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(54) RETROFLECTIVE DEVICE AND METHOD OF MANUFACTURE THEREOF

(76) Inventors: **Ian I. Durant**, Lancashire (GB); **Richard H. Hughes**, Northwich (GB)

Correspondence Address:
WELSH & KATZ, LTD
120 S RIVERSIDE PLAZA
22ND FLOOR
CHICAGO, IL 60606 (US)

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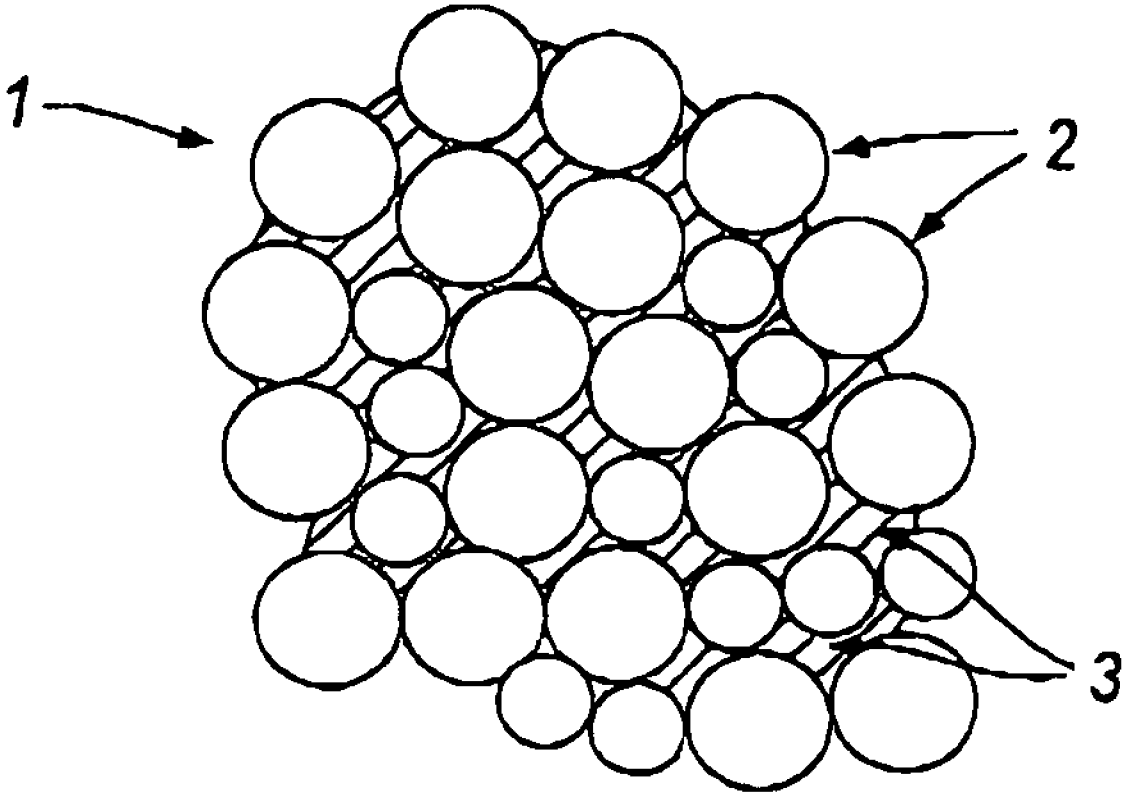
(57) ABSTRACT

A retroreflective device **1**, for use in creating a retroreflective surface, comprises an agglomeration of glass beads **2**, formed by binding together glass beads **2** of a specific size with an adhesive material **3**. Selected properties, for example refractive index, of each glass bead **2** are chosen in accordance with the desired retroreflectivity of the device **1**. The adhesive material **3** may be pigmented, thereby to colour light retroreflected from the device **1**. Preferably, the agglomeration of glass beads **2** is approximately spherical or ovoid and the glass beads **2** are approximately spherical. A retroreflective road marking coating may comprise a road marking material applied to the surface of a road and a plurality of the retroreflective devices **1** embedded in the road marking material so as to protrude partially therefrom. The retroreflective devices **1** may also be used with a coating from which they protrude so as to provide a road surfacing material.



