July 2, 1935. P. E. NOBBS 2,006,648

LIGHTING SYSTEM

Filed Feb. 21, 1934 2 Sheets-Sheet 1

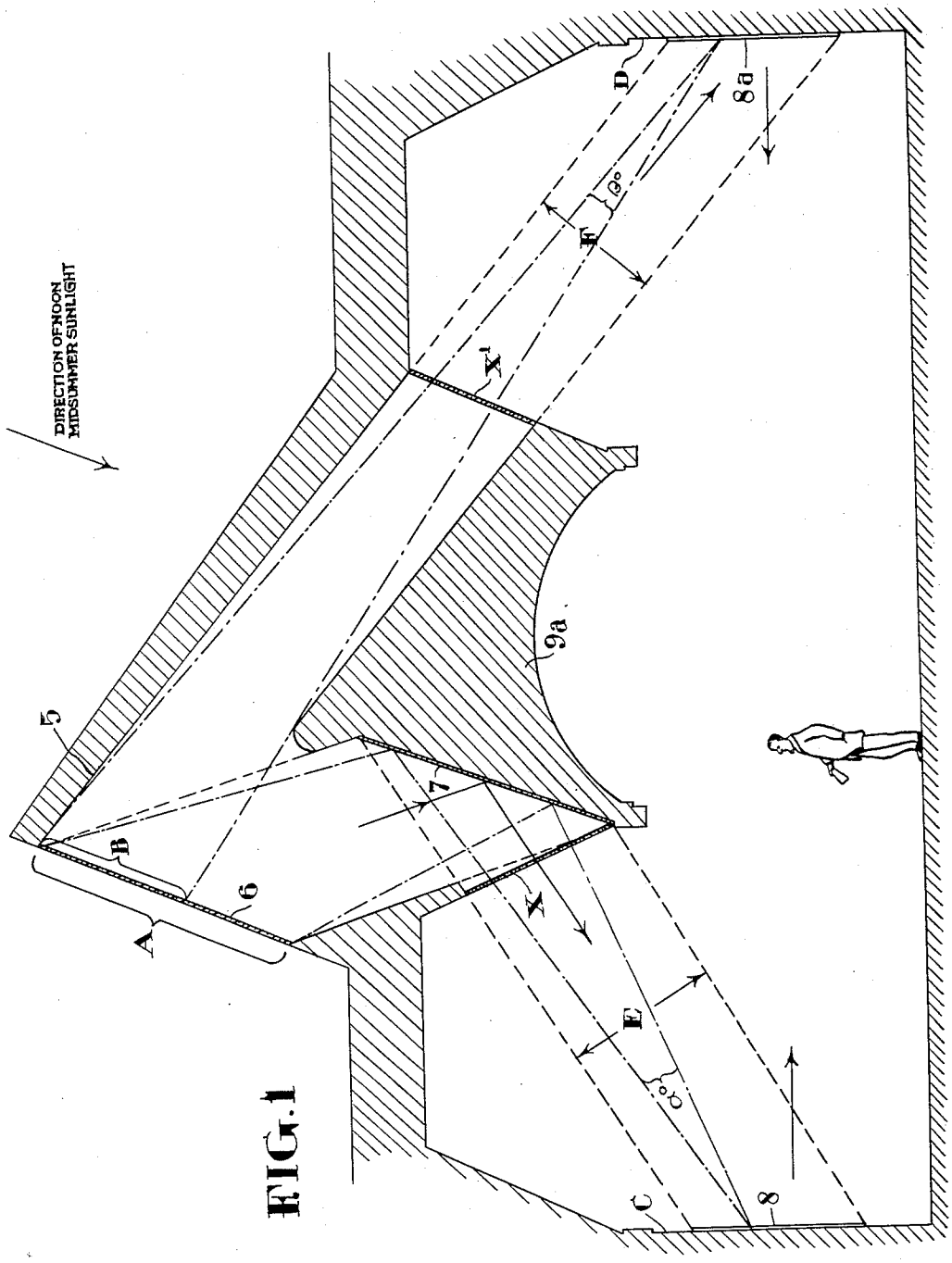

FIG. 1

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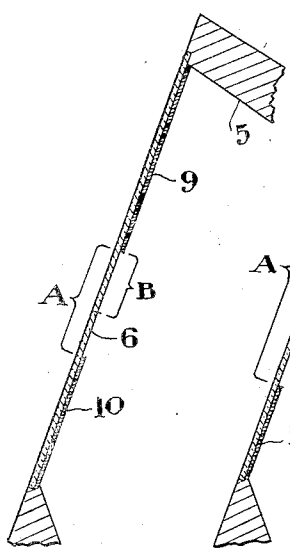

