

Nov. 1, 1966

M. L. FREEMAN
LIGHT REFLECTORS

3,283,142

Filed July 1, 1963

2 Sheets-Sheet 1

Fig. 1.

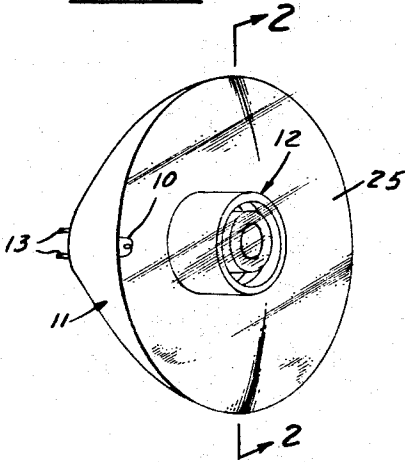


Fig. 2.

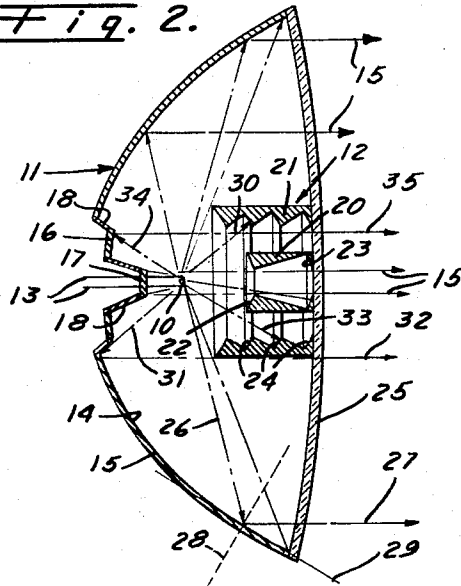


Fig. 3.

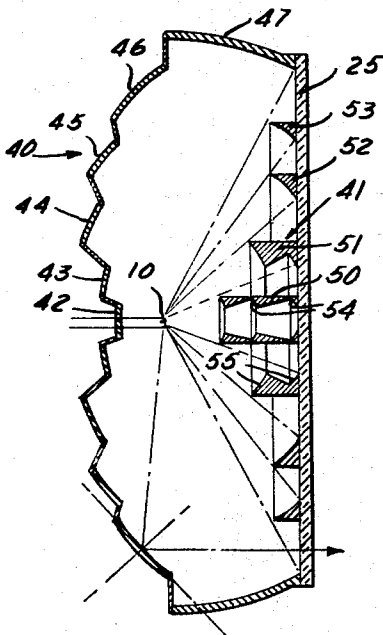
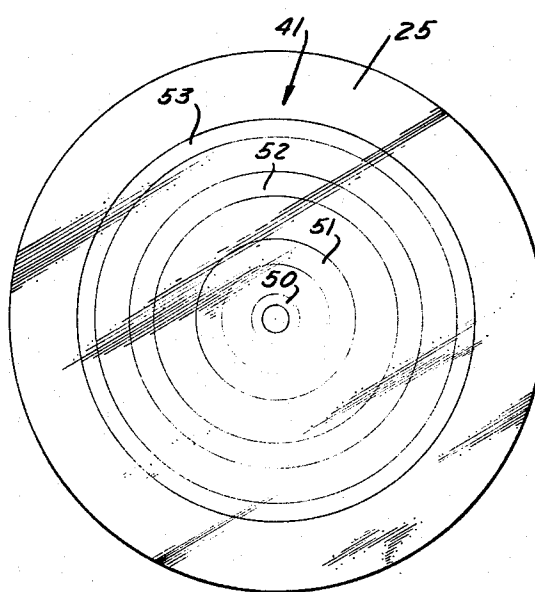


Fig. 4.



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Fig. 5.

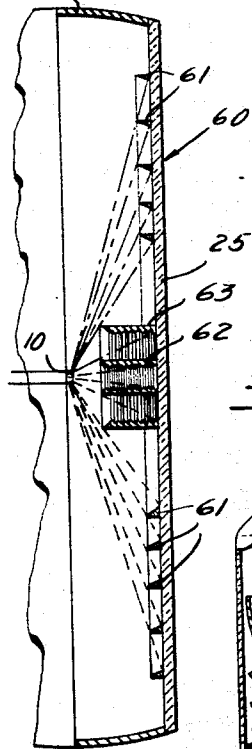


Fig. 7.

