, both from existing retroreflective materials, and from existing retroreflective components.

It is a further object of the present invention to provide a novel coating adapted to provide nighttime retroreflective characteristics on horizontal surfaces even when those surfaces are wet.

It is another object of this invention to accomplish the above object, with particular adaptation to highway surfaces.

It is a further object of this invention to provide novel techniques for manufacturing elements adapted for use in providing highway markers, delineation lines, and lines on other horizontal surfaces, that employ retroreflective characteristics and that are effective for nighttime illumination of those lines, markers, etc., even under adverse or wet weather conditions.

It is a further object of this invention to provide a retroreflective element that is highly efficient in both dry weather and under adverse or wet weather conditions.
A further object of the present invention is to provide a retroreflective element and/or coating employing retroreflective elements, that will return light of any desired true color.

It is another object of the present invention to provide retroreflective elements that can be applied to either vertical or horizontal surfaces, as desired, that will be extremely durable, and that can be produced easily and economically, and that preferably can take advantage of existing equipment and methods for application.

Other objects and advantages of the present invention will be readily apparent to those skilled in the art by reading of the following brief descriptions of the drawing figures, detailed descriptions of the preferred embodiments, and of the appended claims.

**Brief Description of the Drawing Figures**

Figure 1 is a perspective view of a roadway employing reflective coatings in the form of delineation lines, stripes in the horizontal plane, and of a sign employing indicia in the vertical plane, with the indicia and stripes, lines, etc. being constructed in accordance with the present invention, and including retroreflective elements in accordance with the present invention.

Figure 2 is a side elevation illustrating angles of incidence from light of a given source, on different horizontally disposed and vertically disposed surfaces, of the type contained in the illustration of Figure 1.
Figure 3 is an enlarged transverse sectional view, taken through a stripe illustrated in Figure 1, generally along the line III-III of Figure 1, and wherein retroreflective elements disposed or embedded in a paint or binder as applied to a road surface, are illustrated, under wet or rainy conditions.

Figure 3A is a view similar to that of Figure 3, but wherein alternative retroreflective elements are illustrated.

Figure 3B is a view also similar to that of Figure 3, but wherein a combination of other alternative retroreflective elements is illustrated.

Figure 4 is an enlarged sectional view taken through one of the elements illustrated in Figure 3, generally along the line IV-IV of Figure 3.

Figure 5 is an enlarged fragmentary cross-sectional view, taken through a suitable retroreflective sheet material for use with the present invention.

Figure 6 is a view similar to that of Figure 5, but wherein an alternative retroreflective sheet material is illustrated, also suitable for use with the present invention.

Figure 7 is a schematic view, in perspective, of one technique for manufacturing retroreflective elements in accordance with one embodiment of retroreflective elements of the present invention.

Figure 8 is an enlarged perspective view of one of the elements manufactured by the technique of Figure 7.

Figure 9 is a perspective view of an element somewhat similar to that of Figure 8, but having a modified
longitudinal configuration.

Figure 10 is a schematic view, in perspective, of a manufacturing technique for making another form retroreflective element in accordance with the present invention.

Figure 11 is an enlarged perspective view of one of the elements made in accordance with the technique of Figure 10.

Figures 12, 13, and 14 are each perspective views of different modified forms of retroreflective elements in accordance with the present invention, each employing a different geometric shape, but each embodying retroreflective sheet material on the surface thereof, and a core of hardenable material.

Figure 15 is a schematic perspective view of another manufacturing technique for making retroreflective elements in accordance with the present invention.

Figure 16 is an enlarged perspective view of a retroreflective element made in accordance with the technique of Figure 15.

Figure 16A is an enlarged fragmentary detailed view of a portion of the illustration of Figure 16, wherein the components of the retroreflective element embedded in a transparent plastic binder are more clearly illustrated.

Figure 17 is a schematic perspective illustration of one technique for applying retroreflective elements made in accordance with the present invention, to a paint or binder disposed along a surface, for example, such as a highway surface.
Figure 18 is a transverse cross-sectional view, taken through a three-dimensional reflective marker in accordance with this invention.

Figure 18A is a view similar to that of Figure 18, but through a different style of marker, in accordance with this invention.

Figure 19 is a view similar to that of Figure 18, but taken through another different style of road marker in accordance with this invention.

Figure 19A is a view similar to that of Figure 18, but taken through another style of road marker in accordance with this invention.

Figure 20 is a view similar to that of Figure 18, but taken through still another style of road marker in accordance with this invention.

Figure 21 is a top perspective view of a low profile three-dimensional reflective marker in accordance with the present invention.

