

Nov. 15, 1932.

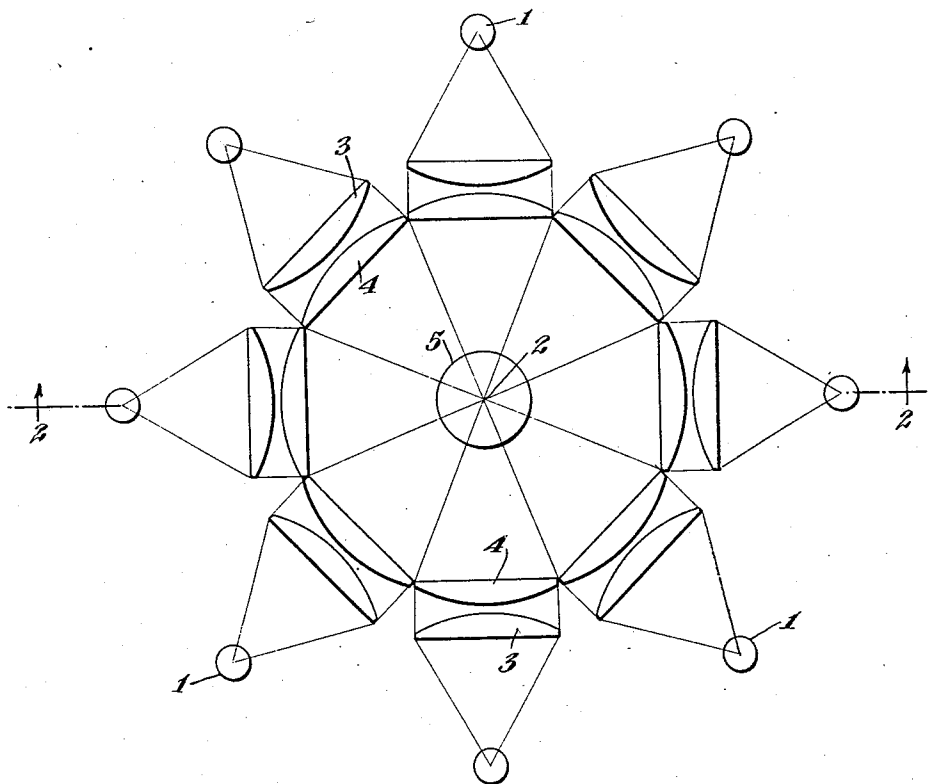
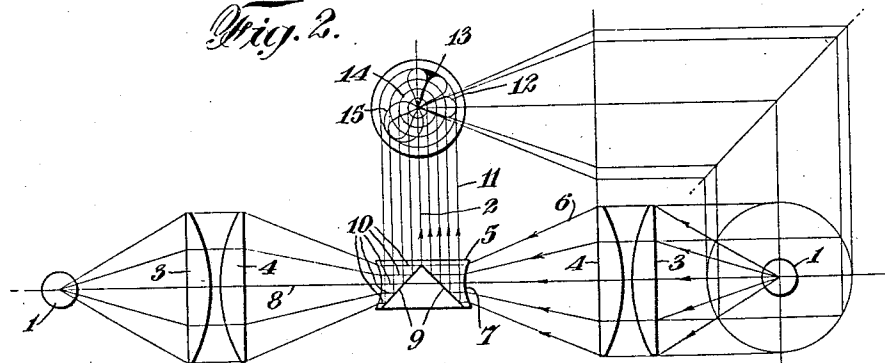
C. W. LARNER ET AL

1,887,650

LIGHT CONTROLLING APPARATUS

Filed May 27, 1926

2 Sheets-Sheet 1

*Fig. 1.**Fig. 2.*

Inventors  
 Chester W. Larner  
 Sydney J. Sanford.

By their Attorneys  
 Edwards, Sager and Brown

Nov. 15, 1932.