FIG.2

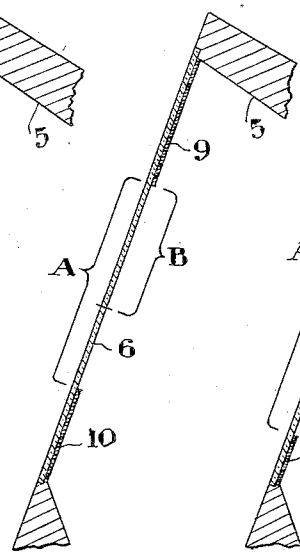

FIG.3

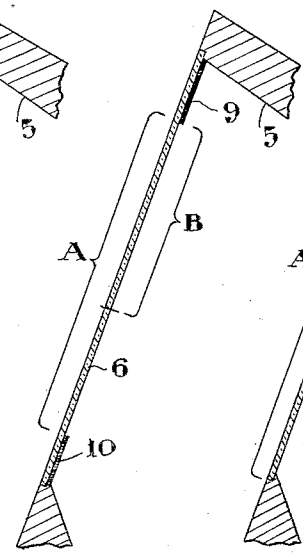

FIG.4

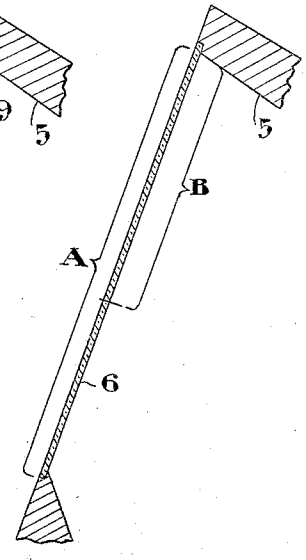

FIG.5

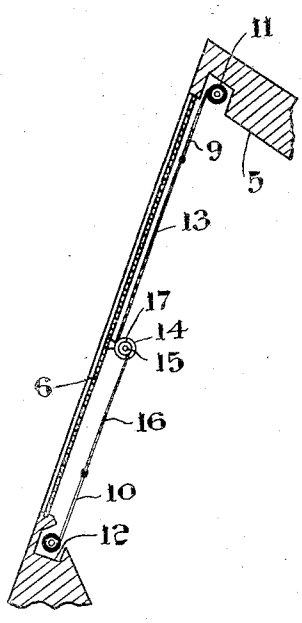

FIG.6

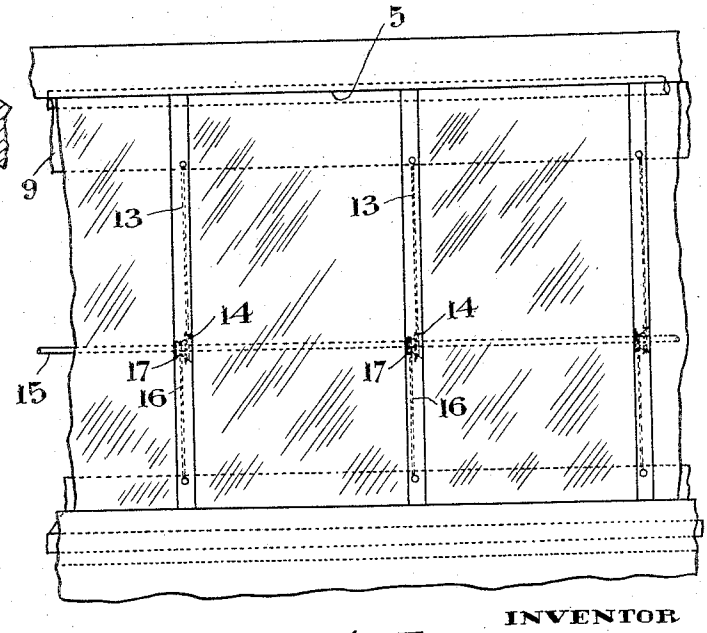

FIG.7

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LIGHTING SYSTEM

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12 Claims. (Cl. 88—57.5)

This invention relates to the lighting of picture galleries, museums, exhibition rooms, studios, workshops, laboratories, and other enclosures. More particularly, it comprises an improved system and method of lighting whereby direct and reflected beams of sunless white light, admitted through a single appropriately designed skylight, are respectively directed towards different walls or areas of an enclosure to afford adequate and otherwise satisfactory illumination of exhibits or working spaces.

One of the chief objects of this invention is to provide, in the case of a picture gallery, for the illumination of opposite walls with sunless white light that is of the required intensity; is directed towards the walls at a suitable angle from the horizontal; and is distributed with an adequate degree of uniformity over the pictures hung on said walls.

Another object is to provide, in the case of a picture gallery, for relatively low illumination of the floor area used by visitors, thus reducing reflections in the glasses or varnished surfaces of the pictures so that they appear to better advantage.

A further object is to provide a system of lighting, of the character described, requiring only a moderate amount of exterior glazing and thus more economical as regards construction, maintenance and heat losses than the lighting systems commonly in use in picture galleries.

A still further object is to provide a system for lighting interiors by sunless white light in which reflected light is employed to give effective illumination of areas which could not be reached by a direct flux of sunless light from the sky; or which could be reached only by light transmitted through openings exposed to sunlight.