Detailed Descriptions of the Preferred Embodiments

Referring now to the drawings in detail, reference is first made to Figure 1, wherein a roadway 20 is illustrated having a divider 21 against oncoming traffic, along with lane dividers 22, 23, and 24.

A signpost 25 is disposed alongside the road with a sign 26 containing indicia 27 thereon.
The dividers 21 through 24 are each constructed to comprise a coating having retroreflective qualities, in accordance with the present invention. Similarly, the indicia 27 is likewise constructed.

It will be understood that the coatings 21 through 24, and in fact the coating 27 may be of the paint-on type, whereby a paint, binder or the like is applied to the surface 20 or 26, as appropriate, with retroreflective elements then being dispersed onto thus painted surface, or in the alternative, the coating may be in the form of a non-fluid, solid laminate having retroreflective elements projecting therefrom; embedded therein. As a further alternative, the coating could be applied in the form of a paint with retroreflective elements already dispersed through the paint prior to its application to the surfaces desired, although such would not be preferable.

With reference to Figure 2, it will be seen that a light source 28 is provided, that may comprise for example a headlight of an automobile or the like, shining down the roadway 20, and depending upon the speed of the vehicle, the angular orientation of the head lamp (i.e., whether high beams or low beams are on), the curvature of the road, etc., it will be seen that light may strike the highway markers or dividers 23 and 24, as indicated. For example, light from the source 28 may approach the lane divider 23 in the direction of the arrows 30, at an angle of incidence "a" (angle with the perpendicular 31 to the surface 20). Upon striking retroreflective elements 32 in the coating 23,
light is returned towards its source, as indicated by the arrows 34.

The light from the source 28 is also illustrated as being directed toward and reflected from retroreflective elements 35 of the divider or marker 24, such light approaching the elements 35 in the direction of the arrows 36 at an angle of incidence "b", and returning from the elements 35 as indicated by the arrows 37.

It will be noted that each of angles "a" and "b" are substantially in excess of 45°, and realistically, in excess of 80°.

It will also be noted that light from the source 28 is illustrated in Figure 2 as proceeding toward the retroreflective surfaces 27 of the sign 26, in a direction of the arrow 38, and returning therefrom in the direction of the arrows 40, at an angle of incidence "c", of about 15°, more or less.

The binder 23, 24 and even the binder for the indicia 27 on the sign 26 may comprise a paint, resin or the like, preferably of originally liquid composition, that is hardenable to comprise a solid. The binders 23, 24 are generally applied to the road surface 20 when wet. Various compositions for the binders may be utilitzed, including but not limited to any of the binders disclosed in the several U. S. patents mentioned herein, for example, the pigmented binder film disclosed in U. S. Patent 2,267,995, embodying an organic silicate vehicle, or any other desired type of binder. It will generally be preferable that the binder be
pigmented, and in instances in which highway stripes are to be utilized, preferably white or yellow pigments are desirable. However, red pigments or other warning-related colorings may be utilized as desired.

With particular reference to Figure 3, a transverse cross-sectional view taken through the marker 21 of Figure 1 is illustrated, as comprising a plurality of randomly oriented elements 41, projecting upwardly from the marker 21 disposed on the road 20. Each of the elements 41 is of multiple surface construction, partially embedded within the marker 21, and preferably being sized to have its largest dimension across its shape within the range of about 0.015 inches up to about 0.090 inches, but the sizes of the elements or shapes can vary from about 0.005 inches to about 0.250 inches; or even up to any size that is practical to form or fabricate from existing retroreflective materials. The numerical sizes indicated immediately above are preferably for highway or pavement markings, but larger sizes can be utilized if desired as a substitute for expensive raised plastic units. Additionally, elements 41 in larger sizes, used either with or without other binder or coating material 21 may be employed either as components of the indicia 27, or separately for use on vertical surfaces such as median barriers, abutments, etc.

The numerical size ranges indicated herein are applicable to the various styles or types of retroreflective elements embraced within this application and claims, irrespective of any particular manner of manufacture.
A film 42 of rain is illustrated coating the elements 41 in Figure 3.

In Figure 3A, a solidified liquid-applied binder 43 is illustrated on a road, with an alternative form of element 44 embedded therein, and in Figure 3B, another coating or binder 45 is illustrated on a road 46, with four different alternative element shapes 47, 48, 50 and 51 embedded therein, such shapes respectively being cylindrical, spherical, triangular or prism-like, and rectangular. Additionally, other shapes such as conical, frusto-conical, and irregular may also be utilized (note shown).

