A flashing reflector system in which at least one retro-reflective reflector having at least one wide angle area thereon is mounted on one side of a revolvable wheel member. When this assembly is revolved, a characteristic, highly visible flashing of retro-reflected light is produced which is visible over wide side angles relative to the revolving wheel member.
FLAS}ING REFLECTOR SYSTEM

RELATED APPLICATION

This application is a continuation-in-part of our earlier filed U.S. Pat. application Ser. No. 355,796 filed Apr. 30, 1973 and now abandoned.

BACKGROUND OF THE INVENTION

It has now come to be generally recognized that bicycles need to be equipped with reflective devices adapted to provide a reasonable level of recognition and identification at nighttime under illumination of the active headlamps of a motor vehicle over an extreme wide angle relative to the position of such headlamps to reflective devices associated with a bicycle in motion. One of the major deficiencies involving the use of prismatic reflectors on bicycles has been the narrow reflectance angle commonly associated with such devices.

Even though positioned on the side or rear of a bicycle, so-called "blind spots" were frequently left which made the bicycle operator more or less unprotected from the standpoint of the operator of a moving motor vehicle approaching a moving bicycle at night. Indeed, when presented at certain angles, bicycles equipped with older types of prismatic reflectors appeared to have no reflectors at all.

Recently, governmental authorities have recognized that reflectors can be manufactured which provide retrorefection at wide side angles up to about \( \pm 50^\circ \) or even more with respect to either side of a vertical thereto as compared with the previous retroreflectors of the molded plastic type which provided retroreflection at standard angles of only about \( \pm 30^\circ \) on either side of a vertical thereto.

BRIEF SUMMARY OF THE INVENTION

The present invention is directed to a flashing reflector system wherein at least one so-called wide angle retroreflector is mounted on a wheel member. A wide angle retroreflector used in this invention is preferably of single-piece, integral construction, and is typically formed of molded plastic. Such retroreflector is adapted to receive and retroreflect light rays reaching the reflector from any position within an extremely wide angle preferably ranging from at least about \( 30^\circ \) up to at least about \( 50^\circ \) or even higher on at least one side of the reflector relative to a vertical thereto.

The wheel member can be of any conventional type, but preferably is of the spoke type used generally on foot powered and two wheeled vehicles including bicycles, tricycles, motorcycles, and the like.

The system of the present invention is adapted to provide in combination with a vehicle a system which produces distinct, strong flashes of retroreflected light in various side regions around such vehicle as it moves. The system uses at least one wide angle retroreflective surface per wheel member, and preferably each side of a given wheel member has mounted thereon at least one retroreflective reflector having side viewability from at least one side thereof. Typically, each such wide angle retroreflective reflector comprises at least two wide angle retroreflective surface portions, one portion being retroreflective at an angle which diverges relative to the other thereof.

Fig. 1 is a side elevational view of a bicycle whose wheels have mounted thereon wide angle retroreflective reflectors;

Fig. 2 is a top plan view of one embodiment of a retroreflective reflector adapted for use in the present invention;

Fig. 3 is a vertical sectional view through the embodiment of Fig. 2 with diagrammatic lines showing representative paths of incident and reflected light beams striking such reflector;

Fig. 4 is a view similar to Fig. 2 but showing another embodiment of a retroreflective reflector adapted for use in the present invention;

Fig. 5 is a view similar to Fig. 2 but showing another embodiment of a retroreflective reflector adapted for use in the present invention;

Fig. 6 is a view similar to Fig. 2 but showing another embodiment of a retroreflective reflector adapted for use in the present invention;

Fig. 7 is a view similar to Fig. 2 but showing another embodiment of a retroreflective reflector adapted for use in the present invention;

Fig. 8 is a view similar to Fig. 2 but showing another embodiment of a retroreflective reflector adapted for use in the present invention;

Fig. 9 is a view similar to Fig. 2 but showing another embodiment of a retroreflective reflector adapted for use in the present invention;

Fig. 10 is a side elevational view of the reflector of Fig. 9 mounted on the spokes of a bicycle wheel adjacent the rim thereof;

Fig. 11 is a perspective view of a pin suitable for use in the manufacture of a centrally reflective prismatic surface in a retroreflective reflector of the present invention;

Fig. 12 is a top plan view of four pins of the type shown in Fig. 11 in an aligned configuration;

Fig. 13 is a top plan view of a single wide angle retroreflective reflector having integrally formed therein two wide angle reflective surfaces;