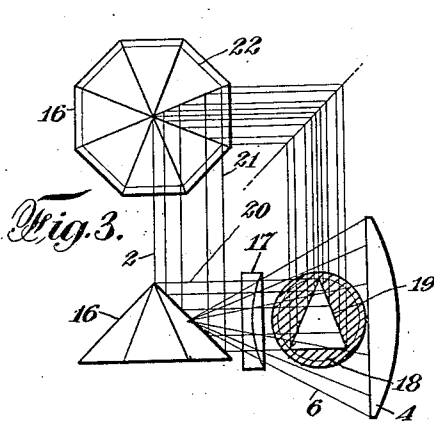
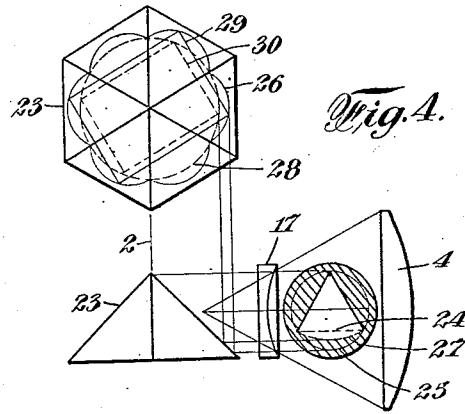
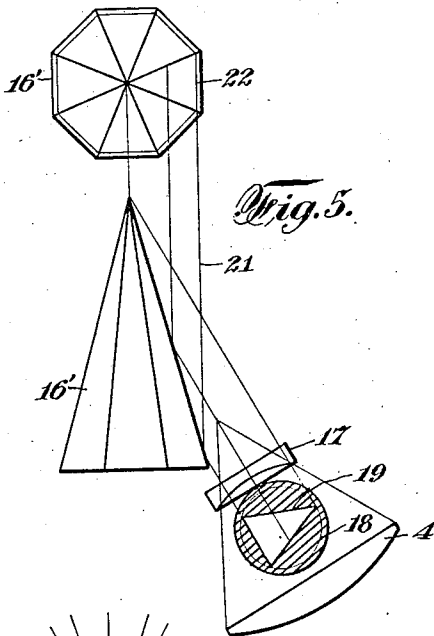
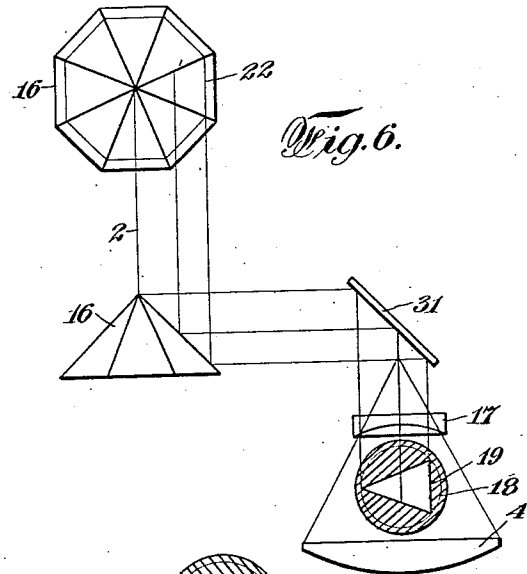
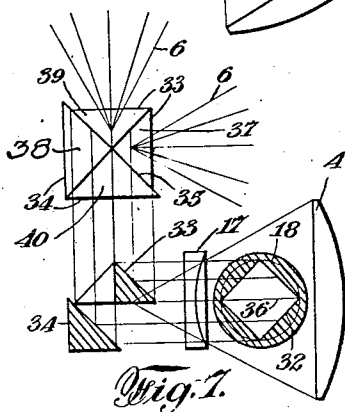
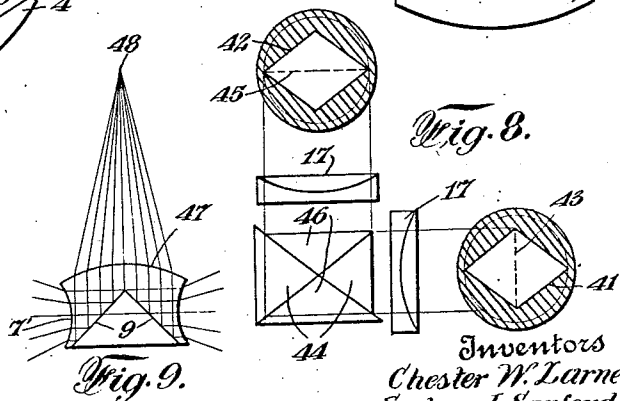
C. W. LARNER ET AL