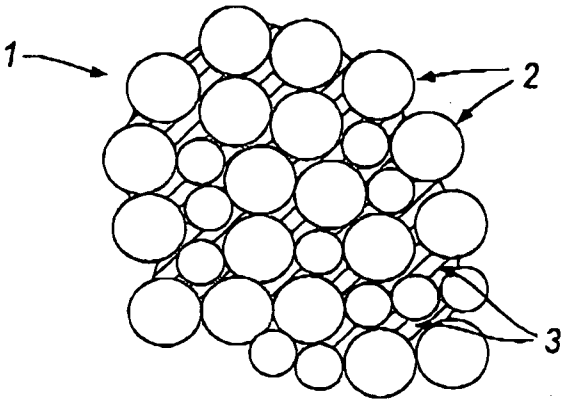



Fig.1

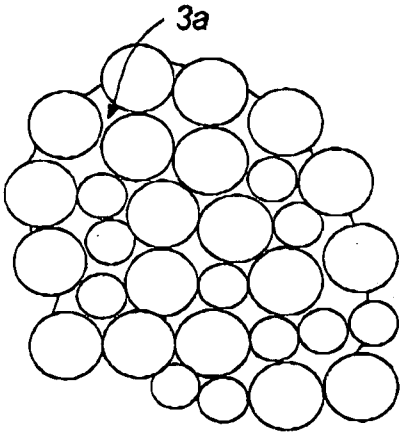



Fig.2A

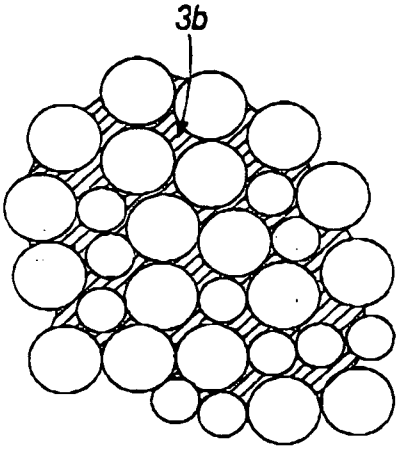



Fig.2B

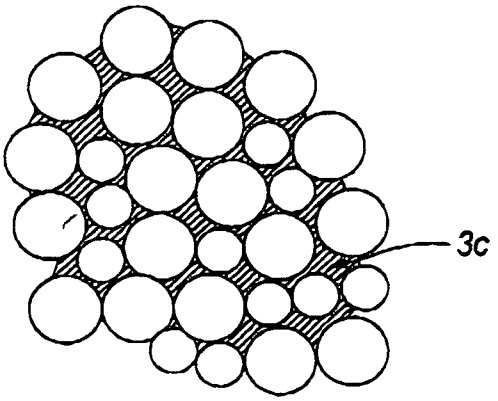



Fig.2C

# RETROFLECTIVE DEVICE AND METHOD OF MANUFACTURE THEREOF

[0001] The present invention relates to a retroreflective device for use in creating retroreflective surfaces, for example for use as reflective markings and delineators, and high visibility coatings for improving visibility of surfaces by increasing reflective characteristics, particularly but not exclusively on roads and road signs, and a method of manufacturing such a retroreflective device.

[0002] Markings for highway (road) marking are usually required to be reflective at night. Light emitted from vehicle headlights is reflected back in the direction of the source, i.e. retroreflected, from the surface of the marking or other reflective surface. The retroreflective characteristic of the marking material is typically improved by use of added retroreflective elements or devices. In road markings, spherical glass beads are often added to the surface of the marking during application, or sometimes premixed in the body of the marking material, and by this means the retroreflective characteristics are significantly improved over the natural reflective property of the marking surface. However, road markings are usually applied in locations likely to be exposed to traffic, i.e. contacted by vehicle wheels, and such contact leads to deterioration, through abrasion and other effects, of the reflective material, thereby reducing its retroreflective properties.