With particular reference to Figure 4, one of the elements 41 is illustrated as comprising a pair of originally planar sheet-like portions of retroreflective material of any desired commercial type, 52 and 53, secured together with any suitable adhesive 54 therebetween, and which have been bent into a "V" shape as illustrated in Figure 4, to have an acute included angle between internal surfaces 55 and 56, and obtuse angle between outer surfaces 57 and 58. Each of the originally flat sheets 53 and 52 may be constructed by any of the techniques disclosed herein for making flat retroreflective sheets of material, as indicated in the several U. S. cited patents herein, but preferred constructions of the sheet material may reside in any of U. S. Patents 2,326,634; 2,713,286; 2,592,882; and 2,543,800. Most if not all of these disclosures involve the use of glass spheres, although alternatively the spheres could be of plastic or like construction. However, with particular reference
to Figure 5, a typical construction for the sheet material is illustrated as comprising an optional base layer of paper, plastic or the like 60, which has a layer of metal (for example aluminum) foil 62 disposed thereon, with dimples or recesses therein, for accommodating glass beads 63, each of minute (microns) size. The glass spheres 63 will have a refractive index within the range of 2.0 to 2.9 and more generally within the range of 2.2 to 2.6, with the index 2.9 being optimum. A transparent, but optionally colored paint, plastic or the like comprises a layer 64 disposed over and about the layer of spheres 63, such layer 64 having a refractive index of about that of water, or of about 1.4, or within the range of about 1.338 (generally a fluoroplastic) to about 1.70 (a phenol-formaldehyde or phenol-furfural); but preferably within the narrower range of about 1.4 to about 1.65. By the use of coloring in the transparent layer 64, the light returned to a source retrorefracted off of a surface of the type 65, can have any desired coloring, such as red for danger, yellow for caution, etc. Also, the surface 65 will generally be flat for efficient light bending into the spheres. Water 66 from inclement weather or otherwise will generally have a refractive index of about or substantially the same as that of the substance 64, to prevent lenticular distortion of, or destruction of the retroreflective capabilities of an element thus constructed, while rain water 66 is on a surface 65 thereof.

With reference to Figure 6, another alternative construction for the sheet layers 52 and 53 is illustrated,
such construction being the one that comprises the several exterior surfaces of the elements 44 of Figure 3A. In Figure 6, a backing 70 of paper, plastic or the like is illustrated, with a foil layer 71, similar to that 62 of Figure 5, and with glass spheres 72 also being provided in dimples of the foil layer, but wherein the spheres 72 are each constructed to have a refractive index of about 1.90 to about 1.92, (optimum range) and with a plurality of paper, plastic or the like spacers 73, 74, as illustrated in Figure 3A, having an overall weblike arrangement, serving to space the outer transparent layer 75 from the foil 71, with only air 76 disposed therebetween around the spheres 72. The transparent layer 75 may, like the layer 64 of Figure 5, be tinted or colored, and may be constructed of any suitable laminate, paint, plastic or the like, that will have the desired refractive index, again like that of water, within the range of about 1.338 to about 1.70, and preferably within the range of about 1.40 to about 1.65. The advantage of construction such as that of Figure 6 for the sheet material that is used to make elements 41, 44 or the like, is that the glass beads 72 do not have to be the same high quality that will yield the high refractive index required by the beads 63 of Figure 5, in the construction of Figure 6. Also, in Figure 6 a water layer 77 is illustrated, as in Figure 5.

The sheet materials 52 and 53, and that that have constructions similar to those illustrated in Figures 5 and 6, or suitable constructions are available commercially,
such as the SCOTCHLITE and "FLAT-TOP" brands of reflective sheeting (all grades) and are designated by those trademarks, and manufactured by 3M Company of St. Paul, Minnesota. Other companies manufacturing suitable sheet materials for use in making elements in accordance with the present invention may include the Morgan Adhesives Company of Stow, Ohio, that provide a reflective sheeting designated by the trademark MACLITE (7200 Series). Similar materials are manufactured by other companies, many of which would be usable in accordance with the present invention. Further examples would be products of Fasson Products Company, and new corner cube material produced by Rowland Development Company under the trademark name "REFLEXITE". Many of these products come in various colors, and the color of the returned light can be predetermined by selection of the proper color of sheeting.

Many of the retroreflective materials are referred to in the literature as being "reflex-reflective". It will be understood that these terms are used synonymously herein.