Fig. 14 is a plot in polar coordinates illustrating the type of characteristic patterns of retroreflectance achieved using the reflector of Fig. 13;

Fig. 15 is a top plan view of a retroreflective reflector having integrally formed therein left hand and right hand wide angle retroreflective surfaces and standard retroreflective surfaces;

Fig. 16 is a view similar to Fig. 15 but showing an alternative arrangement for the wide retroreflective reflector surfaces therein;

Fig. 17 is a plot in polar coordinates illustrating the type of characteristic patterns of retroreflectance achieved using either the reflector of Fig. 15 or Fig. 16;
FIG. 18 is a top plan view of a single wide angle retro-reflective reflector having integrally formed therein single wide angle reflective surfaces;

FIG. 19 is a side elevational view of a bicycle whose wheels have mounted thereon the wide retroreflective reflector of FIG. 18;

FIG. 20 is a vertical sectional view horizontally taken through the reflector of FIG. 18 with diagrammatic lines showing paths of incident and reflected light beams striking such reflector;

FIG. 21 is a schematic, diagrammatic representation of the type of light pattern generated when the reflector of FIG. 18 is revolved as on a wheel of a bicycle of FIG. 19 as respects the eye of a viewer located at a retroreflective viewing angle with respect to such revolving reflector;

FIG. 22 is a top plan view of a single retroreflective reflector having integrally formed therein left hand and right hand wide angle retroreflective surfaces and standard retroreflective surfaces;

FIG. 23 is a schematic representation of the reflector of FIG. 22 illustrating a series of orientation planes between 0° and 90°;

FIG. 24 is a side elevational view of one cube corner in a molded, transparent retroreflective reflector body made from a mold which is formed using the pins of FIGS. 11 and 12;

FIG. 25 shows plots in polar coordinate of the characteristic retroreflective light pattern produced by each of two different facet pluralities in a standard reflector body of the type having cube corners as illustrated in FIG. 24;

FIG. 26 is a series of plots in polar coordinates illustrating the manner in which the field of reflected light patterns change in a molded transparent reflector body as the axes of the pins employed are angled from a vertical position as illustrated in FIG. 25 to position inclined to the vertical;

FIG. 27 shows illustrative plots of intensity versus incident angle for a reflector of the type having both standard reflector facets (or surfaces) and wide angle reflector facets (or surfaces);

FIG. 28 is a plot illustrating the relationship between angle of reflected light and intensity of reflected light at such angle both horizontally and vertically for a combination of wide angle and standard reflectors in a single reflector body;

FIG. 29 is a plot in polar coordinates showing curves illustrative of the type of retroreflectance produced by a reflector equipped with one section of standard type retro-reflecive facets (or surfaces);

FIG. 30 is another plot in polar coordinates showing further curves illustrative of the type of retroreflectance produced by a reflector, such as the reflector of FIG. 22 equipped with two sections of standard type retro-reflecive facets (or surfaces), each section having a 180° opposite pin orientation relative to the other thereof, and with the wide angle reflective surfaces opaqued;

FIG. 31 is another plot in polar coordinates but showing curves illustrative of the type of retroreflectance patterns produced by a reflector equipped only with wide-angle retro-reflecive facets (or surfaces) produced by a reflector, such as the reflector of FIG. 22, with standard type retro-reflecive facets (or surfaces) opaqued and one wide angle side reflector opaqued as shown by the shaded lines in FIG. 22.

FIG. 32 is a plan view of a bicycle equipped with an illustrative embodiment of a retro-reflective flashing system of this invention, and

FIG. 33 is an isometric, diagrammatic view of the center plane of a wheel member illustrating the manner which a reflector used in this invention is positioned and mounted thereon.

DETAILED DESCRIPTION

Turning to the drawings, there is seen in FIG. 1 a bicycle 29 equipped with different reflector assemblies numbered, respectively, as 30, 31, 32, 33 and 34, each such reflector being a retroreflective reflector having at least one wide angle reflective surface or area. Reflectors 30 and 31 illustrate suitable positions upon the sides of a bicycle wheel member 27 or 28 respectively, where reflectors incorporating wide angle retroreflective surfaces may be positioned and mounted in the practice of this invention.