[0003] GB 2164762 (Potters) discloses a tetrahedron retroreflective device formed by passing a sheet between two rollers to press the tetrahedrons out of the sheet. Lines 43 to 53 of page 4 state that the spheres may be fabricated from some of the titanium glasses having a higher index of refraction or they may comprise spheres having varying indices with spheres located in the interior of the granules having an index of 1.5 and with the exposed spheres having an index of 1.9. Lines 81 to 89 on page 4 state that additional spheres may be applied to the surface having an index of 1.9 for high retroreflectivity with the interior having an index of 1.5 for rigidity and good wear resistance. However, when the exterior of the tetrahedron becomes worn, the high retroreflecting spheres disappear exposing the low index spheres thus reducing significantly the performance of the device.

[0004] U.S. Pat. No. 3,254,563 (Prismo) discloses reflecting devices with glass spheres on the exterior of binder material. No spheres are totally embedded. Thus when the glass spheres are worn off the device it has no retroreflectivity qualities. Lines 7 and 8 in column 2 refer to an installation in which the devices are covered with binder. In such installations it is said that high index spheres of 2.4 are required. Low index spheres though may be mixed with the high index spheres such that when the transparent covering binder is worn away to expose the spheres, these low index spheres may only then reflect light.

[0005] DE 19521847 (Cammann), U.S. Pat. No. 3,043,196 (Palmquist), U.S. Pat. No. 6,398,369 (Cleanosol), U.S. Pat. No. 5,942,280 (3M), EP 0322671 (Eigenmann) and U.S. Pat. No. 4,609,587 (Potters), all relate to retroreflective devices.

[0006] Accordingly, it is desirable to provide a retroreflective device which, when used in combination with a road marking paint or coating, will impart very good and consistent reflectivity characteristics and be durable under the action of traffic.

[0007] According to an embodiment of a first aspect of the present invention there is provided a retroreflective device for use in creating a retroreflective surface, which device comprises an agglomeration of glass beads.

[0008] Preferably, the agglomeration is formed by binding together glass beads of a selected size.

[0009] Advantageously, selected properties of each glass bead may be chosen in accordance with the desired retroreflectivity of the device, for example its refractive index.

[0010] Desirably, the glass beads are bound together by an adhesive material, for example epoxy resin, acrylic, polyurethane or a hot melt adhesive, or any other suitable adhesive.

[0011] The adhesive material may be pigmented, thereby to colour retroreflected light from the device.

[0012] The agglomeration of glass beads is desirably approximately spherical or ovoid and the glass beads are preferably approximately spherical. The diameter of the glass beads is preferably selected to be within one of the following ranges: from 100 microns to 700 microns or from 100 microns to 300 microns, from 200 microns to 400 microns, or from 400 microns to 700 microns. Larger beads may be used to form agglomerations, but the ranges specified are preferred sizes for the application.

[0013] The glass beads are preferably spherical and formed of good quality clear glass substantially free from faults and inclusions. They preferably exhibit a refractive index of 1.5, 1.9 or 2.1 or 2.3.

[0014] The spacing between adjacent glass beads may be less than

[0015] **2** times the diameter of the beads or less than 1 or less than 0.5.

[0016] There may be a ratio of glass beads to volume of binder of more than 1:10 or 2:10 or 4:10 or 6:10 or 1:1 or 1.5:1.

[0017] Each device may include more than 20 or 30 or 40 or 50 or 60 or 80 or 90 or 100 beads.

[0018] Retroreflective devices embodying the present invention can advantageously be used to enhance the reflectivity of road surfacing materials and road markings, including coloured road surfacing, traffic calming, etc.

