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P. H. MITCHELL
REFLECTOR FOR LIGHTING

2,414,657

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2 Sheets-Sheet 1

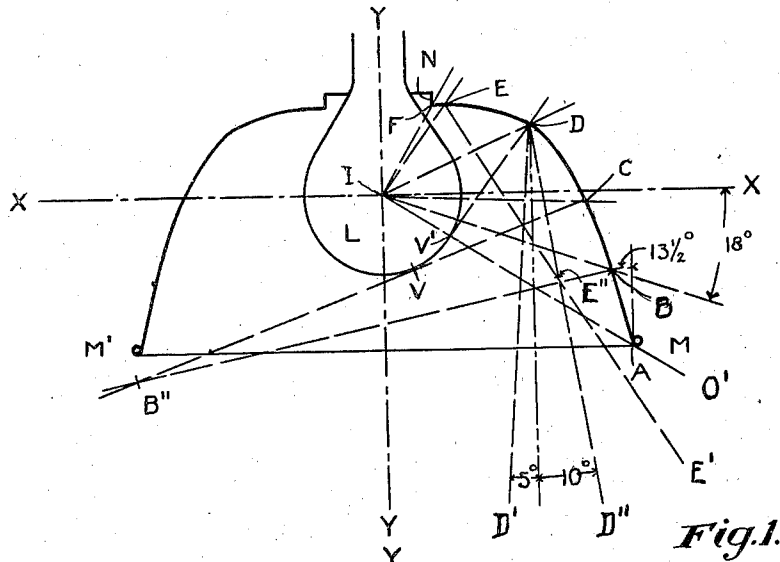


Fig. 1.

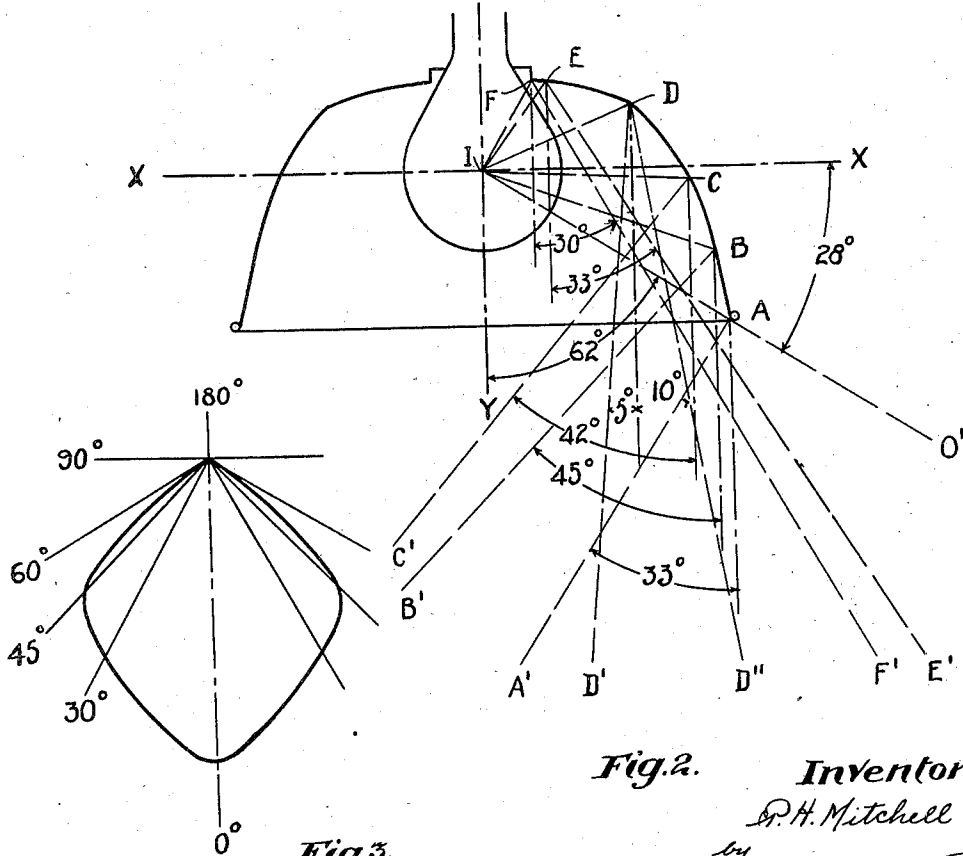


Fig. 2.