With reference to Figure 3B in particular, it will be noted that the elements of the present invention, 47, 50, 51, 44 and 41 (the latter two not being specifically illustrated in Figure 3B), may be used separately, or together with other element shapes of the present invention, and either separately, or in conjunction with glass beads 48. The reason for this is that, as applied to a highway line, for example, the glass beads 48 function in a highly
efficient manner during conditions of dry weather. By mixing conventional glass beads with elements in accordance with the present invention, an economic saving can be effected, in that, the elements constructed in accordance with the present invention have such high retro-reflectivity, that the degree of saturation that would normally be used of glass beads is not required for elements in accordance with the present invention. Accordingly, a percentage of the solids that are dispersed onto the surface of a binder 45 may comprise elements in accordance with the present invention and another percentage of those solids may comprise glass beads or spheres 48, that, when taken together, will provide the desired retro-reflectivity under both wet and dry weather conditions.

With reference now to Figure 7, one technique for manufacturing elements in accordance with the present invention is illustrated; as comprising commercially available sheets retroreflective material provided in the form of rolls of ribbons of such material 81, 82 and 83, and delivering them in the direction of the arrow 84 of Figure 7, to pass through the junction 85 formed by the forming wheels or rollers 86, to make a long ribbon 87 of layers of the commercially available sheet retroreflective material, having three continuous legs thereof, each with two surfaces of retro-reflective material, angularly related to each other, and then serially and sequentially severing the elongate material 87 thus formed by passing the same through a severing knife 88 and knife block 90, to yield a plurality of elements 91, formed one after the other,
each identical.

With particular reference to Figure 8, the element 91 is illustrated in greater detail as comprising three legs 92, 93 and 94, each having its two opposite surfaces comprised of originally planar sheet retroreflective material, of an above-discussed commercially available type.

With reference to Figure 9, another example is given of a configuration that may be desired, having some similarities to that illustrated in Figure 8, with three legs 95, 96 and 97, but being constructed from flat circles of sheet retroreflective material. Generally, elements made in accordance with Figure 9 will not be mass-produced in accordance with the process of Figure 7, and will be somewhat larger, for application to poles, bridge abutments, bicycle spokes, with the sizes being selected depending upon the desired application.

With particular reference now to Figure 10, an alternate version of the manufacturing technique of the present invention is disclosed, wherein the three dimensional elements 100, illustrated in somewhat larger form in Figure 11, in the form of sheet retroreflective material 101 on the surface of a triangular core 102. This is made by first providing a roll 103 of a ribbon of sheet retroreflective material of a commercially available type with one or both (preferably both) surfaces having retroreflective qualities, running the same through a series of rollers or the like 104 that comprise a forming die that forms the ribbon 105 into a triangular or trough-like configuration 106. A thermo-
setting resin or like hardenable or settable material 107 is applied to the trough 106 by an appropriate dispensing nozzle 108, and the whole process being practiced continuously, the trough with the resin therein is then delivered past or beneath a heater 110 that serves to set or harden the resin, followed by delivery of the then hard or almost hard composite 100 to a shearing mechanism 111, comprising a blade 112 and a suitable support fixture 113. The result is a solid retro-reflective element 100 having surfaces of retroreflective sheet material. If the material is comprised of two sheets back-to-back of retroreflective material, and if the resin 107 is transparent, the element 100 is more efficient.

With reference once again to the embodiment of Figures 11 through 14, the core, if desired may be comprised of any suitable material, other than those specifically disclosed herein above. For example, extruded polyvinyl chloride, polycarbonates, or cellulose acetate butyrate are typical plastics that can be utilized. The oelfin group of plastics, including polyethylene is not generally suitable due to problems with adhesion of the same to the retroreflective sheet material, although the same may be suitable upon overcoming the adhesion problems.

Typical resins that may be usable in the embodiments of Figures 10 through 14, may include polyesters such as Reichhold Chemicals', trademark brand "POLYLITE" of polyester resins, and epoxies such as the epoxy designated by the trademark "BAKELITE" of Union Carbide. Suitable specific resins, preferably of thermosetting types may be selected from these examples, and from others commercially available.
Figures 12 through 14 disclose other configurations. Generally, the configuration of Figure 12, indicated by the number 114, resides in providing sheet retroreflective material, in circular form, by spiral configuration or otherwise, and then filling the hollow cylindrical configuration thus formed with a hardenable resin or other suitable material followed by cutting the composite thus formed off to size by a shear or the like. An alternative method of manufacture thereof would be to extrude a core of resin material, and then wrap the core thus extruded with a tape of sheet retroreflective material. Similarly, the rectangular configuration of Figure 13, and the triangular configuration of Figure 14 may likewise be constructed, either by first preparing the casing of retroreflective material and filling it with a hardenable substance, or by first extruding a rod of hardenable substance having the desired cross-sectional configuration, and then wrapping or otherwise covering it with a covering of sheet retroreflective material. The core material could also be wood, metal, etc or any other hard or hardenable substance, and may be of any desired shape; e.g. triangular, semi-circular in transverse cross-section, etc, with retroreflective material wrapped, adhered or otherwise applied to surfaces thereof. Moreover, the core could be of a rigid, but non-filling construction, e.g. metal angle with retroreflective material on a surface or surfaces thereof.