[0019] The use of a pigmented adhesive or binder allows for coloured reflection of light depending on the type and properties of the pigment and binder/adhesive used. Retroreflective devices embodying the present invention, and which comprise pigmented adhesive or binder, have been found to exhibit far superior reflectance of colour when compared to known products. This beneficial property is due to a number of factors including: the use of glass beads of a specific quality/refractive index and of a predetermined uniform size, and the closely packed construction of the device, i.e. the glass beads are bound together in very close proximity. In addition to close packing of glass beads throughout the body of the retroreflective device, the glass beads on the surface of the bead cluster are also close packed thereby achieving optimum reflective performance and resistance to traffic and/or weathering. A retroref lective device embodying the present invention will therefore have

a high density of glass spheres on the surface which are in contact with a large surface area of colour thereby maximising the extent to which the colour of incident light will be modified by the device. This achieves far superior colour density and intensity of reflected light and is demonstrably better than known products comprising ordinary glass beads of various sizes simply embedded or partially embedded in a coloured binder.

[0020] According to an embodiment of a second aspect of the present invention there is provided use of a plurality of retroreflective devices embodying the first aspect of the present invention in combination with road marking material as a retroreflective road marking coating or road surfacing material.

[0021] According to an embodiment of a third aspect of the present invention there is provided use of a plurality of retroreflective devices embodying the first aspect of the present invention in combination with a binder material as a retroreflective surface dressing.

[0022] According to an embodiment of a fourth aspect of the present invention there is provided a retroreflective road marking coating comprising a road marking material applied to the surface of a road and a plurality of retroreflective devices embodying the first aspect of the present invention embedded in the road marking material so as to protrude partially therefrom. The retroreflective devices may be premixed or otherwise immersed in the road marking material.

[0023] According to an embodiment of a fifth aspect of the present invention there is provided a retroreflective surface dressing comprising a binder material coating the surface to be dressed and a plurality of retroreflective devices embodying the first aspect of the present invention adhering to the binder material so as to protrude partially therefrom.

[0024] According to an embodiment of a sixth aspect of the present invention there is provided a method of manufacturing a retroreflective device, which method comprises the steps of (a) forming a bed of glass beads of a selected size, and (b) introducing droplets of a binder material into the bed of glass beads so as to cause groups of the glass beads to bind together as the binder material hardens, or is cured, to form respective retroreflective devices, the size of the droplets being controlled in dependence upon the size of the glass beads so as to obtain a plurality of retroreflective devices in a preselected size range.

[0025] The binder material may be sprayed, with suitable droplet size, onto the bed of glass beads.

[0026] Preferably, the bed of glass beads is moved from a first position at which the binder material is introduced to a second position at which, after the binder material has set/cured, the retroreflective devices are removed from the bed and any loose beads are returned to the first position.

[0027] Reference will now be made, by way of example, to the accompanying drawings, in which:

[0028] **FIG. 1** shows a retroreflective device embodying the first aspect of the present invention; and

[0029] **FIGS. 2A, 2B** and 2C show respective alternative embodiments of the first aspect of the present invention.