Fig. 3.

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2 Sheets-Sheet 2

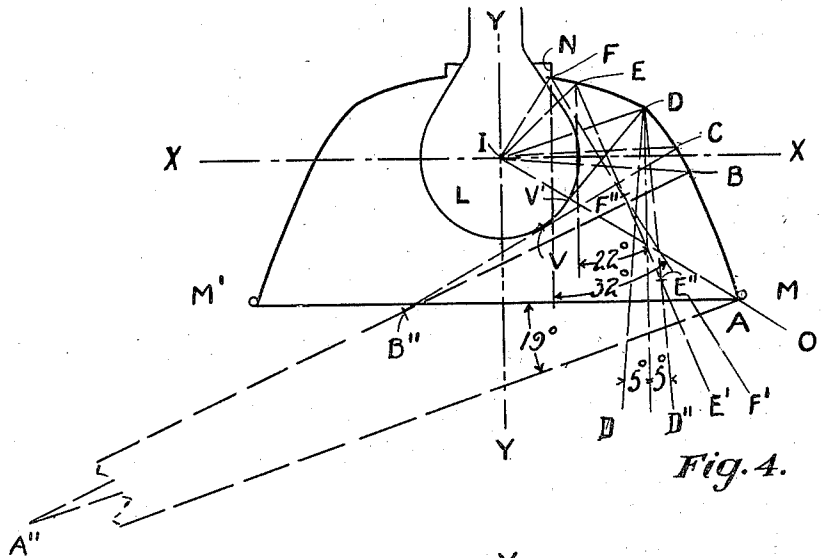


Fig. 4.