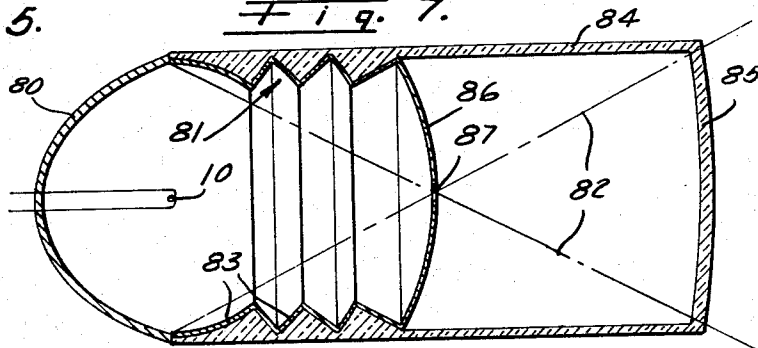


Fig. 8.

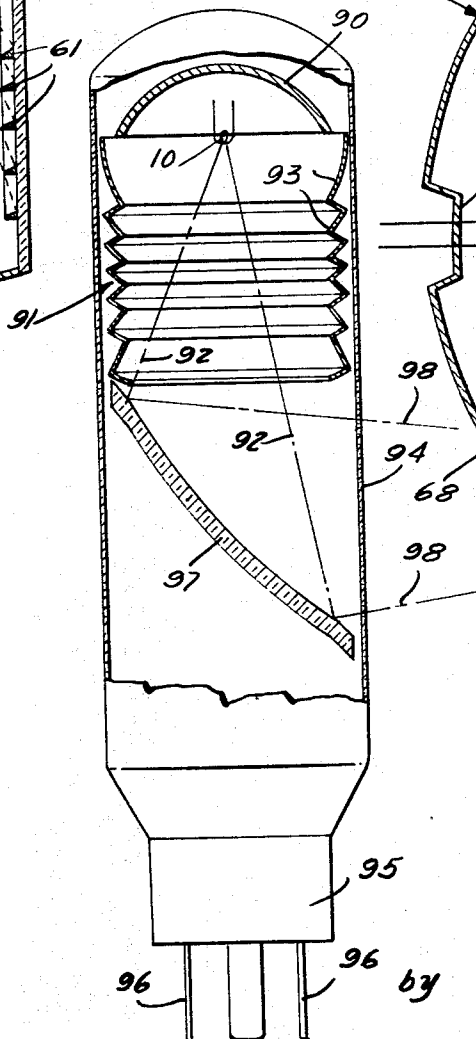
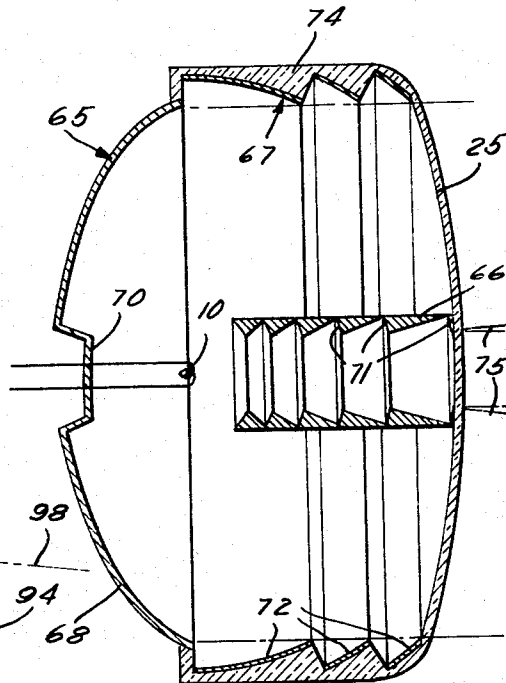


Fig. 6.

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3,283,142

LIGHT REFLECTORS

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7 Claims. (Cl. 240-41.36)

This invention relates generally to a reflector system for radiant energy and particularly relates to a reflector of light or other radiant energy for directing the light emitted by a source in a desired direction with a minimum of loss and improved efficiency.

Light reflectors are well known which serve the purpose of controlling and directing light emitted by a light source into a desired direction such, for example, as a parallel beam of light or a conical beam of light. To this end, a rear reflector is conventionally provided which collects at least half of the light emitted by the source and directs it, for example, into a parallel beam. Such a reflector is usually further improved by the provision of a front lens which collects another portion of the light emitted by the source to direct it, for example, into a parallel beam.

