

[54] **LIGHT CONTROL DEVICE**

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[51] Int. Cl. **F21v 11/02**

[58] Field of Search..... **240/46.31, 46.33, 46.35, 240/41.35 R, 41.35 C, 41.35 D, 41.36, 240/103 R, 106 R, 78 LK; 340/74, 84; 350/259, 276**

[56]

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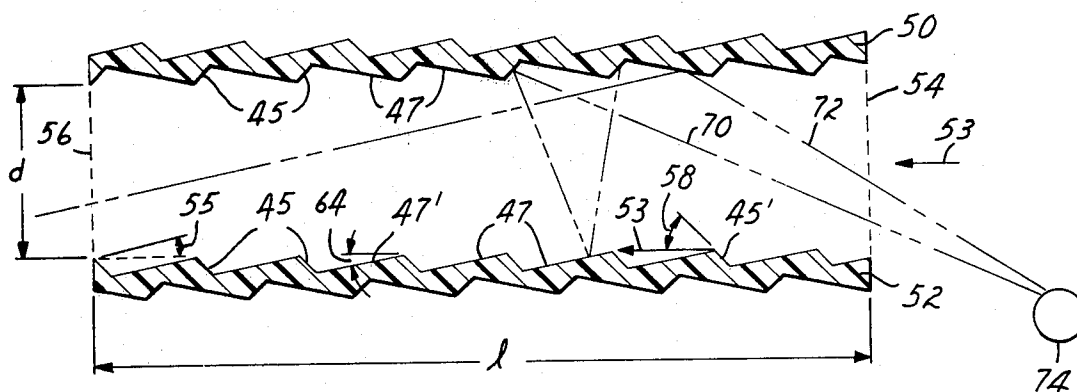
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[57]

ABSTRACT

A light control device especially suited for use in traffic signal lights, having at least a pair of opposing light control elements defining an unobstructed channel, each of which elements comprises a series of broad, specularly reflecting surfaces alternately facing the input and output ends of the device. In one embodiment, the device comprises a plurality of vanes positioned parallel to each other, in which each vane has on a major surface thereof a plurality of planar specularly reflecting surfaces alternately facing the input and output ends of the device. The input facing surfaces are disposed at an angle such that light rays diverging from a given direction at an angle in excess of a given angle are obstructed. The output facing surfaces are positioned at an angle such that some divergent rays may be redirected, hence adding to the light output within the allowed divergent limits, while also cooperating with the input angled faces to block outward reflections of other divergent light rays. When used in a traffic signal device, side reflections are minimized, thus thwarting drivers outside controlled lanes, who would use such side reflections to anticipate signal changes.