Referring to FIGS. 2 and 3, there is seen an embodiment of a retroreflective reflector suitable for use in the present invention which is herein designated in its entirety by the numeral 35. The reflector 35 is seen to comprise a panel 36 of light transmitting material, such as acrylic plastic, or the like. The panel 36 has an outer face 37 and an inner face 38, the inner face 38 being in generally spaced relationship to the outer face 37. The panel 36 has an imparted, circumferentially extending flange 39 formed about the periphery thereof. Flange 39 abuts against a flat base member 41 which has spaced, parallel faces, and which is opaque, the base member 41 being conveniently formed of an opaque plastic material, such as an ABS resin, or the like. The rim of flange 39 is conveniently secured to the base member 41 by any convenient means, such as sonic welding, adhesive, or the like, as those skilled in the art will appreciate.

The outer face 37 of panel 36 is generally smooth, generally continuous, and generally flattened, but the inner face 38 thereof has formed therein a plurality of retroreflective prismatic surfaces. This plurality of prismatic surfaces is arranged into at least three zones or areas in the inner face 38, these zones being numbered for identification purposes as 42, 43, and 44.

Zone 42 comprises prismatic surfaces adapted both to receive and to retro-reflect parallel rays of light striking the outer face 37 at a first zone angle with respect thereto ranging from about 60° up to about 90° (90° being vertical 47, commonly alternatively expressed as 30° on either side of vertical 47). The included angle marked 46 in FIG. 3 illustrates a first zone angle of about 60° to 90° (or 30° to either side of the vertical axis 47 of reflector 35).

Zone 43 comprises prismatic surfaces adapted to receive and to retro-reflect parallel rays of light striking the outer face 37 at a second zone angle with respect thereto, ranging from about 20° to about 75° (preferably from about 30° to 75°), 90° being vertical 47 as before, commonly alternatively expressed as 70° to 15° on either side of vertical 47.

Zone 44 comprises prismatic surfaces adapted to receive and to retro-reflect parallel rays of light striking the outer face 37 at a third angle with respect thereto, which is complimentary with, and opposed to, the second zone angle. Thus, parallel rays of light strike the outer face 37 of the zone 44 at a third angle ranging from about 20° to about 75° (preferably from about 30° to about 45°).
to 75°) and reflect retroreflectively such incident rays back.

Those skilled in the art will appreciate that a reflector 35 may contain more than three zones of prismatic surfaces. For example, in FIG. 4, there is seen a reflector designated in its entirety by the numeral 48 which is similar to the reflector 35 except that the reflector 48 has two sets of central prismatic reflector areas designated, respectively, as 49 and 51, and four wide angle or side reflector areas designated, respectively, as 52, 53, 54 and 55. The reflector areas in FIG. 4 which are viewable from the left-hand side (when frontally viewing a reflector 48 as shown in FIG. 4) are the reflector areas designated 53 and 55 which are marked by a left pointing arrow; similarly, the reflector areas viewable from the right-hand side are the reflector areas numbered 52 and 54 which are marked with a right pointing arrow. Such an arrow scheme for the side viewable reflector areas is also employed in each of FIGS. 5 and 6 for the reflectors 57 and 58, respectively, in these FIGS. 2, 7, as well as in FIGS. 8, 9, 13, 15, 16, 18 and 22. Those skilled in the art will appreciate that it has heretofore been common in the retroreflective reflector art to employ one or two zones or areas of reflex reflectors, such as 49 and 51, for central or so-called standard viewing. Sometimes, one may slightly curve outwardly the central portion or area of such a reflector, such as is shown, for example, in FIG. 3, in an effort to avoid a problem of specular reflection, as those skilled in the art appreciate, but usually these areas are flattened.

While a wide angle reflector area, such as areas 43 and 44 in reflector 35 of FIG. 2, commonly has side viewing angles, such as included angles 59 and 61, as shown in FIG. 3, for left side and right side reflection, respectively, it is sometimes desirable to intensify the retroreflected light from each of these regions or angles 59 and 61, and such an intensification is achieved by using the two sets of side reflector areas 52, 53, 54 and 55, such as illustrated in the reflector 48, areas 52 and 54 being like area 43 but totalling together a larger surface area than area 43, and areas 53 and 55 being like area 44 but totalling together a larger surface area than area 44.

In place of the circular configuration employed in the reflector 35 and in the reflector 48, one can use an elongated arrangement, such as is illustrated by the reflectors 57 and 58. Reflectors 58, for example, is adapted for affixing to the front, rear or sides of a bicycle, especially the wheels thereof. The reflective device 58 is suitable for mounting so that a plane corresponding to its reflective surface (which is perpendicular to its zero optical axis or perpendicular) is parallel to the center plane of the wheel or a plane tangent to the conical spoke cage on either side of the wheel. Such a wheel side mounted reflective device is preferably adapted not to interfere with any wheel adjustment or to cause or aggravate wheel imbalance. The reflector 57 is suitable for use on the side, front or rear of a bicycle, as well as on the wheels thereof, as shown by the curved, longitudinal, peripheral edge thereof.