With particular reference to Figure 15, another alternative manufacturing technique is provided in the form of an extruding apparatus 120, into which resin and beads are delivered continuously, with the extruder 120 being suitably
motor driven or otherwise, to provide a continuous rod 121 of a circular or other desired cross-section, that comprises a mixture of the resin and beads dispersed or embedded therein, at least near the surface portions of the rod 121, and with the composite rod 121 thus formed then being delivered past the knife 122 of a shear 123 for cutting of the same to length, to yield retroreflective elements 124. The element 124 is illustrated in somewhat greater detail in Figure 16, as comprising a plurality of glass bead components 125 embedded in a resin 126. The beads 125 each have half-silvered surfaces, such silvering or metalizing if desired, having been pre-provided by conventional techniques. The spheres or beads 125 will be randomly oriented such that light passing through the transparent color or non-colored plastic or other suitable binder 126 will likely strike some of the beads at the desired angular orientation to penetrate the beads, be reflected off of the silvered or otherwise metalized surface and to be returned toward the source of light. It will be understood that colored light returned can be achieved by introducing transparent pigments into the resin or other suitable binder 126. It will also be understood that the exterior surfaces of the element 124 will be smooth, for purposes of light penetration.

In the embodiment of Figures 15 through 16A, the glass spheres will each have a refractive index of at least about 2.0 and up to about 2.9 and the binder 126 will have a refractive index within the range of about 1.338 to about 1.70, and preferably within the range of about 1.40 to about 1.65.

With reference to the embodiment of Figures 15, 16.
and 16A, the binder 126 may comprise a thermoplastic resin, such as that provided by General Electric Company under the trademark "LEXAN" brand of polycarbonate.

An alternative process for producing the elements 124 is by casting. A mixture of a clear polyester casting resin and half-silvered glass spheres each preferably having a refractive index in the range of about 2.2 to about 2.6, poured into a metal mold having a V-shaped groove in its surface, upon curing, will yield small triangular strips with glass spheres embedded therein, that can be sheared to length. The binders 124 will generally be suitably pigmented as for example as described in U.S. Patent 2,543,800, or any other commercial resin or other type of binder commercially available, either with the pigmentation already supplied therein by the supplier, or added thereto for desired coloring, at the situs of manufacture of the elements, as is desired. The cast or extruded elements may take on any of various shapes and may even be hollow at their interiors; e.g., hollow cylindrical configurations, hollow rectangular configurations, with the minute retroreflective components near, but embedded in exterior surfaces thereof. Also, the minute retroreflective components, in lieu of comprising half-silvered spheres could comprise small chips or particles of sheet retroreflective material, if desired, with either one or both sides thereof having retroreflective qualities.

With particular reference to Figure 17, a suggested manner of application of the elements for highway or pavement markings is illustrated, wherein means 130 are provided for...
delivering paint, as from a spray gun or the like onto a surface 131 of a road, such spray gun 130 being mounted on the back of a truck or the like, whereupon movement of the truck will yield a ribbon of paint 132, with a second truck or a down-stream portion of the same truck or other vehicle including a dispenser 133 of elements in accordance with the present invention, dispensing the elements from the dispensing container 133 onto the wet paint or other suitable binder 132, from a conventional sphere dispenser. It will be noted that the elements dispensed from the dispensing container 133 may be either all elements in accordance with the present invention, or a mixture of those elements with spheres or other suitable elements, as desired, and as has been discussed herein above. The thickness of the binder or paint 132 will be controlled in order to provide proper adhesion of the binder to the roadway 131, and most especially to provide proper embedment of the elements 134 being dispensed from the dispenser 133, into the binder 132. As an alternative, a separate dispensing device similar to that of 133 may be used to provide glass spheres into the binder 132 separately from the dispensing of elements in accordance with the present invention into the binder 132. The binder, besides comprising paint, may be any similar type of binder disclosed herein for the intended purposes, including thermoplastic binders or the like, depending upon the desired durability of the marker.