14 Claims, 5 Drawing Figures



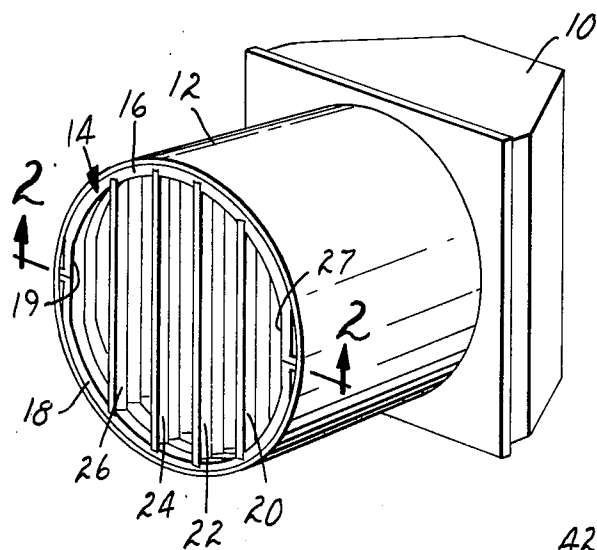


FIG. 1

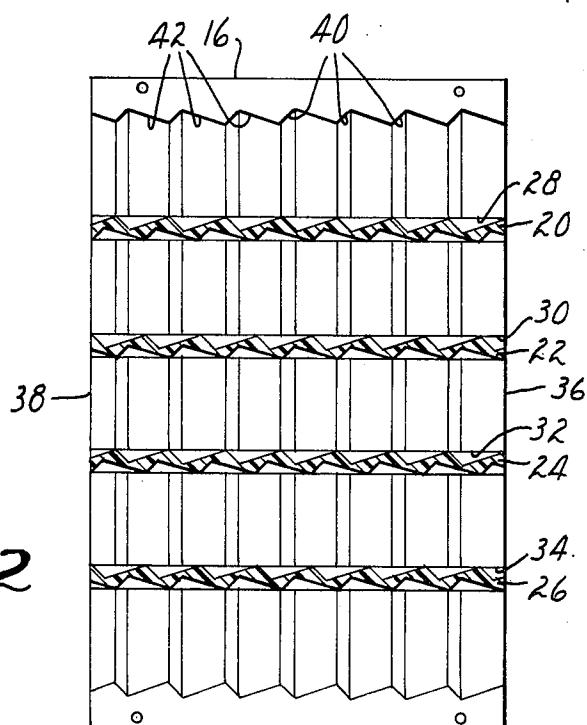


FIG. 2

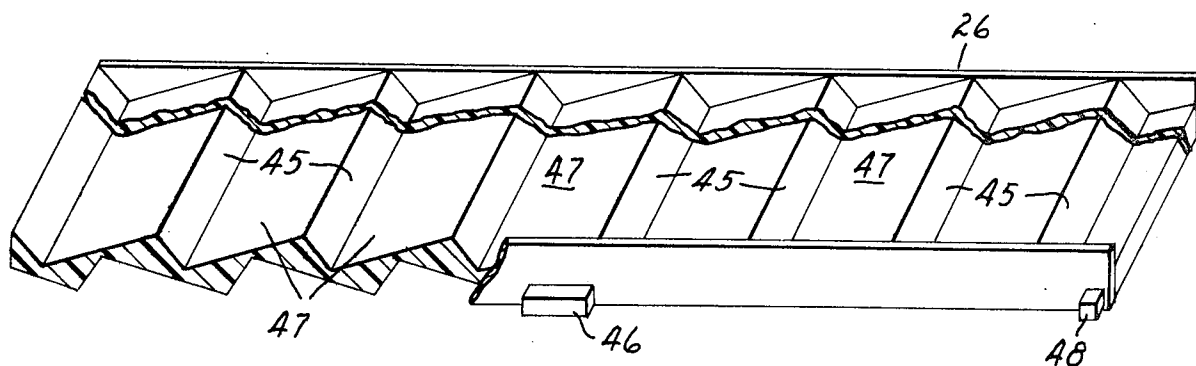


FIG. 3

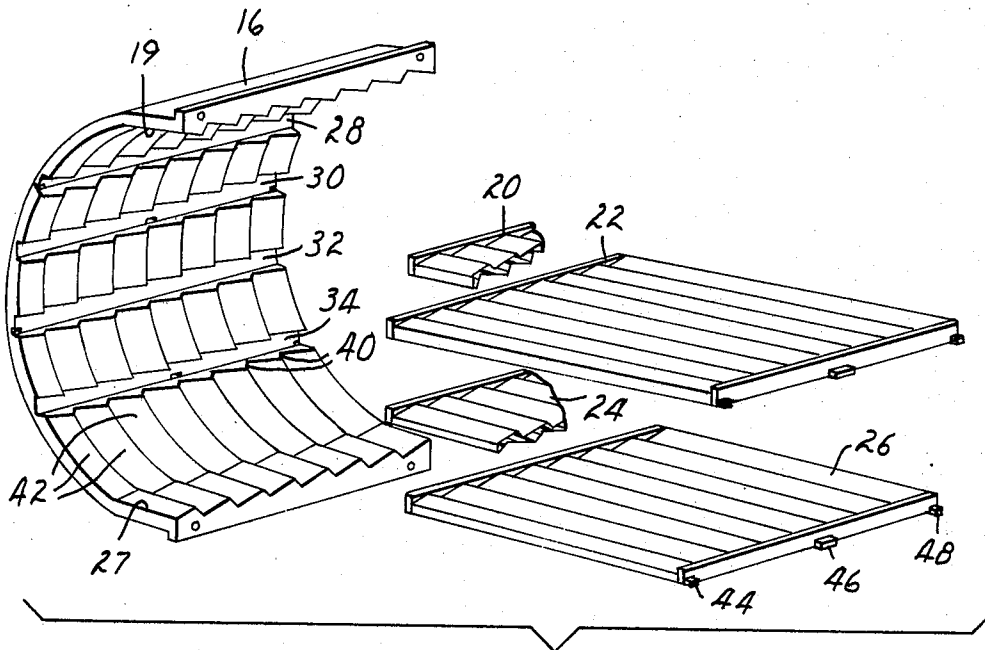


FIG. 4

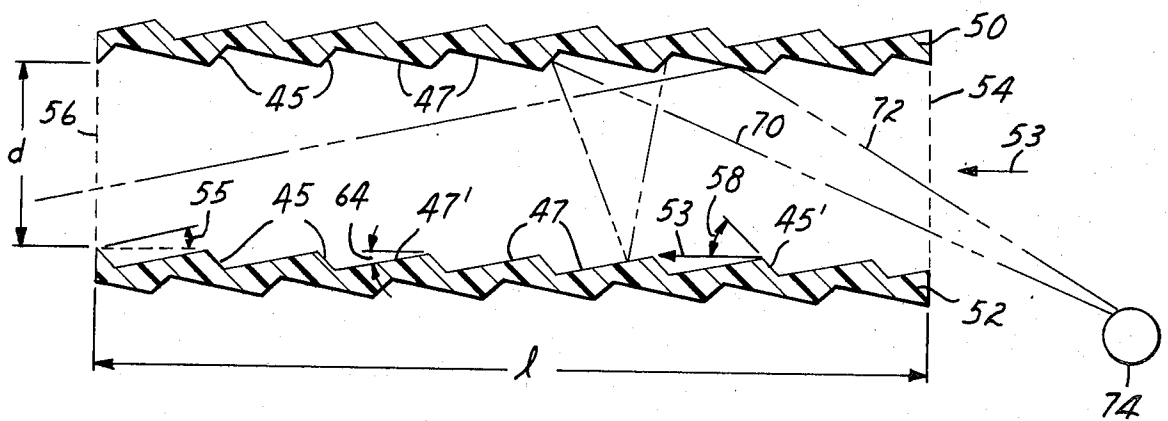


FIG. 5

LIGHT CONTROL DEVICE

BACKGROUND OF THE INVENTION

1. Field of the INVENTION

This invention relates to optical devices used to shield light directed through the device from being scattered or reflected, thereby avoiding unwanted reflections. In particular, the invention relates to louver constructions for use with traffic control signal lights, wherein light shields are desired to prevent drivers outside a predetermined angle, i.e., in another traffic lane, from seeing the signal light.

2. Description of the Prior Art

The simple expedient of surrounding a light source with a shield extending outward from the source to colimate the light and to restrict the line of sight thereof is well known. Such devices are generally provided with optically diffuse light absorbing surfaces to minimize reflections. Where such shields are provided for use with traffic control signals, sideward reflections off the shields may enable drivers in other lanes to anticipate changing signals or to become confused as to allowable motion.

U.S. Pat. No. 2,701,298, discloses a light shield in which a plurality of flat, generally horizontal, thin shields are secured in a parallel, closely spaced relationship within a frame. The shield is intended to be mounted in front of automotive headlights to minimize upward reflections of the lights thereby preventing reflections, such as produced by fog, back into the driver's eyes. The surface of the thin shields are said to be finished to be non-reflecting, however, in practice such surfaces do scatter appreciable quantities of light, rendering them unsuitable for critical applications. Similar devices having a plurality of vertically positioned parallel vanes are commercially available for use with traffic signal devices.

SUMMARY OF THE INVENTION

The present invention relates to an improved light control device which overcomes the shortcomings of the aforementioned prior art devices and which may be conveniently and inexpensively formed from molded plastic. The device has a light input end and a light output end through which a beam of light may be transmitted in a given direction, and includes at least one pair of opposing light control elements defining a channel. Each of the elements comprise a series of broad, specularly reflecting surfaces alternately facing the input and output ends, in which the angle formed between any output facing surface and the given direction is greater than an angle whose cotangent is the ratio of the length of the channel over the distance between the elements at the output end, and less than 20°, and in which the angle formed between any input facing surface and the given direction is greater than 45°. In a preferred embodiment, a plurality of substantially planar vanes having the broad specularly reflecting alternately facing surfaces on major faces thereof are positioned parallel to each other within a cylindrical shell. The alternately facing surfaces cause light from the beam which diverges from the given direction by more than a desired angle to be obstructed.

A preferred use for such a device is a traffic signal light shield adapted to be positioned in front of a traffic signal device to minimize side reflections. In such a use, a plurality of vanes such as described hereinabove are

vertically positioned to intercept horizontally directed light rays diverging from the given direction by more than a desired angle.