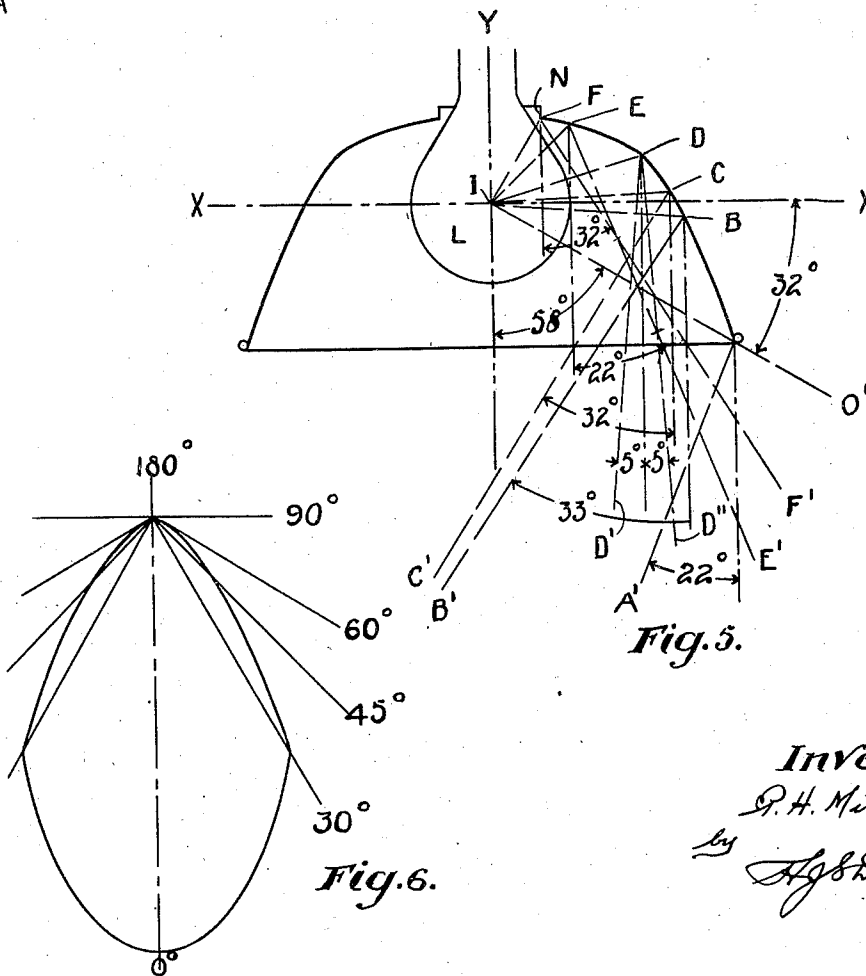


Fig. 5.

Fig.6.

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UNITED STATES PATENT OFFICE

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REFLECTOR FOR LIGHTING

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5 Claims. (Cl. 240—103)

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This invention relates to improvements in reflectors for lighting and particularly for illuminating factory or working areas and the principal objects of the invention are to provide means for distributing the light from a group of light sources substantially uniformly over a given area and to effectively project the maximum quantity of the produced light to illuminate the area without harmful glare effect from the light sources themselves.

A further and important object is to provide a lighting unit of relatively small over-all diameter which will produce high efficiency in lighting effect.

A still further object is to provide a reflector which will enable the efficient use of standard inside frosted light bulbs.

The principal feature of the invention consists in the novel construction of a specular reflector whereby the direct rays from the light source are permitted to shine downwardly and outwardly within a limited area and rays emanating from various portions of the sides and upper portions of the light source are reflected downwardly and spread angularly free from interference or absorption by the light bulb to illuminate a centralized area by reflection from a systemic sequence of annular specular reflecting surfaces.

In the accompanying drawings—

Figure 1 is a vertical mid-sectional view through a reflector constructed in accordance with this invention and illustrating its arrangement of systemic sequence of annular surfaces relative to an electric light bulb.

Figure 2 is a view similar to Figure 1 illustrating diagrammatically the angles of light distribution from the several annular surfaces.

Figure 3 is a polar diagram of the distribution of light from the reflector illustrated in Figures 1 and 2.

Figure 4 is a vertical mid-sectional view similar to Figure 1 illustrating a modified construction of reflector with the same general principles as the reflector illustrated in Figures 1 and 2.

Figure 5 is a diagram similar to Figure 2 illustrating the light reflection from the reflector illustrated in Figure 4.

Figure 6 is a polar diagram of the light distribution from the reflector illustrated in Figures 4 and 5.

In area lighting where lamp and reflector combinations are spaced apart and mounted above the area it is extremely desirable that there will be substantially uniform illumination throughout such area.

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A common practice in such lighting has been to use reflectors having diffusing reflecting characteristics with clear or inside frosted incandescent lamps, and where such reflectors are relatively small, as is desirable for economic reasons, such reflectors reflect an appreciable portion of the light incident on them from the incandescent light source back through the lamp bulb or back onto the reflectors and loss of lighting effect occurs from extra reflecting paths or absorption by the glass bulb.

It will be readily understood that when inside frosted lamps are used the transmission of reflected light back through the bulb is quite low. Consequently the efficiency of such lighting is quite low.

If clear glass incandescent lamp bulbs are used considerable loss of efficiency occurs if reflecting the light back through the bulb and it is also found that a smooth gradation of intensities cannot be obtained when using a specular reflector as the filament of the lamp when reflected produces an irregular and sharply contrasting distribution and uniform illumination of the area cannot be obtained.

The present invention has been devised so that no light emanating directly from the filament of an inside frosted lamp is reflected back through the lamp bulb, nor is there any material second surface reflection of such light. All light distributed over the area from a lighting unit constructed in accordance with this invention is directed to the area either directly from the lamp bulb or in a single reflection from the filament to the area, and the light from different sections or areas of the light bulb is distributed to different zones of the lighted area.