However, it will be apparent that a large fraction of the light which is not reflected by the rear reflector nor collected by the front lens is lost. This loss shows up either as heat or else it may produce side light which is undesired and may cause glare.

In order to improve the efficiency of a light reflector and to reduce glare caused by light emitted in an undesired direction, it has been proposed to provide an additional small front reflector which closely surrounds the light source and is disposed within the rear reflector. The front reflector reflects all light which might otherwise emerge in a conical beam onto the rear reflector. However, it will be apparent that this conventional front reflector casts a central shadow thereby removing the middle portion of the controlled light beam. Thus, this conventional light reflector system gives very good control of the emerging light but has low efficiency because still a large fraction of the light is lost which is converted into undesirable heat.

Another prior art light reflector utilizes a parabolic rear reflector coupled with a spherical front reflector disposed entirely outside the rear reflector. The parabolic rear reflector will reflect the light from the source into a parallel beam. The spherical front reflector reflects a portion of the light which would otherwise emerge into a conical beam onto the rear reflector. However, unless the spherical front reflector is made very large and bulky, there will still be a portion of the light which emerges as an undesired conical beam causing glare and distraction. Such a prior art reflector system is relatively large and bulky and still does not eliminate all of the light which emerges in a conical beam.

It is accordingly an object of the present invention to provide an improved reflector system for directing radiant energy in a desired direction which is relatively small in size and which directs substantially all of the radiant energy into the desired direction thus greatly improving the efficiency.

Another object of the present invention is to provide a reflector system of the character described which permits the directing of radiant energy into a parallel beam in such a manner that substantially all of the radiant energy is directed into the desired direction thereby increasing the efficiency and substantially eliminating glare caused by radiant energy which does not emerge parallel and with a resulting savings in the cost of operation.

A further object of the present invention is to provide a reflector system of the type referred to which permits

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to direct radiant energy into a divergent cone and which minimizes loss of radiant energy which would otherwise result in undesired heat.

Still a further object of the present invention is to provide a light reflecting system for radiant energy such, for example, as visible light, infrared light or ultraviolet light which permits an improved control over the direction and distribution of the light with a resulting reduction in the production of heat, an increased efficiency and a savings in the cost of operation.

In accordance with the present invention there is provided a reflector system for directing radiant energy from a source in a desired forward direction. Thus, the reflector system may direct visible light, infrared light or ultraviolet light or other electromagnetic waves or radiant energy. There is provided a source for emitting radiant energy substantially in all directions. This could, for example, be an incandescent or filamentary light or a gas-filled lamp which may be a point source. There is further provided a rear reflector partly surrounding the source in a rearward direction for reflecting a first portion of the radiant energy emitted by the source and for directing the first portion into the desired direction.

For example, it may be desired to direct the radiant energy such as light into a parallel or into a conical divergent beam. A second portion of the radiant energy emitted by the source will of course directly emerge in the desired direction. There is finally provided a front reflector disposed ahead of and about the source for reflecting substantially all of the remaining radiant energy emitted by the source toward the rear reflector and then into the desired direction. The front reflector is disposed between at least two parallel planes extending substantially through the rear reflector.

Preferably, the reflector system has rotational symmetry utilizing a point source in which case the front reflector is disposed in a cylinder extending through the edges of the rear reflector. The front reflector includes a plurality of separate portions each reflecting a solid angle of radiant energy from the source onto the rear reflector. As a result, substantially all of the radiant energy is directed into the desired direction. To this end, the front reflector, in order to provide a substantially parallel beam, may include a plurality of cylindrical hollow portions having at least one reflecting surface for reflecting light from the source to the rear reflector.

In that case, the rear reflector has a plurality of stepped sections, each section reflecting radiant energy reflected from one of the cylindrical portions through the space about one of the associated cylindrical portions. On the other hand, if the reflector system is designed to direct a conical divergent beam, the front reflector may be of generally cylindrical shape substantially coextensive with the outer edge of the rear reflector. The front reflector may have a plurality of individual portions spaced from each other, each reflecting radiant energy from the source onto the rear reflector and thence into a conical beam.