Reflectors, such as 35 and 48, are each adapted for use as side, front or rear reflectors in addition to wheel mounting, with reflector 48 being a preferred embodiment. Preferably such a mounted reflector 35 or 48 is not obscured by a cyclist or his clothing.

FIGS. 7 through 10 illustrate various other embodiments of reflectors of the present invention. These embodiments demonstrate that one can combine into a single reflector suitable for use in the teachings of the practice of the present invention at least two different reflecting areas (zones), a central zone and a pair of side zones (or wide angle zones), the latter being opposed as respects each other so as to permit a given reflector to be viewable from an extreme angle on opposed sides of a reflector.

The side reflecting zones (or wide angle zones) may be definable as separated or adjacent regions, or the side zones can be continuous with the differences defining two zones being apparent by the angle at which light striking such a zone is retro-reflectively reflected. For example, in FIG. 8 the side reflector is in the nature of segmented disk which continuously extends circumferentially about a centrally located, centrally retro-reflective reflector element. In this FIG. 8 embodiment, the segments define two different zones when viewed from opposed complimentary sides of the reflector shown, as shown by the arrows.

The central, or so-called standard retroreflective, reflector region is preferably centrally located in a reflector body used in this invention if such surfaces are present. The arrows in FIG. 7 indicate side viewability as is done in FIG. 4.

To enhance side (wide angle) viewability, the size (wide angle) of the side viewable reflector of the present invention may be enlarged, as has been done, for example, in FIG. 9 at the expense of the centrally viewable (standard) area. A circular type of reflector, such as shown in FIG. 9, may be mounted on a bicycle wheel as shown, for example, in FIG. 10.

The side viewable (wide angle) reflector regions may be slightly spaced from the centrally viewable reflector regions, as is illustrated, for example, in FIG. 7. Alternatively, the side viewable (wide angle) reflectors may be mounted in a circumferentially spaced but adjacent relationship such as is illustrated in FIG. 8, the respective reflector assemblies of FIGS. 7 and 8 each being adapted for use on a bicycle wheel, as for mounting on the spokes, or the like, using the clips shown on opposed side regions thereof.

As indicated above, it is preferred to use a centrally viewable reflector region (or zone or grouping) which has a viewing angle of approximately 30° on either side of the vertical. The side viewable reflector regions (or zones or groupings) are then chosen to have preferably viewing angles of from at least about 56° on up to at least to some angle, such as about 56°, 75°, etc., so as to complement the centrally viewable (standard) reflector.

In accord with the teachings of this invention, when a reflector with wide angle, side viewable reflector regions as described herein is mounted on a wheel, and such reflector is rotated with the wheel, the reflector seems to flash as each individual zone or grouping of reflecting surfaces comes into a position where it reflects light towards the eye of the viewer as that zone rotates on the wheel. The effect is to heighten the ability of a reflector used in this invention to be visible (detactable) to the eye of a viewer, such as a motorist in an approaching automobile as respects a bicycle.

Reflectors used in the present invention wherein three different zones of reflectors are formed in the inner face of a light reflecting panel of light transmi-
ting material are made in molds. As those skilled in the art appreciate, the centrally viewable reflecting zones employed in the reflectors used in the present invention are made in a mold formed by using a hexagonally sided pin formed of steel, or the like, of which the pin shown diagrammatically in FIG. 11 is illustrative. Such pins currently commercially available typically have a dimension of about 0.094 inch from one flat side to the next. Such a pin is ground on one end thereof so as to have three faces defined about a common axis 60. Each face has a polished surface, as those skilled in the art will appreciate.

The side viewing elements may likewise be formed of hexagonally shaped pins. After making side viewable and centrally viewable pins, the pins are set up into a configuration as desired and mounted together into a bundle with the aid of a pin clamp. After the completion of such a clamping operation, it is convenient to electroform a mold having a reflecting-forming surface over the clamped pins, the clamped pins serving as a master element for the electroforming operation. The electroforming operation is typically carried out by using stainless steel pins and nickel or the like as the electrodipositing metal, so as to be able to remove the electrodiposited metal from the master, and thereby to permit re-use of the master to permit separation of the electrodiposited metal from the pins easily and conveniently. After the master is removed, and the resulting nickel die has been built up with a backing to a thickness as desired, a die may be shaped and machined. Thus, one can prepare separate dies for the centrally viewable reflector prismatic surfaces and separate dies for the side viewable surfaces. Finally, the three different types of elements, if all are to be used in a single reflector, are assembled into a mold, and reflectors are made therefrom.