The retroreflective particles or components of the present invention (that may also be retroreflective elements, if they have a surface coated with a substance
having substantially the same refractive index as that of water) may be constructed from retroreflective sheeting having one side that is retroreflective, that are bent into the shapes illustrated for sheeting herein, and that may take on other configurations. For example, the sheeting may be spirally wound if desired, be wound to hollow cylindrical shapes, if desired, or may be laminates of different layers of sheeting, as desired. In instances in which the sheeting will be of the type having two retroreflective sides, the configurations may be of those types illustrated herein (for example see Figures 8, 9, 11,) for example, as well as Figure 4, and the several embodiments illustrated in Figure 3B, and furthermore, L-shaped sections may be utilized, or almost any other shape desired.

Where solid or substantially solid constructions are to be made, that do not have sheet portions of retroreflective material on the surface thereof like those of Figures 11 through 14, but are constructed more along the lines of the constructions of Figures 16 and 16A, it will be apparent that, here again, any of various forms may be used. In such instances, the components may comprise spheres disposed adjacent a metallic surface for retroreflective components, then the metallic surfaces and the spheres covered with a coating similar to the substance 126 in Figure 16A. In the alternative, the spheres may be of the half-silvered type. In other instances, a metallic foil core could have a plurality
of beads disposed thereabout, then all of which are embedded in a substance such as that 126 in Figure 16A. In this embodiment, the metallic core would take the place of the silvering on the spheres 125 of Figure 16A. Thus, retroreflective elements, it will be seen, may take on many configurations. However, each of the configurations will have a surface coating (that may or may not be the same substance in which the elements are embedded), that is of substantially the same refractive index as that of water, and with some means inside for reflecting light backwardly toward its source. In many instances that means may comprise beads that are half-silvered to reflect light or the beads may be disposed on some embedded metallic surface, as desired. A further alternative is to construct retroreflective elements by embedding in a substance such as that 126 of Figure 16A, or some suitable other resin, minute flecks of sheet retroreflective material, dispersed at random in the resin, and all of which, when taken together, comprise a retroreflective element in accordance with the present invention. One manner of providing such flecks would be to provide either single or double face sheet retroreflective material, and to quickly freeze it, as by application of liquid carbon dioxide, and while such sheet material is frozen to run it between a pair of fracturing rollers, that will fracture the sheet material into separate particles. These particles may then be dispersed in larger beads (up to about 1/4 inch, if desired), randomly, or even arranged, if desired in resin drops, or other desired
three-dimensional shapes such as cylinders, tetrahedrons, etc.

Also, various irregular shapes may comprise cores, that are provided with silvered-spheres adhered to the surface thereof, and that then have a smooth coating of a resin of any of the types mentioned herein as would be suitable for the substance 126 of Figure 16A, for example.

In instances in which minute half-silvered beads or tiny flecks of planar sheet retroreflective material are embedded in small droplets of resin that have the same refractive index as about that of water, the droplets comprised thereby may, if desired, be sprayed out of a spray gun and solidified in various forms, as desired. Still another alternative would be to utilize sheets of retroreflective material of the type described herein for example with reference to Figures 5 and 6, such sheets either being back-to-back, or not, and to then extrude an overlay of a substance such as that 126 in Figure 16A thereover, in any of many various shapes for subsequent severing of the extrudate-on-sheets thus formed into discrete elements.

With reference now to Figure 18, it will be seen that a roadway 140 is provided with a large retroreflective element 141. These elements 141 may on many highways, and in many applications, protrude upwardly above the road an amount T that may be 3/4 of an inch or more, as desired. The elements 141 are provided with an adhesive 142 for securement to the roadway 140. The elements 141 basically comprise a plurality of particles 143 embedded in a
shaped resin 144. The resin, like many of the other components of the present invention may be the same as is used in the process of Figure 15, to make the water-like structural coating 126 of Figure 16A, or of any other suitable, preferably transparent or substantially transparent coating material having a refractive index similar to that of water.

In Figure 18A, a structure 150 is provided, generally similar to that 141 of Figure 18, but having a hollow center 151.

In Figure 19, a structure generally similar to that of Figure 18 is provided, as an element 153, but, instead of having its retroreflective components 154 of the type of the minute flecks of sheet retroreflective material 141 as in Figure 18, the particles 154 in Figure 19 comprise half-silvered beads or the like. It will further be apparent that the particles, be they of the type 143 or the type 154, may be mixed, and a given element 141 or 153 may comprise either one, or the other style of retroreflective elements, or a mixture of both, as desired.

Figure 19A illustrates an element 155, that is generally similar to the element 153, but which has a hollow central portion 156.

Figure 20 illustrates an element 158, also with an adhesive 160 for securing the same to a road 161, but with the view of Figure 20 being taken through an elongated sheet of retroreflective material 162 that traverses substantially the entire element 158, and is upwardly extending, or perpendicular to the lower surface 163 of the element,
for returning light at the desired angle from a headlamp of an automobile or the like as has been discussed herein above.