The novel features that are considered characteristic of this invention are set forth with particularity in the appended claims. The invention itself, however, both as to its organization and method of operation, as well as additional objects and advantages thereof, will best be understood from the following description when read in connection with the accompanying drawings, in which:

FIG. 1 is a view in perspective of an automobile headlight in accordance with the present invention for projecting a substantially parallel light beam;

FIG. 2 is a sectional view taken on line 2-2 of FIG. 1 and illustrating particularly the front and rear reflectors of the headlight of FIG. 1;

FIG. 3 is a sectional view of a spotlight embodying the preferred embodiment of the present invention;

FIG. 4 is a front elevational view of the spotlight of FIG. 3;

FIG. 5 is a partial sectional view illustrating particularly the front reflector suitable for a spotlight or headlight;

FIG. 6 is a sectional view of a spotlight providing a substantially parallel light beam;

FIG. 7 is a sectional view of a floodlight in accordance with the present invention for developing a divergent conical light beam; and

FIG. 8 is a sectional view of a projecting-type bulb for developing a divergent conical light beam and including a reflector for redirecting and focusing or concentrating the resulting light beam.

Referring now to the drawings and particularly to FIGS. 1 and 2, there is illustrated a reflector system embodying the present invention. This reflector system is particularly adapted for use as an automobile headlight such as a sealed beam light. The reflector system includes primarily a light source 10, a rear reflector generally indicated at 11 and a front reflector shown at 12.

The light source 10 may be any source of visible, infrared, or ultraviolet light, for emitting radiant energy. The light source 10 may, for example, be a filamentary source as illustrated in FIGS. 1 and 2 to provide substantially a point source. Certain auto headlights designed as direct replacements for existing units may require two filamentary light sources for a high and a low beam. Alternatively, the light source 10 may be a gas-filled lamp such as a lamp operated with xenon gas, mercury vapor or sodium vapor. The light source 10 shown as a filament may have a pair of wires 13 extending through the rear reflector 11 and may be connected to a suitable voltage source for energizing it.

The rear reflector 11 consists essentially of a parabolic reflector of light. The rear reflector may, for example, consist of metal having a polished inner surface 14 for reflecting the light from the source 10 forwardly into a substantially parallel beam as shown by the arrows 15. Alternatively, the rear reflector 11 may, for example, be made of glass or some other material provided with a reflecting metallic surface 14. It will be noted that the rear reflector 11 consists of a main parabolic section 15 and two stepped parabolic sections 16 and 17 interconnected by portions 18 extending along radii through the source 10. The purpose of these stepped portions 16 and 17 will be subsequently explained. The stepped portions 16 and 17 are also portions of a paraboloid for reflecting the light from the source 10 outwardly or forwardly into a substantially parallel beam.

The front reflector 12 consists of two cylinders or barrels 20 and 21. The two barrels 20 and 21 are disposed concentrically with respect to each other and have a common axis parallel to the forward light beam. The inner barrel 20 is provided with two reflecting surfaces 22 and 23. The reflecting surfaces 22 and 23 each form a portion of a sphere having its center in the source 10. They serve the purpose to reflect light from the source 10 back onto the rear reflector 11 as will be more fully explained hereinafter. Essentially, the purpose of the front reflector is to make use of the light or radiant energy from the source 10 which would otherwise be directed into the conical beam which in turn would cause glare and loss of efficiency.

The outer front barrel 21 is also provided with a number of reflecting surfaces 24. As shown in FIG. 2, there are four such reflecting surfaces. Again each of the reflecting surfaces 24 is a portion of a sphere having its origin or center at the light source 10.

The rear reflector 11 may be closed by a transparent front window or glass cover 25 to provide a sealed space between the glass cover 25 and the rear reflector 11. It is preferred to seal the light source 10 as well as the rear reflector 11 and the front reflector 12. This makes it unnecessary to surround the filamentary light source with a glass envelope. The same applies to a gas-filled lamp which would also require a special envelope. In addition,

the sealed construction protects the reflecting surfaces of the rear reflector 11 and the front reflector 12 from oxidation or corrosion by the atmosphere.

As pointed out before, the rear reflector 11 may be constructed of glass, plastic, metal or any other suitable material. The reflecting surface 14 may be applied to the front surface in any suitable manner. It may be a polished surface layer or the metal of the reflector itself may be polished. Similarly, the front reflector such as the barrels 20 and 21 may be constructed of glass, metal or plastic material. The reflecting surfaces, such as 22, 23, and 24 may be blown, cast, embossed, molded, stamped, spun, machined or otherwise shaped. The barrels, such as 20 and 21, may be made in one piece or in two halves or as segments of rings or cylinders. Preferably, the barrels 20 and 21 are attached to the transparent front window 25 in any suitable manner.