The relationship between a group of facets in a conventional so-called standard retroreflective reflector (which, characteristically, is considered to be adapted to retroreflect impinging incident light over angles of about ±30° usually horizontally), and a group of facets in a conventional so-called wide-angle retroreflective reflector (which, characteristically, is considered to be adapted to retroreflect impinging incident light over angles ranging from not less than about 30° of up to at least about 45° in one direction, usually horizontally) is illustrated, for example, by FIGS. 11, 12 and 24 through 28. In the manufacture of retroreflective reflector elements of such conventional types, which are incorporated into the systems of the present invention, a plurality of so-called pins 70 may be employed. Each pin 70, as shown here, is hexagonally shaped. The transverse distance between pin 70 flat sides is variable, but is typically of the order of about 0.094 inches, while the distance between opposing edges is also variable, but is typically of the order of about 0.108 inches. Three facets 71, 72 and 73 are formed at the forward end of each pin 70. Each facet 71, 72 and 73 traverses two sides of the hexagonal pin 70 and has an apex coinciding with the axis 60 of each pin 70. Each facet 71, 72 and 73 has an angle relative to the axis 74 of about 35° degrees.

To make a reflector, a plurality of pins 70 are arranged with their respective faceted heads grouped into a pattern, such as shown, for example, in FIG. 12, and an electroform mold, or the like, is made therefrom, as indicated above, using such pin pattern. An electroform mold is currently made, as indicated, by electroplating nickel or the like onto and over a pin pattern. In such process, the high points and the low points, respectively, over such a group of pins 70 are reversed in mirror image fashion in the product electroform mold over their respective positions in the pin 70 pattern, as those skilled in the art will appreciate. From the product mold, a transparent, plastic reflector element is moldable. A section through one molded facet in a resulting reflector so made is shown, for example, in FIG. 24.

When such reflector body having such a plurality of individual facets, such as shown, for example, in FIG. 24, is caused to retroreflect incident light, a characteristic plot of reflectance angle versus light intensity results, such as illustrated by the solid line 68 in polar coordinate plot shown in FIG. 25. If one rotates the pins 70 of FIG. 12 through 180° and makes a mold, and then a reflector, such reflector has a pattern of reflected light, such as shown by the dotted line 69 of FIG. 25. However, when one tilts the axis 60 of each pin 70 (see FIG. 11) of a plurality thereof arranged in a pattern or assembly such as shown, for example, in FIG. 12, from the vertical position shown in FIGS. 11, 12 and 24 through increasing angles of common inclination relative to pin axes 74, there is produced a family of characteristic plots of reflectance angle versus light intensity, such as shown in FIG. 26, each succeeding plot 76, 77 and 78 representing a greater common inclination angle for each of a group of such pins 70, which are electroformed into a mold, and then the mold used to make a reflector body. When one tilts the axes 60 of such a plurality of such pins 70 in the opposite direction, there is then produced a changing family of characteristic curves 76, 77, 78, like those in FIG. 26, but reversed by 180° (not shown). The plots of FIGS. 25 and 26 are not for any specific reflectors, but are given herein to illustrate the known principles involved.

When one combines into a single reflector body both the type of reflex reflectance shown in FIG. 26 with the type shown in FIG. 25, there is produced in a single reflector body both such types of reflex reflectance. The reflector area shown in FIG. 25 is sometimes known as "standard" reflectance, which has a characteristic maximum reflectance value generally at 90° and which retroreflects incident light at an angle of about ±30° on either side of a vertical or perpendicular thereto. The reflection area shown in FIG. 26 is sometimes known as "wide angle" reflectance, which has a characteristic maximum reflectance value which can range very widely as from about 10° to 88° on one side of a perpendicular thereto, though values between about 25° and 70° are particularly and preferably useful. Such a reflectance as shown in FIG. 26 retroreflects incident light through extreme angles on one side of a vertical thereto, typically from about 8° to 88°, though values between about 30° and 50° are currently commercially particularly and preferably useful. To achieve horizontal side (wide angle) viewability in both left and right directions, of course, two different groupings of preferably identical wide angle facets are commonly used, one group having pin axes vertically relative to the other.