In the construction of reflectors as illustrated in Figures 1 and 2, the lower or rim zone forming an annulus extending upwardly from the line MM' and indicated by the letters AB, preferably converges at an angle of about $13\frac{1}{2}^\circ$ from the perpendicular, or a line parallel to the axis YY.

The upper limit of the zone AB intersects the line IB 18° below the line XX which passes horizontally through the centre of the filament I of the lamp bulb L.

An annular zone BC, to which the annular zone AB is tangent, is formed by the revolution of an arc about the axis YY having the radius BB'', and the radius B'' cuts the perimeter of the light bulb at V.

The annular zone CD extending upwardly and converging inwardly from the zone BC is curved inwardly, the line C—D being in the form of an

involute having its evolute VV' on the surface of the lamp bulb L .

The curvature of the arc CD is such that rays of light emanating from I are reflected from the upper terminus D of the annular zone CD inwardly from the vertical, that is, parallel with the axis YY , 5° .

From the upper terminus D of the zone CD the reflector converges sharply inward in an elliptical curvature represented by the line DE and rays of light emanating from I are reflected from the zone DE at a point adjacent to D outwardly at an angle of 10° from the perpendicular.

Rays of light emanating from I and reflected from the inner terminus E of the zone DE are reflected downwardly and outwardly at an angle 33° from the perpendicular, and the foci of the elliptical curve of the zone DE are the point I and the point E'' , which is the intersection of the 33° angle of reflection from the point E and the 10° angle of reflection from the point D .

The zone EF extends horizontally inward from E to the collar N , which extends vertically and forms a means for attaching the reflector to a suitable support in which the lamp L is secured.

It will be seen on reference to the diagram Figure 2 that light rays emanating from I striking the zone FE are reflected downwardly and outwardly from angles ranging from 30 to 33° from the perpendicular, and these rays pass inside the rim circumference A of the reflector. Rays of light emanating from I and reflected from the elliptical surface ED are projected downwardly and outwardly from the point E as described, and from points between E and D the reflected rays spread downwardly toward the line DD'' , which has been stated is 10° from the perpendicular on the outward side from the line EE' .

Rays emanating from I and reflected from the annulus DC are reflected on the line DD'' and spread inwardly to the line CC' , and rays from I are reflected angularly inward from B on the line BB' and spread to the line AA' .

It will be understood that the direct rays of light from I extend outwardly and downwardly in a zone bounded by the line IO' at an angle 28° from the horizontal line XX . All other rays of light extending radially from I and intercepting the reflecting surfaces of the reflector above the point A are directed angularly inwardly, angularly downwardly and angularly outwardly within the space between the perimeter of the light bulb L and the reflector without secondary reflection or without intersecting the bulb. The maximum of light emanating from the bulb is thus conserved and spreads with desirable gradation in intensities over the area illuminated and the polar diagram of distribution is in the form illustrated in Figure 3, which it will be understood is a very desirable distribution of illumination leading to substantially uniform illumination of an area where several such lighting units are grouped.

In the modification of the reflector illustrated in Figures 4 and 5 the design has been altered from that illustrated in Figures 1 and 2 to produce a narrower distribution of light than that of the reflector described and is particularly adaptable to use at higher mounting heights, such narrower distribution being illustrated by the polar diagram of Figure 6.

According to the design shown in Figure 4 the inwardly converging zone AB is represented by the line AB formed as the arc of a circle with

a radius AA'' approximately equal to four times the diameter of the reflector MM' , the radius from A being inclined at an angle of 19° below a line extending from M to M' .

The arc of the zone from A to B is extended until the point B reflecting light from I , the centre of the filament of the lamp bulb L , reflects at 33° to the vertical. The arc from B to C producing the annular zone BC is formed on a radius BB'' with a radius CB'' cutting the curvature of the lamp bulb at V .

The zone CD is formed with a curvature of an involute of the evolute VV' on the perimeter of the lamp bulb, the point D being at a position which will reflect light rays emanating from I downwardly and inwardly 5° from the vertical.