Unlike prior art devices which rely on light scattering and absorption to minimize transmission of light, the present invention utilizes controlled reflection from precisely angled faces to either reflect divergent light rays back to the input of the louver device or to reflect such rays several times until such rays are either absorbed or scattered so as to be sufficiently low in intensity as to be generally undetectable. Accordingly, in the present invention the angled surfaces are smooth and reflecting to minimize light scattering therefrom. Light scattering is further decreased by ensuring that the peaks between the input and output angled faces are sharp, i.e., have a radius of curvature of less than 0.015 inches (0.4 mm). In operation, the louver devices of the present invention when used in traffic signal devices are especially useful in preventing motorists outside controlled areas from anticipating their own signal changes by "stealing the signal". The advantages of the present invention over prior art devices are especially evident at night, when even low level side lighting due to unwanted reflections are more visible due to dark background conditions.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a perspective view of a louvered embodiment of the light control device of the present invention utilized with a traffic signal light;

FIG. 2 is a sectional view of the light control device of FIG. 1 along the lines 2—2;

FIG. 3 is a partially broken away perspective view of a single vane for use in the louvered embodiment;

FIG. 4 is a view of a half shell providing a pair of opposing light control elements and of partially broken away vanes which may be used together with the shell; and

FIG. 5 is a cross section of two of the vanes used in the louvered embodiment, showing the projection of two light rays passing between the vanes.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. 1, a traffic signal light 10 is shown in perspective, the signal light 10 having a cylindrical visor 12, concentrically mounted within which is a cylindrical louvered embodiment 14 of the light control device of the present invention. The device 14 is preferably constructed from two mating half shells 16 and 18, respectively, containing recesses within which vanes 20, 22, 24 and 26 are positioned. The two half shells 16 and 18 are designed to be secured together with adhesives or mechanical fasteners prior to insertion in the cylindrical housing 12.

The half shells 16 and 18 and vanes 20, 22, 24 and 26 are preferably molded plastic constructions fabricated by injection molding a smooth surface black plastic material such as polycarbonate. Such material is desired in that it readily forms smooth surfaces which decreases light scattering and improves specular reflections.

Inasmuch as the reflections from the arcuate interior surfaces of the half shells 16 and 18 are not as critical as the reflections off vanes 20, 22, 24 and 26, it may be preferred to fabricate the half shells 16 and 18 from a structural foam plastic material in order to produce as

light a weight construction as possible, even though such a material is somewhat less smooth, thereby producing some light scattering. Alternatively, the interior opposing flat portions 19 and 27, may cooperate to form a pair of opposing light control elements in the manner described hereinafter without vanes inserted therebetween, in which case the flat portions will preferably be as smooth as is practical.

A cross section of the assembled louvered device 14 is shown in FIG. 2, taken along the lines 2—2. The half shell 16 is shown to have a plurality of parallel recesses 28, 30, 32 and 34 each containing appropriate apertures into which projections on the respective vanes 20, 22, 24 and 26 may be inserted, to position the vanes upon assembly of the respective components. The interior walls of the half shell 16 are shaped to have a series of angled bands, which bands alternately face an input end 36 and an output end 38 of the shell 16. Accordingly, the input angled bands 40 face the input end 36, while the output angled bands 42 face the output end 38.

Each major face of the vanes 20, 22, 24 and 26 has a series of reflecting surfaces, each of which extends widthwise across the vanes. The surfaces alternately face toward opposite ends of the vanes.

A partially cut away view of vane 26 is shown in FIG. 3, to more clearly show the positioning of the alternately facing surfaces. Surfaces 45 uniformly face the right side of FIG. 3, which, in the manner to be described hereinafter, corresponds to the input end of the device, while surfaces 47 face the left of FIG. 3, i.e., the output end. Each vane is designed with mounting projections 46 and 48 to facilitate positioning the vanes into the recesses 28, 30, 32 and 34 in the half shells 16 and 18. The alternately facing surfaces 45 and 47 on opposite sides of each vane are preferably staggered in the manner shown in FIG. 3 to allow the thickness of the vanes to be minimized, thereby minimizing both the extent of light blockage due to the vane and the weight thereof. Accordingly, when the vanes are assembled into the half shells 16 and 18, it is preferable that alternate vanes be inverted from the position shown in FIG. 3, such that the opposing surfaces on adjacent vanes are aligned to have the peaks and valleys between the input and output facing surfaces of one face in line with matching peaks and valleys of the opposing face. In an embodiment where the peaks and valleys are not staggered, no such inversion is necessary. When so inverting the vanes, care must be taken not to reverse the vanes, thereby facing the input and output facing surfaces the wrong way. The projections 46 and 48 on the vane 26 (the other vanes are similarly provided) and the apertures in the recesses of the half shells 16 and 18 are designed so that when the vanes are positioned as shown in FIG. 3, i.e., with the projections toward the bottom of the vane, they may be inserted into recesses 30 and 34 as shown in FIG. 2. Similarly, when the vanes are inverted such that the projections 46 and 48 are not at the top of the vanes, they may be inserted into the recesses 28 and 32.