A combination reflector body including both standard and wide angle reflectance displays a characteristic plot of retroreflectance angle versus reflected light intensity, as shown, for example, in FIG. 27 by illustra-
tive curves 79, 80 and 81 wherein the curve 80 is produced by a combination of both of the so-called "standard" retroreflective facets (surfaces) sensitive to light on the left side of the ordinate 82 (such as in FIG. 27), and the curve 81 is produced by the so-called wide-angle retroreflective facets sensitive to light on the right side of the ordinate 82. If, for example, the number of standard facets in a given reflector is increased, the amount of reflected light therefrom increases, and there is produced a reflectance curve, such as, for example, the dotted curve 83. If, for example, both the number of wide angle facets and their respective angles of inclination are increased equally for both right and left members, the type of dotted reflectance curves 84 and 85, respectively, result. For example, current U.S. federal government standards for a bicycle reflector comprising such a combination of left and right angle reflector facets in further combination with standard reflector facets are illustrated in FIG. 28 where, for specific degrees of reflectance horizontally or vertically measured, a corresponding intensity in candlepower per foot candle of reflected light is indicated. By combining different pin groupings at different respective pin axis 60° angles, as those skilled in the art will appreciate, one can produce an almost unlimited gradation of retroreflectance characteristics in a given retroreflector, so that any given desired reflector type, or set of reflectance characteristics, can be produced in a given reflector by one skilled in the art within the limitations of pins, materials of construction, design standards, and the like, using known technology.

In FIG. 29 is shown in polar coordinates a family of curves showing retroreflected light characteristics for one embodiment of a standard retroreflector wherein a plurality of pins (and, consequently, facets molded in the back of the reflector surface) are oriented in the manner shown, for example, in FIG. 12. Observe that, in the region next to the origin, a small zone of 100 percent reflectivity is provided, and, as one moves radially outwardly, the percentage (or efficiency) of retroreflectance drops, as shown.

In FIG. 30 is shown a family of retroreflected light curves in polar coordinates for another embodiment of a standard retroreflector, such as the reflector of FIG. 22, which is equipped with two sections of standard type retroreflective facets, each section having a 180° opposite pin orientation relative to the other thereof, but wherein, for present purposes, the wide angle reflective surfaces thereof (marked with the arrows shown in FIG. 22) are opaqued. Each of the two different groups or sections are each comprised of a plurality of pins (and, consequently facets). One such section of pins (or facets) is oriented as shown in FIG. 12, while the second such section is oriented as though the FIG. 12 pins had been rotated through 180°. Observe that, with this type of construction, the characteristic curves produced by one such section as shown in FIG. 29 is changed to that shown in FIG. 30. This change is caused by retroreflected light patterns produced from the effectively superimposed curves from each such single section. Observe that, just as in the case of FIG. 29, a small region of 100 percent reflectivity exits near the origin, and that the percentage (or efficiency) of retroreflected light drops as one proceeds radially outwardly away from the origin.

In FIG. 31 is shown in polar coordinates a family of curves of retroreflected light for one embodiment, such as the reflector of FIG. 22, of a particular wide angle retroreflective surface which is side reflective in one direction only. Here, (see FIG. 22 shaded lines), the standard type retroreflective facets are opaqued together with the wide angle facets which retroreflect towards one side or direction, leaving only side reflective facets for one direction only. Observe that 100 percent retroreflectivity is obtained in this embodiment at two small regions each inclined at an angle of about 15° with respect to the horizontal and at an angle of about 35° with respect to the vertical. The percentage of retroreflectivity decreases with increasing angles of incident light from 35°. Observe that retroreflectance is here achieved over a wide range of from about 6° through about 77°, in the particular embodiment shown in FIG. 31, but is more efficient in the range from about 15° to 55° in terms of percentages of retroreflected light, and is most efficient between about 30° and 40°.

When a reflector whose reflected light pattern is as illustrated in, for example, FIGS. 29 and 30, is mounted upon the side of a revolving wheel member parallel to the center plane thereof only slight relative variations in the intensity of retroreflected light occur from the standpoint of a viewer situated within the retroreflective viewing angle associated with such a reflector, regardless of reflector position on the wheel member, so that, as a wheel rotates, a more or less constant source of reflected light is viewed by such a viewer. On the other hand, when a reflector whose reflected light pattern is as illustrated in FIG. 31 is mounted upon the side of a wheel member parallel to the center plane thereof, and such wheel member is rotated, the light pattern emitted retroreflectively by the reflector is only intermittently seen by a viewer situated within retroreflective viewing angles of the reflector body. As a consequence, such viewer sees a flashing source of retroreflected light caused by the fact that the retroreflective surface moves into and out of such viewer's line of vision on a continuing and regular basis as the wheel rotates. A wide angle, side viewable, retroreflective surface mounted on a rotating wheel as indicated thus produces a characteristic flashing effect not possible with a standard reflective surface mounted substantially parallel to the center plane of the associated wheel member.