Figure 21 illustrates a low profile road marker 170 that may readily be cast, molded, or extruded and then cut off into sections of the shape illustrated in Figure 21, as comprising a resin like all of those discussed with respect to Figures 16, 16A, and 18 through 21, in which there are embedded components 171. The components 171 may be like those 154, like those 143, like those 125, or of any suitable type, even those 162 discussed herein above. The markers of the type illustrated in Figure 21 may extend an inch or more above the road to which they are applied T', if desired, and may be four inches or more long, as indicated by the dimension L in Figure 21, as desired.

The several U. S. Patents identified herein, and the subject matter of the parent application of which the present application is a continuation-in-part are all herein incorporated by reference into the subject matter of this application. It will be apparent from the foregoing that various modifications may be made in the details of construction of the elements of the present invention, the materials from which such elements may be constructed, the materials with which the elements may be used, in application to roadways, signs or the like, and in the general utility of elements and coatings containing the elements, whether they be markings, signs, lettering or the like, as well as in the manners of manufacture and of application of elements and coatings.
embodying elements, all in accordance with the spirit and scope of the present invention as set forth in the appended claims.
CLAIMS
The Claims defining the invention are as follows:

1. A reflective coating for surfaces comprising a plurality of three dimensional shapes, a carrier for said shapes, said carrier comprising means for adhering said shapes to a surface to be coated, with at least a substantial portion of said shapes having at least one outer shape surface at least a portion of which is of retroreflective qualities and:
   a. projecting out of the carrier away from the surface to be coated an amount within the range of about 0.005 inch to about .250 inch;
   b. for defining an angular non-parallel relationship with the surface to be coated;
   c. comprising means for reflecting back toward its source light received thereon at an incident angle with the surface to be coated that is in the 45° to 90° range; and
   d. the exterior of which is of a refractive index similar to that of water, or within the range of about 1.338 to about 1.70.

2. The coating of Claim 1, wherein said means for reflecting back light is effective for light received at an incident angle with the surface to be coated that is in excess of 80°.

3. The coating of Claim 1, wherein the carrier is a solid of originally liquid composition.
4. The coating of Claim 3, wherein the carrier is a resin.

5. The coating of Claim 3, wherein the carrier is paint.

6. The coating of Claim 1, wherein said shapes are comprised of retroreflective sheet material originally of substantially flat surfaced sheet construction.

7. The coating of Claim 1, wherein said shapes are of three dimensional multiple surface geometric core construction, at least one surface of which is provided with retroreflective sheet material secured thereto.

8. The coating of Claim 1, wherein said shapes are of three dimensional multiple surface construction each comprising a multiplicity of reflective elements carried in embedded relation in a substantially light-transparent binder.

9. The coating of Claim 1, wherein said retroreflective qualities of said shape surfaces are comprised of a composite sheet construction including a layer of minute spheres of refractive index within the range of about 2.4 to about 2.95, disposed adjacent reflective means, and with said exterior of said shape surfaces comprising a coating or protective layer in which said minute spheres are partially embedded, sandwiched between said reflective means and protective layer.
10. The coating of Claim 1, wherein said retroreflective qualities of said shape surfaces are comprised of a composite sheet construction including a layer of minute spheres of refractive index within the range of about 1.8 to about 1.95 on a reflective layer, and with said exterior of said shape surfaces comprising a protective layer in which the minute spheres are not embedded, said protective layer being essentially spaced from the reflective layer and comprising a sandwich of said spheres between said reflective layer and protective layer.

11. The coating of Claim 1, wherein said retroreflective qualities of said shape surfaces are comprised of minute glass spheres that have reflective coating on portions of their surfaces and which have a refractive index within the range of about 1.9 to about 2.95 and which are embedded in a substantially transparent binder having a refractive index of about that of water, or about 1.338 to about 1.70.

12. A retroreflective element adapted for use in providing visible light reflection when applied to a surface even when the angle of incidence of light relative to the surface of use exceeds 45°, and even when the exterior of the element is water-wet, said element comprising a three dimensional shape the exterior of which includes a plurality of surface portions, at least some of which are angularly disposed in non-parallel relation relative to other surface portions thereof, at least one of said
element surface portions having a plurality of minute retroreflective components, said components being covered by a protective exterior covering having a refractive index similar to that of water, or within the range of about 1.338 to about 1.70.

13. The element of Claim 12, wherein at least a plurality of said element surface portions have a plurality of minute retroreflective components therein.