1,887,650

LIGHT CONTROLLING APPARATUS

Filed May 27, 1926

2 Sheets-Sheet 2



Inventors  
Chester W. Larner  
Sydney J. Sanford  
By their Attorneys  
Edwards, Leger and Bowser

## UNITED STATES PATENT OFFICE

CHESTER W. LARNER AND SYDNEY J. SANFORD, OF PHILADELPHIA, PENNSYLVANIA

## LIGHT CONTROLLING APPARATUS

Application filed May 27, 1926. Serial No. 111,949.

This invention relates to light controlling apparatus and more particularly to an arrangement whereby light from a multiplicity of sources of illumination can be combined in a single beam, thereby producing a beam of larger cross sectional area or one having greater intensity than could be produced from a single source of light.

While this invention finds many and diverse applications it is as illustrated particularly applicable to a motion picture projector. In the present practice it is customary, where the projection screen is large, to use an arc lamp in order to secure sufficient light to produce a brilliant picture. Even an arc lamp, however, is sometimes insufficient for this purpose; and it is always more or less undesirable in practice because of the auxiliary apparatus required, such as motor-generator sets for the purpose of transforming alternating current into direct current, and also because of the constant attention required to keep an arc lamp in good operating condition.

Where the projection screens are smaller, incandescent lamps are used, but they have to be low voltage in order to reduce the size of the filament, and thus approximate a so-called "point illumination". These lamps are short lived and quite expensive. They frequently burn out during the showing of a picture, thus causing interruption while the lamp is being renewed.

An object of our invention is to provide an improved arrangement of light directing means whereby light from a plurality of sources may be combined in a single beam. A further object is to provide an improved arrangement of parts whereby the intensity of light of said single beam will be substantially uniform.

Other objects will appear from the following description of the accompanying drawings, in which

Fig. 1 is a diagrammatic view showing a multiplicity of light sources and a central lens;

Fig. 2 is a diagrammatic view taken on line 2—2 of Fig. 1 and shows by geometrical projection of the light rays how a single beam

is obtained and the cross sectional shape thereof, such geometrical projection also being employed in connection with certain of the following figures;

Fig. 3 is a modification showing means for producing a beam of uniform intensity;

Fig. 4 is a modification of Fig. 3 showing means for employing six light sources;

Fig. 5 is a further modification of Fig. 3 and shows the sources of light beams coming from an obtuse angle to the final beam;

Fig. 6 is a still further modification of Fig. 3 and wherein all source light is substantially parallel to the final combined beam;

Fig. 7 is a modification showing an arrangement whereby a square beam is produced from two lights;

Fig. 8 is a modification of Fig. 7 adapted to produce a rectangular beam of uniform intensity, and

Fig. 9 is a modification of Fig. 2 showing means to produce a converging beam of light rather than a straight one.

Referring to the drawings there is diagrammatically shown in Fig. 1, a group of eight lamps 1 symmetrically disposed with respect to a central point 2. Each of these lamps is provided with the customary condensing lenses 3 and 4, which gather the rays of light from the lamps 1 and bring them to a common focus at 2. The usual mountings for the lens or housings for the lights are not shown, as these are well-known in the optical art. The light from the several lamps passes through a combination lens and reflector 5 located centrally with respect to the lights 1 and so designed that the converging conical beams 6 from lenses 4 impinge upon its outer circumference 7. The surface 7 is a surface of revolution about the point 2 and is so curved as to receive the converging rays from lenses 4 (see Fig. 2) and change their direction into a direction parallel to the axis 8 of the condensers. Referring to Fig. 1, however, it will be seen that all of the rays from the condensers 4 strike the surface of lens 5 normal to the circumference of 5 and therefore proceed towards the focus 2 without change of direction.