In the cylindrical louvered embodiment shown in the FIGS. 1, 2 and 4, the vanes are designed to be equal length, i.e., the distance between the input and output end of the louver device is the same. Inasmuch as the subtended chord length within the shell varies with the position of a vane within the shell, the width of the various vanes must be adjusted consistent with the respec-

tive position of a given vane. In the embodiment shown in FIGS. 1, 2 and 4, vanes 20 and 26, and vanes 22 and 24, respectively, are identical. The recesses 28 and 34 for accommodating vanes 20 and 26, and the recesses 30 and 32 for accommodating vanes 22 and 24 are thus positioned at equal length chords within the shell. Where a rectangular louver construction is utilized, the vanes may, of course, be of a uniform width and thus be completely interchangeable.

Inasmuch as the vanes are designed to controllably reflect, rather than scatter light, it is important that the vanes be fabricated from a material having characteristics such that smooth, highly reflecting surfaces, and sharp peaks between the faces are obtained. Injection molded black polycarbonate has been found exemplary in this regard. The sharp peaks are especially desired to minimize light scattering from the peaks. Thus, where injection molded components are utilized, special care is desirably taken to ensure that the radius of curvature along the respective peaks is less than 0.015 inches (0.4 mm). The radius of curvature in the corresponding valleys between the input and output facing surfaces is not subject to such limits in that light tends to be trapped in the valleys and does not appreciably contribute to uncontrolled light scattering.

FIG. 4 is an exploded view of a substantially cylindrical half shell 16 containing flat portions 19 and 27 which cooperate to form a pair of opposing light elements, between which an unobstructed channel extends from the input end to the output end. Each of the flat portions 19 and 27 is provided with a series of broad, specularly reflecting surfaces alternately facing the input and output ends. In a preferred embodiment, each half shell 16 and 18 is provided with recesses 28, 30, 32 and 34 into which may be inserted the vanes 20, 22, 24 and 26. In FIG. 4, the half shell 16 and vanes 20, 22, 24 and 26 are shown positioned with the vanes horizontal. In a traffic signal device such as shown in FIG. 1, the assembled shells and vanes are rotated to have the vanes positioned vertically so as to control horizontal light scattering. The projections 44, 46 and 48 on vanes 22 and 26 are shown in full in FIG. 4.

FIG. 5 is a sectional view of two vanes 50 and 52 disposed parallel to and adjacent each other, showing the manner in which light rays diverging from a direction indicated by the arrow 53 by more than a desired angle are controllably reflected and thereby obstructed from passing through the device. The length of the vanes and the spacing therebetween is such as to provide an aspect ratio, which is defined as the ratio of the length, 1, of the enclosed channel and the spacing, d, between the elements at the output end, of slightly more than 4 to 1. As may be seen, the aspect ratio is the cotangent of the widest angle 55 through which light may directly pass from the input to the output end of the adjacent louvers 50 and 52 without hitting either of the opposing light control elements. In the present invention, the angle of the input facing surfaces 45, only a few of which are labeled in the interest of clarity, are ideally 90° to the direction 53 of light entering parallel to the parallel positioned louvers 50 and 52. In practice, it is sufficient that the angle of the input facing surfaces 45 be greater than 45°, as most divergent light rays will still be reflected several times across the channel until sufficient absorption occurs as to effectively minimize the transmission of such divergent light rays. This reduction in the angle of the input facing surfaces 45 is desir-

able inasmuch as it enables a further reduction in the physical thickness and weight of the vanes. The angle of the input facing surface 45' is shown to be angle 58 which is formed between input facing surface face 45' and the direction 53.