[0030] As shown in **FIG. 1**, a retroreflective device **1** embodying the present invention is manufactured by binding a quantity of spherical glass beads **2** of a desired size with an adhesive **3** so as to form a spherical or ovoid agglomeration or cluster **1**, preferably 2 to 4 mm in diameter (although other sizes may be useful according to the application). The size of the glass beads **2** is preferably selected to be within one of the following ranges, from 100 to 700 microns or from 100 to 300 microns, from 200 microns to 400 microns, or from 400 microns to 700 microns diameter, although larger beads may also be used to form agglomerations where appropriate. The adhesive **3** may, for example, be epoxy resin, acrylic, polyurethane or hot melt adhesive. The cluster **1** of beads **2** so formed has retroreflective properties as its surface is made up of a number of glass spheres in close packed formation presenting a large number of reflecting elements. Light entering a bead **2** is reflected internally and re-emitted in the direction of the source. The light returning to the source (e.g. the vehicle) can be modified in colour by using a pigmented adhesive **3***a,* **3***b* or **3***c* to bind the beads **2**, as shown in **FIGS. 2A** to **2**C. The pigmented adhesive **3***a,* **3***b,* **3***c* forms a coloured backing to the glass beads **2**. Light entering the glass beads **2** is subject to internal reflection and allows some diffusion into the pigmented adhesive **3***a,* **3***b,* and **3***c*. By this means the light colour is modified by the effect of the pigmented adhesive **3***a,* **3***b,* **3***c* and is thus modified before it returns in the direction of the source. The adhesive material **3** may be pigmented with white, red, yellow, green, or indeed any strong colour, to produce a reflected colour as required. Alternatively, the glass may itself be coloured to modify the light, either by the chemical composition of the glass or by a suitable coating treatment. By this means the bead clusters **1** may be used in road markings and other road surfacing to produce a coloured appearance as an aid to driver safety and to provide information about road layout and possible hazardous situations.

[0031] The properties of the glass used to make the beads **2**, such as its chemical formulation, may be varied to achieve a greater degree of reflectivity. In particular, glass of different refractive index, for example values of 1.5, 1.9 and 2.1 or 2.3, may be used, since glass beads **2** manufactured from higher refractive index glasses return more light and therefore improve the retroreflective performance. Additionally, a mixture of glass beads of different refractive indices may be used.

[0032] Glass beads having a higher refractive index are relatively expensive compared to lower index beads. In one example a stock of high index beads of 2.3 and a stock of low index beads of 1.5 were kept. Different quantities from these two stocks were mixed in varying quantities to obtain devices having different illumination values. This obviates the need to keep a stock of beads having the specific index required to achieve the illumination values. For example, a mix of 20% by number of beads of a reflective index of 2.3 with a mix of 80% 1.5 beads may give a device having reflection of 200 milli candela, a mix of 40% of 2.3 and 60% of 1.5 a reflection of 400 milli candela and 80% of 2.3 and 20% of 1.5 a reflection of 800 milli candela. Furthermore, the required candela will remain even after wear of the product as the beads are closely packed throughout the device.

[0033] In order to obtain a retroreflective surface, a plurality of retroreflective devices **1** embodying the present invention are applied to the still liquid or semi-liquid surface

of a road marking material painted onto a road and become embedded in the surface so that they are anchored in the surface with a portion of each retroreflective device **1** protruding above the surface of the marking, such that the exposed part of the bead clusters **1** can become illuminated with light from head lamps of vehicles and reflect light back to the driver. The bead clusters **1** embedded into the surface are firmly held by the road marking material, the surface structure of each cluster **1** being textured by the presence of glass beads **2** so that the road marking material is absorbed into the textured surface of the cluster **1**, this keying effect increasing retention and strength of adhesion of the bead cluster **1**.

[**0034**] As mentioned above, the size of the cluster **1** is usefully in the range from 2 mm to 4 mm diameter; however, larger or smaller clusters **1** may be used in accordance with the thickness of the coating for which they are intended and the degree of embedment. Thus a road marking paint line nominally 500 microns in thickness could use clusters **1** in the size range 1 mm to 2 mm diameter, whereas a thicker line such as a thermoplastic road marking nominally 3 mm in depth would require clusters **1** of 4 mm to 6 mm diameter to be effective.

[**0035**] An alternative use of the retroreflective devices **1** would be in a road surface dressing, coloured road surfaces for hazard warning, or on vertical surfaces, for example safety barriers, road signs (vertical), etc. These applications would require a relatively low thickness of binder material to allow a large exposed area of reflective material. Such usage requires a particularly strong and durable binder to hold the clusters **1** to the substrate, for example (but not exclusively) two component materials epoxy resin, acrylic and polyurethane.