A conical recess is cut in the bottom of lens 5, the sides 9 of which form an angle of  $45^\circ$  with the parallel rays 10 from the condensers. The surfaces 9 are polished and silvered to form a reflector, and the rays 10 impinging upon 9 are reflected in a direction perpendicular to the direction which they had before reflection, resulting in a beam of light 11 symmetrically disposed about the axis 2, which latter is perpendicular to the plane of the lights 1 represented in Fig. 2 by the line 8.

Assuming that the lights 1 are theoretical points of illumination without dimensions, the conical beams 6 would be of uniform intensity; but Fig. 2 shows by the ordinary methods of geometrical projection that the resulting beam 11 will not be of uniform intensity over its cross-sectional area, nor will the beams from lights 1 combine to form a solid resultant beam, nor will the latter be of circular cross-section. The individual elements combining to form beam 11 will have a form 12 such that between adjacent elements there will be an unlighted space 13. The reflected beams 12 touch each other at only two points, namely on the circle 14 and at the center 2. At all other points there is a gap which would be devoid of light, provided all the rays of beam 11 are exactly parallel. This would be the case if the converging rays from condenser 4 all come to an exact focus at point 2. This, however, is a theoretical condition which cannot be exactly reproduced in practice due to the fact that any source of light cannot be a point. It must have some length and breadth; and, therefore, since all of the rays of the light do not emanate from one point, they cannot be brought to a focus again at one point. This inaccuracy of focusing would result in some stray rays mixed with the parallel rays of beam 11, and these stray rays tend to fill in the gap between the beams 12.

Since the beam from condenser 4 is a cone of light of uniform intensity, it is obvious that the beam 12, which is merely the beam 6 reflected in a different direction, cannot be of uniform intensity since its cross-sectional form has been changed. A right cross-section of the beam 6 at any point is a circle, and the beam 12 would also have to be a circle in order to remain of uniform intensity. For example, if the beam 6 could be so reflected as to produce a circle 15 circumscribed about the beam 12 the beam 15 would be of uniform intensity; but if the same light is gathered together into the beam 12 without changing the distance of the individual rays from the center 2, as is actually done in the construction of Figs. 1 and 2, then it follows that the beam 12 is no longer of uniform intensity. The highest intensity will be at the center 2 and it will gradually diminish from the center outward. It is thus obvious that a single

beam of light of uniform intensity cannot be produced in this way, and if uniform intensity is essential other means of securing it must be provided.

Fig. 3 illustrates a means of producing a beam of uniform intensity and thus overcoming the deficiency of the arrangement just described. Fig. 3 shows the condensing lenses 3 and lights 1 being arranged as in Figs. 1 and 2. A reflector 16 is provided at the center instead of lens 7. This reflector 16 may be of opaque material, such as speculum metal with polished faces to serve as reflectors. The form of 16 is that of an octagonal pyramid, the sides of which make an angle of  $45^\circ$  with the base.

In each of the eight conical beams 6 there is interposed a rectifying lens 17 so designed as to transform the conical beam 6 into a cylindrical beam 18, provided all of the rays from 6 are permitted to pass through 17. The surface of lens 17, however, is covered by an opaque coating as indicated by the shaded portion of the projected view of 17. This opaque covering is so applied as to leave a transparent triangular portion 19 through which light is permitted to pass. The triangle 19 has an angle of  $45^\circ$  at the apex and is inscribed in the circle 18, which latter is the circle of light cast upon the concave surface of lens 17 by beam 6.

The object of inscribing the triangle 19 in circle 18 is to get the largest triangle which would be covered by the impinging beam of light. The angle at the apex depends upon the number of lights used. If there are eight lights this angle is  $\frac{1}{8}$  of  $360^\circ$ , which is  $45^\circ$ . If there are six lights the angle is  $\frac{1}{6}$  of  $360^\circ$ , which is  $60^\circ$ . If there are four lights the angle is  $90^\circ$ .