The rear reflector 11, together with the size and shape of the light source 10 determine the shape and angle of the projected light beam. For example, a light beam such as 26 originating from the source 10 is reflected by the reflector portion 15 of the rear reflector 11 into a beam 27. The two angles which the beams 26 and 27 form with the dotted line 28 are equal. The line 28 is perpendicular to a tangent 29 on the front surface 14. Thus, by drawing various desired beams such as 27, the shape of the curve of which the rear reflector consists may be readily determined as is well known in the art. In order to project a parallel beam from a substantially point light source, the rear reflector 11 has the shape of a paraboloid as is well known.

The front reflector 12, and in particular the barrels 20 and 21, serve the function to redirect that portion of the radiant energy which is not directly reflected by the rear reflector 11 and which is not directly emitted into a parallel forward beam. For example, light originating from the source 10 may be directed into a beam 30 which is reflected by one of the reflector surfaces 24 and eventually returns as shown by the arrow 31 onto the main rear reflector portion 15. From there, the light beam is directed outwardly as shown by the arrow 32. On the other hand, light originating from the source 10 may be projected as shown by the arrow 33 onto another one of the reflecting surfaces 24. This light is then reflected as shown by the arrow 34 onto the stepped reflector portion 16 from which it emerges as a beam 35. Similarly, light from the source 10 is reflected by either of the surfaces 22 or 23 of the inner barrel 20 onto the central reflector portion 17 and thence through the barrel 20 in a parallel beam.

It will now be apparent that the number of stepped portions, such as 16 and 17, corresponds to the number of barrels, such as 20 and 21, of the front reflector 12. The purpose of the stepped portions 16 and 17 is to project the light reflected by the front reflector barrels 20 and 21 through the space between adjacent barrels or through the central barrel 20.

As a result, as seen from the source 10, looking toward the front reflector 12, the front reflector 12 appears as the inside surface of a hemisphere. On the other hand, to the light rays reflected from the front reflector toward the rear reflector, the front reflectors are essentially not in existence because the light passes through adjacent barrels or through the central opening of the central barrel. It will thus readily be seen that the efficiency of such a light reflector construction is very high because the light losses are minimized.

However, it should be noted that a very small amount of light will emerge in the form of a conical beam. This is due to the fact that the opening of the central barrel 20 will have a certain size to permit light to emerge in a conical beam. Obviously, the smaller the solid angle is having its origin in the source 10 and as defined by the central barrel 20, the smaller this conical light beam will appear. It will be pointed out later in connection with

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FIG. 6 how the effect of such a conical light beam can be further minimized.

Referring now to FIGS. 3 and 4, there is illustrated the preferred embodiment of a reflector system in accordance with the present invention. The reflector system of FIGS. 3 and 4 again includes a light source 10, a rear reflector 40 and a front reflector generally indicated at 41. The rear reflector 40 again consists of a paraboloid to project a substantially parallel beam outwardly or forwardly of the source 10. A transparent window 25 may close the rear reflector 40. The rear reflector 40 consists of a large number of stepped portions 42 through 46. On the other hand, the front reflector includes a reflector portion 47, a central barrel 50, an outer barrel 51 and two spaced rings or cylindrical portions 52 and 53. The central barrel 50 is provided with three reflecting surfaces 54. The outer barrel 51 may be provided with two reflecting surfaces 55 while the two rings 52 and 53 each have a single reflecting surface. All reflecting surfaces such as 47, 54, 55 and those of the rings 52, 53 are again portions of a sphere having its origin at the light source 10. The barrels 50, 51 and the rings 52, 53 may again be secured to the transparent front window 25. In general, the construction of the rear reflector 40 and of the front reflector 41 may be the same as previously described.

The operation of the light reflector system of FIGS. 3 and 4 will be apparent from the previous description. It will be noted that the reflector portion 47 actually forms part of the front reflector. It will be obvious that light from the source 10 reflected by the front reflector portion 47 will eventually be reflected by one of the rear reflector portions 44 through 46. Again, the number of stepped portions on the rear reflector 40 corresponds to the number of barrels or rings of the front reflector 41. In other words, there are five spaces between the central barrel 50 and the reflector 47. Similarly, the rear reflector 40 also has five stepped portions, interconnected by radial portions having extensions passing through the source 10.