The annular zone DE converges sharply inward from the zone CD and is in the curvature of an ellipse, the foci of which are the point I , and the point E'' on the line of the angle of reflection from the point E to E'' on an angle 22° from the perpendicular where it intersects with a line of reflection from a point on which the annulus DE adjacent to the point D extends 5° outwardly from the perpendicular on the line DD'' .

The annular zone EF has a curvature of elliptical form having foci at I and F'' and is a continuation of the elliptical arc DE , which is the point of intersection of the line FF'' with the line EE' , the line FF'' being the line of outwardly directed reflected rays from the point F 32° from the perpendicular.

In both forms of the reflector herein shown the light is emitted from the lamp freely downward until the reflecting enclosure is encountered at the rim A , the light extending outwardly on the line IO' , the light striking the lower zones AB and BC being reflected inwardly and downwardly.

The succeeding curvature of the involute zone CD reflects light rays emanating from the bulb L in an inward and downward direction and coincidentally light from the luminous top of the bulb at the neck of the reflector when reflected from any point from C to D is reflected without being obstructed by the reflector in the region of A .

The reflector zones DE and EF , while reflecting light direct from the filament without obstruction, do direct some portions of the light from the luminous bulb to be incident on the light bulb and on the reflector, and in this respect involves second surface reflection, but this does not exceed one per cent of the total light emitted by the lamp.

The total efficiency of the lamp and reflector combination can be computed from the three principal spherical zones of distribution of light from the lamp bulb. A very small portion of the light efficiency is lost in the neck opening of the reflector and this is made as small as possible consistent with the mechanical requirements such loss being approximately from 5 to 7% of the total light.

The light emitted directly from the lamp without being incident on the reflector is of the order of 22 to 27% of the total light. The remainder is incident on the reflector. The resultant efficiency is found to be approximately 84% of the light emanating from the bulb.

Figure 1 shows the curvatures of the reflecting surface which will result in the distribution shown in Figure 3, and Figure 4 shows the curvatures

for the distribution in Figure 6. Curvatures can be modified to obtain distributions of the typical form shown with upper angular limits of high intensity intermediate between the two distributions shown and also higher than shown in Figure 3 and lower than in Figure 6. Variations on the two distributions shown are obtainable by maintaining the sequence of zonal elements in the reflectors but changing radii, angular inclination of surfaces, and the angular boundaries of light incident from the source on the zonal reflector elements.

In the two forms shown in the figures each has a smoothly continuous curvature from A to D and from D to F; tangents to the two curvatures would meet at D at a very obtuse angle. The revolution of this figure about the vertical axis YY describes the complete annular reflecting surface. The curvature from A to D comprises three zones, AB, BC and CD. The curvature from D to F comprises two zones DE and EF. In each form the zone BC has a curvature for the reflector which intensifies the upper angular boundary light while the zone AB distributes light up to this boundary from an angle equal to approximately two thirds of the angle to the boundary. For instance the designed upper boundary in Figure 1 is 45° and in Figure 4 is 33° which results in the "elbow" of the polar diagram curves in Figures 3 and 6 being at about $42\frac{1}{2}^\circ$ and 30° respectively. In each figure, 1 and 4, the zone CD distributes light from near the maximum angle down to adjacent the nadir while the two elements DE and EF distribute light from adjacent the nadir up to the angle corresponding to the angle of light directed from the point A on the reflector. In the two examples shown and in variations from these examples the same sequence of reflecting zones is maintained.

A feature of this design is that the axes for light reflected to the vicinity of the nadir do not direct to the nadir but to an angle of 5° , at the least, from the nadir. The angular spread due to size of the filament does not bring the filament light to the nadir. Actually at the nadir light comes direct from the lamp and also by reflection of the luminous inside frosted lamp bowl from a considerable area of the reflecting surface. It is found that the amount of light reaching the nadir is sufficient to satisfy the intensity requirements to obtain the curvatures of intensities shown in the polar diagrams.

It will be understood that when numerous lighting units such as described will be used to illuminate an extensive area, such as in a large factory, such lights are in sight of the worker, and the open bottoms of the reflectors are visible and appear as ellipses.