[**0036**] Unlike prior art road markings whose reflectivity is provided by individual glass beads and which therefore lose or change reflectivity as the beads become damaged or are dislodged from the surface due to the action of traffic, retroreflective devices **1** embodying the present invention comprise an agglomeration of mixed glass beads **2** having a multilayer structure which enables continuity of reflectivity by exposing a new, inner layer of glass beads **2** after the original outer layer of mixed beads **2** has been removed, for example by the action of road traffic.

[**0037**] The performance of the device is enhanced as the mixture of beads is present and evenly distributed throughout the device. As the resin is more readily worn away than the beads, as soon as one bead becomes detached the next bead is relatively quickly exposed as the resin wears away and remains exposed for some considerable time as the surface of the new bead is now exposed to the traffic and this will not wear anywhere near the same extent as the resin.

[**0038**] Rather than being applied on a surface, the retroreflective devices **1** can also be advantageously used as premixed additives to a road marking material, in a quantity proportional to the thickness of the coating to be applied, the devices becoming exposed as the road marking material wears away.

[**0039**] In a method of manufacturing a retroreflective device **1** embodying the present invention a small droplet of adhesive or binder material **3** is applied to a mass or bed of glass beads **2** and the binder material **3** is absorbed onto the surface of the beads **2** immediately surrounding the droplet. The binder material **3** is then cured and the resultant agglomeration or cluster **1** of glass beads **2** is separated from the uncoated beads **2**. The size of the binder droplet, physical properties of the binder material **3** (particularly is viscosity and cure rate) and the size/gradation of the glass beads **2** are key factors which determine the quality of the agglomeration of beads produced. Two examples of production methods are given below:

Method 1

[**0040**] A flat bed of glass beads **2** of mixed refractive index comprising 40% by number of 2.3 index beads and 60% by number of 1.5 index beads is produced and onto the surface is applied individual droplets of the binder material **3** using a suitable device **1** for generating controlled size of droplets. The droplet size and gradation of glass beads **2** will determine the size of bead clusters **1** produced, the agglomeration of beads **2** increasing in size if there is more binder **3** available. As the binder **3** flows from its point of application it will contact further layers of glass beads **2** and increase the size of cluster **1** formed. An example of a workable system is a glass bead size of nominal diameter 200 microns with a droplet size of 2 mm; this will agglomerate a quantity of beads **2** to produce a cluster **1** of size 3 mm to 4 mm diameter. The flat bed can be produced as a moving bed of beads **2**, for example on a moving belt, with binder **3** applied dropwise with a collection device **1** at a suitable distance to separate clusters **1** from loose beads **2**, the loose beads **2** being recycled back into the moving belt to enable a continuous process. The time between application of the binder **3** and the collection and separation process needs to be controlled to enable setting/curing of the binder **3** to a sufficient degree to allow handling of the product without damage or disruption to the agglomeration of beads **2**. The process of binder cure can be speeded up by, for example, the application of heat, allowing faster processing of the beads **2**.

Method 2

[**0041**] An alternative to the drop application method is to spray the binder **3** on to the surface of a moving bed of mixed refractive index beads comprising 20% of 2.3 index beads and 80% of 1.5 index beads by number of glass beads **2**. This may be advantageous in terms of droplet size, particularly if smaller diameters of droplet are required, for example less than 100 $\mu$m in diameter. It may also be advantageous in allowing faster production rates. Various spray devices may be used, for example air assisted atomisation, spinning disc (prilling), etc.

[**0042**] Thus, retroreflective devices **1** embodying the present invention have a retroreflectivity performance providing efficient retroreflection of incident light. When used in road marking or surfacing materials to increase visibility in low light or night-time conditions the devices have higher durability under traffic than the individual index glass beads or the varied concentration of different index glass beads used in the prior art, owing to the multi-layering of the mixed index glass beads **2** in the cluster **1** and the keying effect of the surface characteristics of the cluster **1**. Larger bead clusters **1** are likely to give extra visibility performance in so-called "wet night conditions", because the clusters **1** stand proud of the road marking line and are more visible when there is water on the road.