Referring now to FIG. 5, there is illustrated again a light source 10 and a modified front reflector 60. The front reflector 60 may again be secured to the front window 25. The front reflector 60 consists of a series of concentric rings 61 of which there may be five as shown. There is also provided a central barrel 62 and an outer barrel 63. The two barrels 62 and 63 may be provided with serrations for reflecting the light from the source 10 onto a rear reflector not shown.

The construction of the rear reflector will be apparent from the previous description. Since there are eight spaces between the central barrel 62 and the rings 60 and the reflecting portion 64, the rear reflector also requires eight stepped portions aligned with the spaces between the barrel 62, 63, the rings 61 and the circumferential reflector 64. Otherwise, the embodiment of FIG. 5 is similar to that illustrated in FIGS. 3 and 4 and may be constructed in the same manner.

Referring now to FIG. 6, there is illustrated a reflector system suitable as a spotlight. Again, the reflector includes a light source 10, a rear reflector 65, a central barrel 66 and an outer front reflector generally designated at 67. The rear reflector 65 may have a main paraboloidal portion 68 and a stepped central portion 70. The front reflector includes a central barrel 66 having a plurality of reflecting surfaces 71 of which six are illustrated. These reflecting surfaces 71 again form portions of a sphere. The front reflector portion 67 consists of three reflecting surfaces 72 which are all also portions of a sphere. A transparent front window 25 may again be provided for enclosing a space within which the light source 10 and the front reflector 66 and 67 is provided.

In this construction, it may be preferred to utilize a glass portion 74 integral with the front window 25 on which the reflecting surfaces 72 are disposed.

The operation of the reflector system of FIG. 6 will be apparent from the description previously given. The

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light emerges essentially in a parallel beam. However, as shown by the dotted lines 75, a portion of the light emerges in the form of a conical beam. This is due to the solid angle which has its origin at the light source 10 and passes through the central barrel 66. However, it is feasible to dispose a lens on the window 25 for refracting the upper portion of the conical beam 75 into a horizontal, parallel beam. Such a construction minimizes glare when the device is used as an automobile headlight. In that case, the lower portion of the conical beam 75 would do no harm and no correction would be required.

FIG. 7 illustrates a reflector suitable as a floodlight which develops a diverging conical light beam. The reflector of FIG. 7 again has a light source 10, a rear reflector 80 and a front reflector 81. The rear reflector 80 has such a shape as to reflect light from the source 10 into a conical beam as indicated by the lines 82.

The front reflector 81 surrounds the light source 10 in a forward direction and includes three reflecting surfaces 83 which are again portions of a sphere. The entire light source may be enclosed in a glass bulb 84 including a transparent front window 85. The front reflector 81 is closed by an opaque reflecting shield 86 having a central aperture 87. Thus, it will be seen that the light is focused through the central aperture 87 and then passes through the front window 85. The reflector 86 may form a portion of a sphere and reflects light onto the rear reflector 80. The front reflectors 81 and 86 collect a major portion of the light otherwise lost and directs it toward the rear reflector 80 and then through the aperture 87. Since the beam is focused in the aperture 87 and since the beam at this point tends to be very hot, it is preferred that no material be disposed in the aperture 87.

It will be understood that the flood beam developed by the reflector of FIG. 7 may have the shape of its beam and its focal point changed in any conventional manner, for example, by movable or adjustable lenses.

FIG. 8 illustrates a light projector which also develops a diverging conical beam. The reflector of FIG. 8 also includes a light source 10, a rear reflector 90 and a front reflector 91. The rear reflector 90 again serves the purpose to focus the light from the source 10 into a divergent conical beam as shown by the lines 92. The front reflector 91 includes, for example, seven reflecting surfaces 93, each forming portions of a sphere. The rear reflector and the front reflector 91 may be enclosed in a transparent bulb 94 having a stem 95 through which leads 96 may extend for energizing the light source 10.

Preferably, a reflecting mirror 97 is provided for reflecting the conical beam outwardly through the bulb 94 as shown by the lines 98. The reflector 97 also serves the purpose to concentrate the light beam. The reflector 97 may be of conventional construction and may be fixed in place, rotatable or movable in any direction. It will be noted that a small portion of the light is lost which emerges as a conical beam past the reflector 97. This loss may easily be remedied by a slight modification in design as is well known in the art. The reflector 97 essentially takes the place of a conventional condensing lens.