Due to the fact that lens 17 resolves the conical beam 6 into a cylindrical beam of parallel rays, the beam 20 passing from lens 17 to reflector 16 will be of triangular cross-section, having the shape of triangle 19 and consisting of parallel rays. Beams 20 impinging upon one face of reflector 16 will be reflected in a direction perpendicular to the direction of incidence, producing a beam 21 of identical cross-section as the beam 20; and the shape of beam 21 will be such that eight of them placed edge to edge will produce a solid octagonal beam 22. Since beam 6 is of uniform intensity, beam 20 will be of uniform intensity and consequently beam 21 will also be of uniform intensity. This, of course, will produce a beam 22 of uniform intensity.

Fig. 4 shows an arrangement using six lights instead of eight. The reflector 23 is a hexagonal pyramid, the sides making an angle of  $45^\circ$  with the base. In this case if the transparent spot on lens 17 were an inscribed triangle, the apex angle being  $60^\circ$  as shown and the base a dotted line 24, the resulting

beam produced by the six lights would be of hexagonal cross-section. If, however, the base 24 of the triangle be omitted and replaced by the arc 25 of the circumscribed circle, the resulting beam will be as shown by the outline 26. If, however, the transparent spot extends only to the dotted line 27, which is an arc struck from the apex of the angle, then the resulting beam will be of circular cross-section as shown by the dotted line 28.

Ordinarily an irregular shape, such as 26, would have no greater covering capacity than the circle 28, but in special cases it may have. For example, in illuminating a motion picture film in the projector, the standard picture space on which is  $\frac{3}{4} \times 1''$ , the covering capacity of the beam 26 would be as shown by the inscribed rectangle 29, whereas the covering capacity of the beam 28 would be that shown by the inscribed rectangle 30, which is somewhat smaller than 29.

Fig. 5 is a modification of Fig. 3, where the axis of the beams of light falling upon the reflector is not perpendicular to the axis of the reflected beam. The object of this arrangement is to gather the cluster of lights together into a smaller space. The details of this arrangement are the same as in Fig. 3, the reflector 16', however, being changed in respect to the angle between the sides of the pyramid and the base. In this case the angle of the sides is such as to reflect the rays in a direction parallel to the axis of the pyramid according to the well-known optical principle that the angle of incidence is equal to the angle of reflection.

Fig. 6 is another modification of Fig. 3, in which the axis of the condensers is parallel to the axis of the resulting beam 21, the lights and condensers being symmetrically disposed about the axis 2 of the combined beam. In this case a flat reflector 31 is provided with each light unit to reflect the triangular beam transmitted through lens 17 to the reflecting surfaces of pyramid 16, where it is again reflected and combined with the beams from the other lights to form an octagonal beam 22.

In Fig. 7 there is shown an arrangement to produce a square beam from two lights. In this case the transparent spot on lens 17 would be square as shown at 32. The reflector consists of two parts 33 and 34. Part 33 is one-half of a square pyramid, the sides of which make an angle of  $45^\circ$  with the base. It is produced by dividing such a pyramid by a plane 35 passing through the axis and two corners of the base.

Reflector 34 is the inverse of reflector 33, and may be considered as a form cast from the outside of reflector 33. The reflecting surfaces of 34 are one-half of an inverted square pyramid identical with the reflecting surfaces of 33.

Considering the square 32 to be divided in-

to two equal right angle triangles by the line 36 it will be seen that the beam from the upper triangle is reflected by 33 and fills the triangular space 37 in the reflected beam. The light from the lower triangle, however, passes below and clear of reflector 33, impinges upon reflector 34 and is reflected to fill the triangle 38 in the reflected beam. Similarly, the beam from the other of the two lights is reflected to fill the triangles 39 and 40, thus forming a complete square beam of uniform intensity.