If one equips, for example, each wheel 81A and 82A of a bicycle 80A with a single side viewable, wide angle, retroreflective reflector 83A and 84A respectively (see FIGS. 18, 19 and 32) in such a manner that a perpendicular 85A and 86 to the center plane (not shown) of each wheel 81A and 82A, respectively, is perpendicular to each such wide angle reflector 83A and 84A on each wheel, each such reflector 83A and 84A is side viewable over a relatively wide viewing angle, such as angles 87 and 88 in FIG. 32. Commonly, such an included angle 87 or 88 can be from about ±60° to 70° on either side of such a vertical or perpendicular 85A or 86, relative to the center plane of each wheel member 81A or 82A of the bicycle 80A. For example, referring to FIG. 19, reflector 83A is adapted to retroreflect incident light up to about 70° on one side of vertical 85B (see FIG. 32). A similar situation prevails upon the respective opposite sides of the wheels 81A and 82A of bicycle 80A.
The manner in which light is retroreflected from such a wheel 81A or 82A having a reflector 83A or 84A, respectively, so mounted thereon is illustrated, for example, in FIG. 21. Light within a viewing angle of, for example, from about 20° to 70° for such a reflector is retroreflected to one side of such a wheel in a transversely continuously expanding three-dimensional viewing zone 89 which revolvably moves through space at a rate corresponding to the associated wheel rotational speed. As the zone 89 sweeps past an eye 90 of a viewer angularly so situated as to be within the viewing zone 87, the reflected light in the zone is viewable by eye 90 for a brief interval of time, producing a flashing effect upon eye 90. It will be appreciated that, for any given wheel/reflector combination, the position of the zone 89 is dependent upon the orientation and the angle a given reflector is mounted upon its associated wheel member. Preferably, these variables for a given wheel/reflector assembly are so chosen that a minimum area of potentially constant or continuous retroreflection exists relative to the side of a given wheel of a wheel/reflector assembly of this invention as such given wheel rotates; in other words, the angle of potential overlap produced near the region of a projected wheel axis as a zone 89 rotates is minimized.

Because of the peculiar, unique retroreflective light patterns generated by wide angle reflectors, they produce distinct flashing effects when mounted on a rotating wheel member not common to standard reflectors mounted substantially parallel to the center plane of the associated wheel member. While the present invention may be practiced using reflectors which contain one or more combinations of standard and wide angle reflector areas, as in a single molded reflector body, a given reflector body for use in the present invention always contains at least one wide angle reflector area, regardless of how such body is mounted on the side of an associated wheel member.

To secure a reflector containing a wide angle retroreflective area of facets (surfaces) to a spoke wheel member, mounting means is provided. Usually, a reflector has a backing member or base member, such as member 41 of reflector 35 (FIG. 3). This backing member 41 is conventionally provided with any one or more of a variety of spoke mounting means adapted for mounting a reflector assembly to a spoke wheel member of the type commonly found on bicycles and the like, including clips (see FIGS. 7 and 8) or snaps (see FIG. 20).