The principles of the reflector system of the present invention may be applied to many different applications. For example, the reflector system may be utilized as spotlights, automobile headlights, aircraft landing lights, airport runway lights, signal lights, beacon lights, flash or photoflash units, picture projectors, or for illuminating roadways, for theatrical lighting or lighting in television studios. It may be used for display purposes, as fog lights, airborne flares for ground illumination, photoelectric beams, searchlights, floodlights, for indoor illumination, general lighting or marine lighting.

There has thus been disclosed a reflector system for radiant energy such as infrared, visible or ultraviolet light.

The reflector system of the invention is characterized by a greater efficiency resulting from a smaller loss of light and less generation of heat. The reflector system is so constructed that substantially all the light generated by a light source is converted into a useful beam which may be parallel or conical. The reflector system essentially comprises a rear reflector and a front reflector. The front reflector is so constructed that it presents to the light source a substantially spherical reflecting surface. The light reflected first by the front reflector and then by the rear reflector in turn passes through the front-reflector substantially without loss of light.

The invention and its attendant advantages will be understood from the foregoing description. It will be apparent that various changes may be made in the form, construction and arrangement of the parts of the invention without departing from the spirit and scope thereof or sacrificing its material advantages, the arrangement hereinbefore described being merely by way of example. I do not wish to be restricted to the specific form shown or uses mentioned except as defined in the accompanying claims, wherein various portions have been separated for clarity of reading and not for emphasis.

I claim:

1. A reflector system for directing radiant energy from a source in a desired forward direction comprising:
 - (a) a source of substantially point shape for emitting radiant energy in all directions;
 - (b) a rear reflector partially surrounding said source in a rearward direction for directly reflecting a first portion of the radiant energy emitted by said source and for directing said first portion into said desired direction to form a beam, a second portion of the radiant energy being emitted by said source directly into said desired direction;
 - (c) a front reflector disposed ahead of and about said source and within the path of said beam for reflecting substantially all of the remaining portion of the radiant energy emitted by said source toward said rear reflector and then into said desired direction, the front edges of said front reflector extending substantially through a plane, and said front reflector including a plurality of separate spherical portions, each reflecting a solid angle of radiant energy from said source onto said rear reflector, whereby substantially all of said radiant energy is directed into said desired direction; and
 - (d) said rear reflector having a plurality of stepped sections, each section reflecting radiant energy reflected from one of said reflecting portions through the space about one of said reflecting portions.
2. A reflector system for directing radiant energy from a source in a desired forward direction comprising:
 - (a) a source of substantially point shape for emitting radiant energy in all directions;
 - (b) a parabolic rear reflector partially surrounding said source in a rearward direction for directly reflecting a first portion of the radiant energy emitted by said source and for directing said first portion into said desired direction to form a parallel beam, a second portion of the radiant energy being emitted by said source directly into said desired direction;
 - (c) a front reflector disposed ahead of and about said source and within the path of said beam for reflecting substantially all of the remaining portion of the radiant energy emitted by said source toward said rear reflector and then into said desired direction, said front reflector including a plurality of separate reflecting surfaces, each forming a portion of a sphere having its center in said source and for reflecting a solid angle of radiant energy from said source onto said rear reflector, and the front edges of said reflecting surfaces lying substantially in a plane at right angles to said parallel beam, where-