Fig. 8, a modification of Fig. 7, is designed to produce a rectangular beam of uniform intensity, such as would be required to cover the picture space on a standard motion picture film. In this case the reflectors are the same as 33 and 34, except for the base of the pyramid, which is a rectangle of the proper size and proportions to produce a rectangular beam of the desired form. The transparent spots 41 and 42 instead of being square are parallelograms. The shape of 41 is such that if divided into two equal triangles by the line 43, each triangle would be identical with the triangles 44 of the combined beam. The shape of 42 is such that if divided into two equal triangles by the line 45, each of these triangles would be identical with the triangles 46 of the combined beam. The result, of course, is a solid rectangular beam of uniform intensity.

In respect to all of these arrangements it should be noted that the object of covering a portion of lenses 17 with an opaque covering is to restrict the transmitted beam to a form which will fit into and no more than fill its allotted space in the combined beam. Covering a portion of these lenses with opaque material, of course, involves a considerable loss of light; and if it is not important to produce a resultant beam of parallel rays, this opaque covering could be omitted. This would not result in any diminution of the resultant parallel rays. It would merely result in adding stray rays irregularly reflected from faces of the reflector other than the face provided for reflection of each individual impinging beam.

Fig. 9 shows a modification of Fig. 2, wherein the face 47 of lens 7' is made of convex form in order to produce a converging beam of light rather than a parallel one. The beam of light reflected from 9 leaves the reflector with parallel rays as in Fig. 2, but these rays when they pass through the convex surface 47 are refracted and brought to a focus at some point 48, depending upon the curvature of 47. With reference to Fig. 9 it is obvious that if the surface 47 were made concave instead of convex the resulting beam would be diverging instead of converging.

It will of course be understood that, in actual practice, the invention may not be carried out with the theoretical nicety as

shown by the drawings and described by the specification and claims, possible deviations being due to the fact that it is not possible to obtain a point source of illumination, upon which the herein disclosed theory is based. However, the possible deviations in practice are not of such a material scope as to interfere with the successful operation of the device which would conform substantially to the theory of operation.

We claim:

1. In combination, a plurality of light sources, a reflecting means, and light directing means including a condenser and a rectifying lens associated with each of said light sources adapted to direct said light in parallel rays impinging upon said reflecting means, said reflecting means adapted to combine all of said impinging rays from all of said light sources into a single beam of substantially uniform intensity constituted by substantially parallel rays.

2. In combination, a plurality of sources of light, means comprising condensing lenses associated with each of said sources, for directing light therefrom so as to have a substantially common point of focus, and means comprising a central lens and a common reflecting member, for combining said light into a single beam, of substantially uniform intensity.

3. In combination, a plurality of sources of light angularly disposed relative to an axis, light directing means comprising condensing lenses associated with each of said sources, for causing light from each of said sources to have a substantially common focal point, and means comprising a central lens and a common reflecting member, for further directing and combining the light so that it will fall substantially along said axis as a single beam, of substantially uniform intensity.

4. In combination, a plurality of sources of light, condensing and rectifying lenses associated with each of said sources, and a common reflecting member upon which light passing through said lenses will fall in a series of beams symmetrically disposed with relation to the axis of said reflecting member and thence be directed as a single beam of substantially uniform intensity.

5. In combination, a plurality of light sources, a reflecting means, and light directing means including a condenser and a rectifying lens associated with each of said light sources adapted to direct said light in parallel rays impinging upon said reflecting means, said reflecting means adapted to combine all of said impinging rays from all of said light sources into a single beam of uniform intensity.

6. In combination, a plurality of sources of light, and combining means comprising condensing lenses associated with each of said

sources, a central lens, and a reflecting member, said central lens and said reflecting member being common to each of said sources, said means combining the light from all of said sources into a single beam constituted by the elements from said sources, which elements follow defined separate, contiguous paths whereby said single beam has a substantially uniform intensity throughout its cross-sectional area.

7. In combination, a plurality of sources of light, light controlling devices comprising condensing lenses and rectifying lenses having opaque and transparent portions of predetermined shape, associated with each of said sources whereby beams of light are obtained each having determined cross-sectional shape, and light directing means comprising a common reflecting member having light controlling surfaces of such shape as to receive said determined shaped beams of light and combine the same as a single beam, as set forth.