When diffusing reflectors are used the reflection of the light source has components along the line of sight of the workers and the visible illuminated elliptical surfaces have the effect of small areas of light in the immediate foreground and as many more distances sources are in view they merge into a general overhead field of high intensity light. Such conditions are considered to produce glare effect and they do not permit comfortable vision.

Reflectors such as herein described eliminate such glare conditions. The direct light cut-off is about 60° so that the actual filament is shielded well below the 65-degree lower limit of the generally accepted critical glare zone. The glow of the visible inside frosted lamp bulb up to about

74° is of a low brightness and within comfortable vision range. The highest elevation of the light reflected from the filament is along an axis from B in Figure 2, which is 45° from the vertical, and from B in Figure 4, which is at 33° from the vertical. The reflection from the bottom of the luminous lamp bulb reaches its highest angle from the point B, which in Figure 1 is approximately 62° and in Figure 5 is approximately 58° but such reflection is of low brightness.

These angular measurements will be fully appreciated when given in spacing-mounting height measurements, and when lighting units, such as described herein, are in the field of vision and the horizontal distance to the unit from the observer is twice the height above the observer's eyes, the incandescent filament is shielded from vision. The low brightness bulb and its reflection is visible but no filament light is reflected by the reflector surface to the observer's eyes. When the horizontal distance to the unit is three and one half times the height above the observer's eyes the luminous bulb is completely shielded and no light is reflected by the reflector surface to the observer's eyes. The ultimate result is that glare is minimized or entirely absent and when several units are in the field of vision a very satisfactory light effect is produced.

What I claim as my invention is:

1. A specular light reflector surrounding a light bulb arranged in its axis and having a lower annular reflecting zone the upper limit of which reflects an annulus of light from the bulb at the highest outward angle of reflection of the reflector and the lower terminus reflects light in a zone intermediately between such high angle and the axis, such annular light beam crossing the axis and forming an annular light cone, a second annular zone continuing upwardly and curving inwardly from the lower zone and reflecting an annular beam of concentrated rays spreading downwardly from an angle immediately below the aforesaid highest angle of reflection, said beam crossing the axis and forming an annular light cone continuing downward and inward from the aforesaid cone, a third annular zone continuing upwardly and curving inwardly from said second zone and reflecting an annular light beam of concentrated light rays crossing the axis and spreading downwardly toward the nadir, none of said zones reflecting light directly to the nadir, and a fourth annular reflecting zone arranged in obtuse angular relation to and extending upwardly and inwardly from the third zone and reflecting an annular light beam downwardly and outwardly beyond the nadir to augment the light reflected by the aforesaid reflecting zones.

2. A specular light reflector as claimed in claim 1, in which the lower reflecting zone comprises a slightly conical annulus, the second reflecting zone being an annulus of arc-shaped curvature to which the lower zone is tangent, the third reflecting zone continuing upward from the arc-shaped zone being of involute curvature, and the fourth reflecting zone arranged in obtuse angular relation to the involute zone is of elliptical curvature.

3. A specular light reflector surrounding a light bulb arranged in its axis, comprising two principal annular reflecting zones forming a discontinuity in the curvature of the reflector surface at their juncture, each of said principal reflecting zones comprising a plurality of annular reflecting zones generated by the revolution of lines

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of different predetermined curvatures but so arranged that the curvature of the reflecting surface throughout each principal zone is continuous, whereby light rays reflected from the lower of the principal zones are carried to form a hollow light cone surrounding the nadir, and the light rays reflected from the upper of the principal zones are caused to diverge and augment the intensity of light surrounding the nadir, said nadir being illuminated mainly by the light rays emanating directly from the bulb.

4. A specular light reflector as claimed in claim

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3 in which all the reflected light rays are directed past the light bulb without obstruction thereby.

5. A specular light reflector as claimed in claim

3 in which the principal reflecting zones are so arranged, and the curvatures of the annular zones comprising the principal zones are such that all light rays striking the reflector are directed between the light bulb and the rim of the reflector eliminating any secondary reflection or absorption.

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