- by said source looks into a hemispherical front reflector; and
- (d) said rear reflector having a plurality of stepped sections, each section reflecting radiant energy reflected from one of said reflecting surfaces through the space about its associated reflecting surface.
3. A reflector system for directing radiant energy emitted by a source into a substantially parallel beam in a forward direction, said system comprising:
 - (a) a source of substantially point shape for emitting radiant energy in all directions;
 - (b) a parabolic rear reflector for directly reflecting a first portion of the radiant energy from said source into a substantially parallel beam in the forward direction, said rear reflector partially surrounding said source;
 - (c) a front reflector for reflecting substantially all of the radiant energy of said source which is not directly emitted as said parallel beam and which is not directly reflected by said rear reflector, said front reflector including at least one cylindrical, hollow portion disposed in said beam and having an axis parallel to said beam, said portion having at least one reflecting surface forming a portion of a sphere having its center in said source, each surface reflecting radiant energy from said source onto said rear reflector and hence into said parallel beam; and
 - (d) said rear reflector having a plurality of stepped sections, each section reflecting radiant energy reflected from one of said cylindrical portions through the space about one of said cylindrical portions, and said stepped sections being interconnected by members disposed along lines passing through said source.
 4. A reflector system for directing radiant energy emitted by a source into a substantially parallel beam in a forward direction, said system comprising:
 - (a) a source of substantially point shape for emitting radiant energy in all directions;
 - (b) a rear reflector of paraboloidal shape for directly reflecting a first portion of the radiant energy from said source into a substantially parallel beam in the forward direction, said rear reflector partially surrounding said source; and
 - (c) a front reflector for reflecting substantially all of the radiant energy of said source which is not directly emitted as said parallel beam and which is not directly reflected by said rear reflector, said front reflector including a plurality of cylindrical, hollow portions disposed in said beam, said portions being concentric to each other and having a common axis parallel to said beam, each portion having at least one reflecting surface forming a portion of a sphere having its center in said source, each surface reflecting radiant energy from said source onto said rear reflector and hence into said parallel beam; and
 - (d) said rear reflector having a plurality of stepped sections, interconnected by members disposed along lines passing through said source, each section reflecting radiant energy reflected from one of said cylindrical portions through the space about one of said cylindrical portions, whereby said source looks into a hemispherical front reflector while said front reflector looks into the free space between said cylindrical portion.
 5. A reflector system for directing radiant energy emitted by a source into a substantially parallel beam in a forward direction, said system comprising:
 - (a) a source of substantially point shape for emitting radiant energy in all directions;
 - (b) a rear reflector of paraboloidal shape for directly reflecting a first portion of the radiant energy from said source into a substantially parallel beam in the forward direction, said rear reflector partially surrounding said source;
 - (c) a front reflector for reflecting substantially all of

- the radiant energy of said source which is not directly emitted as said parallel beam and which is not directly reflected by said rear reflector, said front reflector including a plurality of cylindrical, hollow portions disposed in said beam, said portions being concentric to each other and having a common axis parallel to said beam, at least one of said cylindrical portions having a plurality of serrated reflecting surfaces for reflecting radiant energy from said source onto said rear reflector and hence into said parallel beam; and
- (d) said rear reflector having a plurality of stepped sections interconnected by members disposed along lines passing through said source, each section reflecting radiant energy reflected from one of said cylindrical portions through the space about one of said cylindrical portions.
6. A reflector system for directing radiant energy emitted by a source into a substantially parallel beam in a forward direction, said system comprising:
- (a) a source of substantially point shape for emitting radiant energy in all directions;
- (b) a rear reflector of paraboloidal shape for directly reflecting a first portion of the radiant energy from said source into a substantially parallel beam in the forward direction, said rear reflector partially surrounding said source; and
- (c) a front reflector for reflecting substantially all of the radiant energy of said source which is not directly emitted as said parallel beam and which is not directly reflected by said rear reflector, said front reflector including a cylindrical hollow portion disposed in said beam and having an axis parallel to said beam and having at least one reflecting surface, said reflector further including a plurality of reflecting surfaces lying within a plane arranged substantially transverse to said beam, each of said reflecting surfaces forming a portion of a sphere having its center in said source for reflecting radiant energy from said source onto said rear reflector and hence into said parallel beam; and
- (d) said rear reflector having a stepped section interconnected by a member disposed along lines passing

through said source for reflecting radiant energy reflected from said cylindrical portion through the space thereabout.

7. A reflector system for directing radiant energy from a source in a desired forward direction comprising:

- (a) a source for emitting radiant energy substantially in all directions;
- (b) a rear reflector partially surrounding said source in a rearward direction for directly reflecting a first portion of the radiant energy emitted by said source and for directing said first portion into said desired direction to form a beam, a second portion of the radiant energy being emitted by said source directly into said desired direction;
- (c) a front reflector disposed about said source and within the path of said beam for reflecting substantially all of the remaining portion of the radiant energy emitted by said source toward said rear reflector and then into said desired direction and said front reflector including a plurality of separate portions, each forming a portion of a sphere having its center in said source and for reflecting a solid angle of radiant energy from said source onto said rear reflector, whereby substantially all of said radiant energy is directed into said desired direction; and
- (d) said rear reflector having a plurality of stepped sections, each section reflecting radiant energy reflected from one of said reflecting portions through the space about one of said reflecting portions.

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