8. In combination, a plurality of sources of light, light controlling devices comprising condensing lenses and rectifying lenses having opaque and transparent portions of predetermined shape, associated with each of said sources whereby beams of light are obtained each having determined cross-sectional shape, and light directing means comprising a common reflecting member having light controlling surfaces of such shape as to receive said determined shaped beams of light and combine the same as a single beam having substantially uniform intensity, as set forth.

9. In combination, a plurality of sources of light, means comprising condensing lenses and rectifying lenses having opaque and transparent portions of predetermined shape, associated with each of said sources, for controlling light therefrom so as to produce beams of a determined cross-sectional shape, and a common reflecting member upon which all of said beams fall and from which all of said beams are directed and combined as a single beam, said common member having an individual surface for each of said determined beams of light, and said surfaces having a shape so that the light projected therefrom will be of uniform intensity, as set forth.

10. In combination, a plurality of light sources, means for directing substantially all of the light from said plurality of sources, and a common member upon which the directed rays impinge having reflecting surfaces of an outline similar to the cross-sectional outline of the directed rays from said directing means.

11. In combination, a plurality of light sources, a common member having a plurality of reflecting surfaces of predetermined shape, and each surface cooperating with only one light source, means comprising condensing

lenses, shielding devices and a central lens associated with each of said sources whereby the light from each source impinges only upon its cooperating reflecting surface and substantially covers the same, whereby the beams of light reflected from each of said surfaces are combined into a single beam of substantially parallel rays and of substantially uniform intensity throughout.

12. In combination, a plurality of light sources and means comprising condensing lenses and shielding devices associated with each of said sources, a central lens and a common reflecting member for directing the beams of light from said sources so as to group them symmetrically about a common axis, the adjacent surfaces of said beams being tangent to each other and combined, whereby a substantially single beam is provided, the whole of which is of substantially parallel rays and of substantially uniform intensity throughout.

13. In combination, a plurality of light sources and means comprising condensing lenses, rectifying lenses having opaque and transparent portions of predetermined shape, associated with each of said sources, and a common reflecting member, for directing the beams of light therefrom so as to group them symmetrically about a common axis, the adjacent surfaces of said beams being tangent to each other at all points, as set forth.

14. In combination, a plurality of light sources and means comprising condensing lenses, rectifying lenses having opaque and transparent portions of predetermined shape, associated with each of said sources, and a common reflecting member, for directing the beams of light therefrom so as to group them symmetrically about a common axis, the adjacent surfaces of said beams being tangent to each other at all points, each of said beams thereby forming a single beam composed only of said beams having adjacent surfaces and said single beam being free of overlapping of said component beams, as set forth.

15. In combination, a plurality of light sources, a common member adapted to direct and combine the light from said sources into a single beam, and diaphragmatic means being interposed between said light sources and common member having an opening similar in outline to the surface of said common member upon which the light from said sources falls.

16. In combination, a plurality of light sources, a common member upon which light from said sources falls and are directed into a single beam, and a member interposed between each light source and said common member and having an opaque portion of predetermined shape, thereby to form a predetermined shaped opening through which the light from the sources may pass, and said common member having a surface for each

source and which is similar in outline to said opening.

17. In combination, a reflector, a plurality of light sources, said sources being symmetrically disposed about a central axis coincident with the axis of said reflector, and means for projecting the light from each of said sources upon the adjacent surface of said reflector, the reflector surface being so formed and disposed as to reflect the beams from said light sources into a composite beam whose axis is coincident with the axis of said reflector.

18. In combination, a polygonal reflector, a plurality of light sources symmetrically disposed about a central axis coincident with the axis of said polygonal reflector, and means for projecting the light from each of said sources upon an adjacent plane face of said polygonal reflector, the faces of said reflector being so formed and disposed as to reflect the beams from said light sources into a composite beam whose axis is coincident with the axis of said reflector.

CHESTER W. LARNER.  
SYDNEY J. SANFORD.