[0043] Attention is directed to all papers and documents which are filed concurrently with or previous to this specification in connection with this application and which are open to public inspection with this specification, and the contents of all such papers and documents are incorporated herein by reference.

[0044] All of the features Idisclosed in this specification (including any accompanying claims, abstract and drawings), and/or all of the steps of any method or process so disclosed, may be combined in any combination, except combinations where at least some of such features and/or steps are mutually exclusive.

[0045] Each feature disclosed in this specification (including any accompanying claims, abstract and drawings) may be replaced by alternative features serving the same, equivalent or similar purpose, unless expressly stated otherwise. Thus, unless expressly stated otherwise, each feature disclosed is one example only of a generic series of equivalent or similar features.

[0046] The invention is not restricted to the details of the foregoing embodiment(s). The invention extends to any novel one, or any novel combination, of the features disclosed in this specification (including any accompanying claims, abstract and drawings), or to any novel one, or any novel combination, of the steps of any method or process so disclosed.

What we claim is:

**1**. A reflective device for use in creating a retroreflective surface, including first refractive index beads, second, different, refractive index beads and binder, the binder holding the first and second beads together with the first and second beads being distributed throughout the device.

**2**. A device as claimed in claim 1 in which the beads are in close proximity to each other.

**3**. A device as claimed in claim 1 in which the spacing between adjacent beads is less than two times the mean cross-sectional dimension of the beads.

**4**. A device as claimed in claim 1 in which the ratio of the combined volume of the beads to the volume of the binder is more than 1:10.

**5**. A device as claimed in claim 4 in which the ratio is more than 6:10.

**6**. A device as claimed in claim 1 in which the combined number of first and second beads in the device is more than 20.

**7**. A device as claimed in claim 6 in which the combined number of first and second beads in the device is more than 40.

**8**. A device as claimed in claim 1 in which the first beads have a refractive index of more than 2.0.

**9**. A device as claimed in claim 1 in which the second beads have a refractive index of less than 2.0.

**10**. A device as claimed in claim 1 which is ovoid.

**11**. A device as claimed in claim 1 in which the first and second beads are from 100 to 700 microns in their mean cross-sectional extent.

**12**. A device as claimed in claim 1 in which the first and second beads are spherical.

**13**. Use of a plurality of retroreflective devices as claimed in claim 1 in combination with road marking material as a retroreflective road marking coating or road surfacing material.

**14**. Use of a plurality of retroreflective devices as claimed in claim 1 in combination with a binder material as a retroreflective surface dressing.

**15**. A retroreflective road marking coating comprising a road marking material applied to the surface of a road and a plurality of retroreflective devices as claimed in claim 1 embedded in the road marking material so as to protrude partially therefrom.

**16**. A reflective device for use in forming a retroreflective device including first beads having a refractive index of more than 2.0 and second reflection beads having a refractive index of less than 2.0 and binder, the binder holding the first and second beads together with the first and second beads being distributed throughout the device, the number of first and the number of second beads being selected to give the required refractive properties of the device.

**17**. A method of forming a reflective device having a retroreflective surface comprising determining the number of beads having a first refractive index and determining the number of beads having a second, different, refractive index in order to give a device having the required reflective properties and holding the beads together with binder with the beads being caused to be distributed throughout the device.

**18**. A method as claimed in claim 17 comprising stocking only first and second beads.

**19**. A method as claimed in claim 17 comprising choosing first beads having a refractive value of more than 2.0 and the second beads having an index of less than 2.0.

**20**. A method as claimed in claim 17 comprising binding more than 40 beads into the device.

**21**. A method as claimed in claim 17 comprising varying the reflective properties of at least two batches of devices by altering the ratio of first and second beads that are bound by the binder.

**22**. A method as claimed in claim 17 comprising dropping liquid binder onto the first and second beads and causing the binder to set.

* * * * *