The angle 64 of the output facing surfaces 47, only a few of which are labeled in FIG. 5 in the interest of clarity, are designed such that the surfaces nearest the output end 56 are shadowed from light entering at the maximum angle 55. As shown in FIG. 5, the angle 55, the cotangent of which is equal to the aspect ratio, is about $12\frac{1}{2}^\circ$. Accordingly, the angle 64 of the output facing surfaces 47 is in excess of that angle. The angle 64 of the output facing surfaces 47 is here defined as the angle formed between an output facing surface 47' and the direction 53.

The performance of the angled surfaces in controlling edge illumination from divergent light rays is shown by the light rays 70 and 72, which emanate from the light source 74. In prior art planar louver devices, light rays such as 70, which enter at an angle in excess of that angle 55 associated with the aspect ratio, but less than some predetermined angle, will be reflected once, at an angle in excess of the desired viewing angle, and thus produce unwanted side glow. In contrast, in the present invention, some light rays such as 70 impinge on the input facing surfaces 45, and are thus either directly reflected back to the input end 54 or are multiply reflected as shown. Light ray 72 is illustrative of divergent rays entering so as to strike the output facing surfaces 47, which rays are reflected out at an angle less than that angle 55 associated with the aspect ratio to enhance the total light throughput of the louver device.

In an embodiment where the flat surfaces 19 and 27 of the half shells 16 and 18 are used as the pair of light control elements, the resulting aspect ratio for the depicted geometry would require that the output facing surfaces be positioned at an angle greater than about 53° . Since it is desired that the angle of the output facing surfaces not exceed 20° , it is evident that four such shells must be joined in series.

In the embodiments depicted herein, the pairs of light control elements are all shown to be parallel to each other. It is also envisioned that the elements in some embodiments may be non-parallel, such that the distance between the elements varies along the length thereof between the input and output ends. In such a case, the angle of the output facing surfaces must be greater than the angle whose cotangent is the ratio of the length of the channel formed between the elements and the distance between the elements at the output end.

It is standard practice in the traffic control industry to utilize louver devices having aspect ratios of 4/1 and 6/1. Accordingly, a preferred embodiment of the present invention provides the input and output facing surfaces at angles consistent with these practices. The angle whose cotangent is 6 is approximately $9\frac{1}{2}^\circ$, while that whose cotangent is 4 is approximately 14° . To insure that the output facing surfaces near the output end are wholly shadowed, it is further desirable that the angle of the output facing surfaces 47 be in excess of such angles. Therefore, while the output facing surfaces 47 are desirably between 6° and 20° , a particularly desired construction utilizes the output facing surfaces 47 angled at 16° , thereby forming a construction

in which the desired standardized aspect ratios are simply obtained by appropriate selection of the length of the opposing light control elements.

Similarly, a preferred construction positions the input facing surfaces 45 at 45° plus one-half the angle of the output facing surfaces. Thus, where the output facing surfaces are positioned at 16° , the input facing surfaces are positioned at 53° . This preference ensures that divergent light rays hitting an input facing surface such as shown by the light ray 70, are reflected at least three times so as to adequately absorb and scatter such light rays.

While it is preferable that the peaks and valleys on the opposing surfaces of adjacent vanes such as 50 and 52 be opposite each other, such a preference is not essential. Accordingly, while the angled surfaces on the interior of the shells 16 and 18 of FIG. 1 are desirably angled to match the angles of the surfaces on the vanes, it is not essential that the relative positions of the peaks and valleys on the shells correspond with the positions of the peaks and valleys of adjacent surfaces on the vanes.

Performance of the light control devices has been found optimum not only when the radius of curvature of the peaks is as small as possible, but also when the number of peaks is kept to a practical minimum. Since each peak reflects some light, the total scattered light reaching the output end 56 is increased wherever the number of peaks is increased.

While only vanes having regularly alternating and staggered faces on opposing surfaces of the vanes are shown herein, a number of other constructions falling within the general guidelines set forth hereinabove may be employed. For example, a series of fins along the surface of each vane may be utilized to form the peaks in lieu of alternating input and output angled faces. Similarly, additional narrow, angled faces may be added at the valleys between the input and angled faces to improve mold release characteristics. Unwanted reflections produced by such faces such may be minimized by selective control of the angle of the faces and the radius of curvature at the intersection between the faces and the input and output angled faces.