14. A highway safety aid in the form of a retroreflective element adapted for use in providing visible light reflection when applied to a surface even when the angle of incidence of light relative to the surface of use exceeds 45°, and even when the exterior of the element is water-wet, said element comprising a three dimensional shape the exterior of which includes a plurality of surface portions, at least some of which are angularly disposed in non-parallel relation relative to other surface portions thereof, at least one of said element surface portions having a plurality of minute retroreflective components, said components being covered by a protective exterior covering having a refractive index similar to that of water, or within the range of about 1.338 to about 1.70.

15. The safety aid of Claim 14, wherein said element surface portions are comprised of substantially flat surfaced retroreflective sheet material.
16. The safety aid of Claim 15, wherein said surface portions are in bent relation to other said surface portions to define at least two meeting co-joined generally planar surface portions.

17. The safety aid of Claim 15, wherein said element shape includes an interior having a geometric shape and having the retroreflective sheet material on surface portions thereof.

18. The safety aid of Claim 14, wherein said element shape comprises a three dimensional solid.

19. The safety aid of Claim 18, wherein said surface portions comprise sheet material on the surface of said solid.

20. The safety aid of Claim 18, wherein said components comprise individual retro-reflective particles embedded in said solid near the surface portions thereof.

21. The element of Claim 12, wherein said three dimensional shape further comprises three generally planar leg portions, each of double-faced retroreflective construction, with a common junction, and with said leg portions being angularly disposed relative to each other.

22. The element of Claim 21, wherein said three legs are angularly oriented approximately 180° apart.
23. The element of Claim 22, wherein each said leg is generally rectangular in side elevation.

24. The element of Claim 22, wherein each said leg is generally semi-circular in side elevation.

25. The element of Claim 12, wherein said element surface portions include a binder, and with said retroreflective components being embedded in said binder, and wherein said protective exterior covering comprises said binder.

26. The element of Claim 13, wherein said element surface portions comprise different portions of the same non-planar shape.

27. The element of Claim 13, wherein said retroreflective components include flecks of planar sheet retroreflective material.

28. The element of Claim 13, wherein said retroreflective components include glass beads, each with a reflective substance associated therewith.

29. The element of Claim 13, wherein said protective exterior covering has a refractive index within the range of about 1.40 to about 1.65.

30. The element of Claim 12, wherein said surface portions comprise different portions of the exterior of said
element and wherein said components are dispersed in said protective exterior covering, said element being of at least one-half inch in height.

31. A method of making three-dimensional retroreflective elements adapted for use in providing visible light reflection therefrom, comprising the steps of providing a plurality of strips of sheet retroreflective material, providing a continuous forming station, continuous joining the strips of sheet retroreflective material together, adhering them together, and continuous forming the joined sheets into an elongated, continuous structure, followed by severing the elongated structure thus formed into discrete elements by repetitive and serial severing of the structure into similar elements.

32. A method of making three-dimensional retroreflective elements adapted for use in providing visible light reflection therefrom, comprising the steps of providing a strip of sheet retroreflective material, continuously delivering the sheet to a forming station, continuously forming the sheet to an elongate trough-like configuration, applying into the trough-like configuration thus formed, a non-solid hardenable substance to which the sheet material will adhere upon hardening, setting the substance into a hardened structure, and repetitively and serially severing the structure into similar elements.
33. The method of Claim 32, wherein the substance is a heat-settable hardenable resin and wherein the step of allowing the substance to harden and set comprises applying heat thereto.

34. A method of making three-dimensional retroreflective elements adapted for use in providing visible light reflection therefrom, comprising the steps of providing sheet means of retroreflective material into a formed configuration capable of receiving a hardenable substance therein, extruding into the formed configuration a non-solid hardenable substance to which the sheet material will adhere upon setting, setting the substance into a hardenable structure, and repetitively and serially severing the structure into similar elements.

35. A method of making three-dimensional retroreflective elements adapted for use in providing visible light reflection therefrom, comprising the steps of providing a plurality of minute retroreflective components, providing the retroreflective components as an aggregate to a non-solid hardenable substance that is transparent to visible light, extruding a continuous elongate rod of the substance with retroreflective components dispersed therein beneath the rod surface thereof, with the extrusion step making a composite rod of predetermined cross-sectional structure followed by severing the elongated structure thus formed into discrete elements by repetitive and serial severing of the structure into similar elements.
36. The method of making a three-dimensional retroreflective element comprising the steps of providing a resin or like substance of a refractive index similar to that of water, or about 1.338 to about 1.70 in non-solid condition, providing a plurality of minute retroreflective components, interdispersing the components in the substance, and allowing solidification of the substance.

Dated this 5th day of December, 1975.

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