FIG. 33 illustrates the relationship between a wheel member and a reflector used in this invention. Thus, a wheel member (not detailed) characteristically has a center plane 92 and a reflector such as reflector 93 of FIG. 22, is mounted on such wheel member so as to be substantially parallel to the center plane 92. Each wide angle reflective area 94 and 95 therein (not detailed in FIG. 33) has a mid region of maximum retroreflectance which occurs generally as straight line, such as lines 96 and 97. Each line 96 and 97 projects obliquely outwardly from the reflective surface of reflector 93 at an angle 99 and 100, respectively, somewhere in the range from about 20° to 70° with respect to a perpendicular 98 to reflector 93. In any given embodiment, the angles 99 and 100 are determined by three primary variables: reflector pin angle, angular position of a reflector relative to a wheel’s center plane, and reflector orientation relative to a wheel’s center plane. In the present invention, a particular flattened wide angle reflector area mounted on the side of a wheel is so positioned as to be substantially parallel to the wheel center plane with the flattened face of the wide angle reflector area facing generally outwardly and sideways from the wheel. Owing to wheel construction, as those in 35, in the art will appreciate, as a practical matter, it is sometimes difficult to make the wide angle reflector area extend truly parallelly to the center plane of the associated wheel member as the wide angle reflector area is mounted on the side of a wheel member. Thus, for example, a spoke wheel member of the type commonly used on two wheeled vehicles, such as bicycles, or the like, can tend to produce a slight angular deviation of the flattened face of a wide angle reflector area relative to the center plane of a wheel as the wide angle reflector incorporating such area is mounted on such wheel member so that the flattened reflector face (with the wide angle reflector area therebehind) is not truly parallel to the center plane of the wheel. For this reason, it is possible that a given wide angle reflector area relative to a given associated wheel member may be inclined at an angle relative to the center plane of such wheel. This angle may be as much as about 20°, though preferably such an angular deviation is not more than about ±15° and most preferably is no more than about ±10° at most. Most preferably, this wide angle reflector area is substantially parallel to the center plane in practicing this invention.

In a practical use situation as those skilled in the art will appreciate, the exact attitude and angular position of a particular wide angle reflector area relative to the side of a particular wheel member center plane is determined by a number of variables. It is a distinct feature of this invention that the special attributes of a system of this invention as explained herein are not particularly altered for purposes of the present invention by such non planar angular deviations as just indicated between a wide angle reflector area and its flattened frontal face relative to the center plane of an associated wheel member.

A reflector 93 which is like reflector 93 (see FIG. 33) can be so mounted relative to center plane 92 that a straight line such as 96' from one area such as 94 thereof (see FIG. 22) extends generally parallelly to any plane, such as plane 101, which passes through the center 102 of said wheel member, and center plane 92 thereof, and which also is perpendicular to said center plane 92.

Reflector 93 has a first and a second wide angle reflective area therein. Each has a mid region of maximum retroreflectance lying along a straight line which projects obliquely outwardly from the reflective surface of reflector 93 at a substantially identical angle with respect to a perpendicular to said reflector, though these angles may differ if desired. Each straight line extends in a diverging direction from the other, but these lines could extend in the same direction if desired. Both such lines in reflector 93 lie in substantially the same plane, but they need not, if desired. A given reflector can contain more than two wide angle areas, if desired.

In summary, the present invention relates to apparatus for producing a light flashing effect. The invention utilizes a retroreflective reflector which is characterized by having a generally flattened configuration, a wide angle reflective area therein, and a mid region of
maximum retroreflectance for said wide angle reflective area therein. This reflective area of maximum retroreflectance occurs generally along a straight line which projects obliquely outwardly from the reflective surface of said reflector at an angle in the range from about 20° to 70° (preferably about 30° to 60°) perpendicular to said reflector. Wheel members used in this invention can be of any convenient type.

The invention involves the steps of mounting such a reflector on one side of a wheel so that the wide angle reflective area thereof extends generally parallelly to the center plane of said wheel member, and then rotating said resulting wheel member in the presence of light incident on said one side. The apparatus of this invention involves the assembly of such a reflector being so mounted to one side of a wheel member.

In one mode, such a reflector is so mounted that such straight line projects generally parallelly to any plane which passes through the center of such wheel member and which also is perpendicular to such center plane. In such mode or another, one can, and preferably does, employ a second such wide angle reflective area along with the first, which can be in the same reflective body or a second. Thus, a reflector can have both a first and a second wide angle reflective area therein. Such second area has a mid region of maximum retroreflectance according generally along a second straight line which projects obliquely outwardly from the reflective surface of such reflector at a second angle preferably in the range from about 30° to 60°. This second angle can be substantially equal to said first angle with respect to a perpendicular to said reflector, or such second angle can be different from said first angle.

The said second straight line can extend in a diverging direction from said first line, and can lie substantially in the same plane as said first line. Preferably, one uses a spoke wheel member, and the combination of wheel and reflector(s) is operatively mounted in a bicycle or the like. Preferably a wheel member has at least one such reflector on each side thereof, which may be mounted back-to-back, for example, across the wheel spokes.

Other and further embodiments and variations of the present invention will become apparent to those skilled in the art from a reading of the present specification taken together with the drawings and no undue limitations are to be inferred or implied from the present disclosure.

We claim:

1. An assembly for producing a light flashing effect comprising in combination