It is further envisioned that the louver devices may be constructed within the teachings of the present invention wherein the vanes have unequal lengths, and wherein the input and output angled faces within different vanes may have somewhat different angles. Louver devices may thus be constructed wherein adjacent louvers toward the extremities of the device are differently spaced than those toward the center of the device so as to produce different aspect ratios at various locations within the louver device. Alternatively, the various vanes within the louver device may be equally spaced, however, the aspect ratio may be varied by judicious selection of the length of the various vanes and of the angles of the input and output faces. Similarly, the angles of the input and output facing surfaces may be desirably varied along the length of each control element to optimize obstruction of light rays incident at varying angles such as impinge at varying distances along the channels.

From the foregoing description, the construction, operation and utility of the light control device of the present invention will be apparent. The foregoing is considered as illustrative only of the principles of the invention. Further, since numerous modifications and

changes will readily occur to those skilled in the art, it is not desired to limit the invention to the exact construction and operation shown and described. Accordingly, this particular modification and all other suitable modifications and equivalents may be resorted to which fall within the scope of the invention as claimed.

I claim:

1. A light control device having a light input end and a light output end through which a beam of light may be transmitted in a given direction, which device includes at least one pair of opposing light control elements defining a channel, each of which elements comprise a series of broad specularly reflecting surfaces alternately facing said input and said output ends, the angle formed between any said output facing surface and said direction being less than 20° and greater than an angle whose cotangent is the ratio of the length of said channel over the distance between the elements at the output end and the angle formed between any input facing surface and said direction being greater than 45° , which device obstructs light of said beam which diverges from said given direction by more than a desired angle.

2. A device according to claim 1, further comprising a plurality of substantially planar vanes positioned parallel to each other, major faces of which are shaped to form said series of reflecting surfaces.

3. A device according to claim 1, further comprising a substantially cylindrical shell having interior flat portions forming a pair of said opposing light control elements.

4. A device according to claim 3, further comprising a plurality of substantially planar vanes within said shell, said vanes being mounted parallel to said flat portions, wherein major surfaces of said vanes are shaped to form said series of reflecting surfaces, opposing surfaces of adjacent vanes and flat portions thereby forming pairs of said opposing light control elements.

5. A device according to claim 4, said shell further having interior circumferential bands alternately facing said input and output ends, the angles of said bands matching those of the alternately facing surfaces of said vanes and flat portions.

6. A device according to claim 3, wherein said shell is a molded plastic material, each half of said housing being identical to the opposite half and being joined therewith to form the complete shell.

7. A device according to claim 1, wherein the angle between any output facing surface and said direction ranges between 6° and 20° .

8. A device according to claim 7, wherein the angle

of all output facing surfaces is the same.

9. A device according to claim 8, wherein the angle between all input facing surfaces and said direction is approximately equal to 45° plus one-half of said angle formed between all the output facing surfaces and said direction.

10. A device according to claim 9, wherein the angle between all output facing surfaces and said direction is approximately 16° and the angle between all input facing surfaces and said direction length is approximately 53° .

11. A device according to claim 2, wherein each major face of said vanes has a plurality of said alternately facing surfaces positioned such that the valleys between the adjacent input and output facing surfaces on one face are displaced along the length of the vane from similar valleys on the opposite face to decrease the thickness of the vane, thereby increasing the light transmissivity of the device.

12. A device according to claim 11, wherein said valleys on one face are centered approximately opposite the midpoint of the output facing surface on the opposite face.

13. A device according to claim 1, wherein the peaks between adjacent input and output facing surfaces have a radius of curvature of less than 0.015 inches (0.4 mm).

14. A traffic signal louver device adapted to be positioned in front of a traffic signal device to limit the angle of visibility of the signal device and to minimize side reflections of light emanating therefrom, said louver device having a light input end and a light output end through which a beam of light may be transmitted in a given direction, which device comprises a substantially cylindrical shell and a plurality of substantially planar vanes vertically positioned parallel to each other within the shell, opposing faces of adjacent vanes forming pairs of opposing light control elements defining channels, each of which elements comprise a series of broad, specularly reflecting surfaces alternately facing said input and said output ends, the angle formed between any said output facing surface and said direction being less than 20° and greater than an angle whose cotangent is the ratio of the length of said channel over the maximum distance between the elements and the angle formed between any input facing surface and said direction being greater than 45° , which device obstructs horizontally directed light of said beam which diverges from said given direction by more than a desired angle.

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