Proceeding now to a more detailed description reference will be had to the accompanying drawings, wherein—

Fig. 1 illustrates a preferred example of the invention as embodied in a picture gallery, assumed to require from twelve to twenty foot candles of illumination on opposite walls, with a considerably lower illumination over the intermediate floor area used by visitors.

Figs. 2, 3, 4 and 5 are diagrammatic views illustrating the use of blinds for maintaining constant illumination by regulating the effective light transmitting area of the skylight in accordance with the brightness of the sky.

Fig. 6 is a vertical sectional view through a portion of the skylight illustrating one method of mounting and operating the light controlling blinds.

Fig. 7 is a view, in front elevation, of the structure appearing in Fig. 6.

As clearly shown in the drawings, the light is admitted to the gallery by means of an ordinary "saw tooth" or "weaver beam" skylight **5** having its glazed light transmitting opening **6** facing in a northerly direction and inclined to lie at an angle in the vertical plane appropriate for the exclusion of sunlight during desired hours of use at a given latitude. In calculating the light transmitting area of the skylight it is necessary to take into account (*a*) the degree of illumination required on the wall or walls to be illuminated by reflected light; (*b*) the coefficients of absorption of the light transmitting and reflecting mediums; and (*c*) an assumed minimum outside sky illumination such, for example, as that available at 4 p. m. on the shortest day at 45 degrees of latitude.

Having thus determined the required light transmitting area of the skylight, provision is then made for reflecting the whole of the glazed skylight opening A onto the gallery wall C below the skylight, while admitting a direct flux of light from the part B of the skylight opening to the opposite gallery wall D. This is accomplished by the provision of the reflecting surface indicated at **7**. Such reflecting surface may comprise an ordinary mirror, a silver reflecting surface deposited on glass, or any other kind of reflector having a high light reflecting coefficient.

Correct apportionment of the ratio of the whole area A of the skylight opening (used as the source for reflected light) to that portion B of such opening, which furnishes a direct flux of light to the wall opposite the skylight, is important to successful application of the lighting system described herein. In calculating this ratio the principal factors to be considered are (*a*) the light absorption coefficients of the light transmitting and reflecting mediums respectively indicated at **6** and **7** (and at X and X' if installed); (*b*) the luminosities of the different parts of the sky from which the direct and reflected beams of light employed for illuminating the opposing walls C and D of the gallery are respectively derived; and (*c*) any differences of the angle of incidence between these two beams of light which are respectively indicated at E and F. The geometrical construction for the design of the structure in relation to the required paths of light is based on the above considerations.

Since, in the case of the gallery illustrated in the drawings, the two exhibition walls C and D are assumed to be of equal length, the widths of the whole and of the part of the skylight (respectively indicated at A and B on the drawings) are measures of the whole and of the said part of the skylight area. The plane angles alpha and beta are likewise measures of the solid angles respectively subtended by the areas of the whole and of the said part of the skylight.

It is a well known theorem that "the illumination from a source to a point, in the direction of that point, is proportional to the brightness of the source and to the magnitude of the solid angle subtended by the source". In this case of the present invention the brightness may generally be assumed to be the same, since the source is common to both the direct and reflected beams and the illuminations in the lines of the beams at the two points of observation indicated are directly proportional to the solid angles, the measures of which in the drawings are the plane angles alpha and beta, other things being equal.

The two beams E and F suffer similar absorption in their paths through the transmitting mediums, but the beam E suffers a further absorption at the reflecting surface 7. This is compensated for by laying off the angle alpha (of the reflected beam E) greater than the angle beta (of the direct beam F) in the proportion of the amount of the absorption coefficient of the reflecting surface.

Furthermore, the small differences of the angles of incidence at the corresponding points of observation on the two walls C and D may also be compensated for by adjustment of the angles alpha and beta so as to give equal horizontal illumination at such corresponding points. Still further adjustment of the angles alpha and beta may also be resorted to to compensate for variations of brightness of the sky at the different angles to the horizontal corresponding to the angular directions of the two beams E and F.

In order to provide for uniformity of illumination at all times of the day and at all seasons of the year the present invention also contemplates the installation of adjustable blinds within the skylight adapted to be operated either manually or automatically to regulate the effective light transmitting area of the skylight in accordance with the brightness of the sky.

As it is essential to the maintenance of equality of illumination on both walls C and D that the aforesaid blinds, when reducing the effective light transmitting area of the skylight, should also modify the angles alpha and beta without changing their ratios, separate blinds are employed as indicated in Figs. 2 to 7 inclusive. The blind 9 controls the effective skylight area B which furnishes a direct flux of light to the wall D, while the blind 10 co-operates with the blind 9 to control the skylight area used in reflection. In Fig. 2 the blinds are positioned so that the effective light transmitting area of the skylight is reduced to one-quarter the maximum area available in Fig. 5. In Fig. 3 the blinds are positioned so that the effective light transmitting area of the skylight is reduced to approximately one-half the total area, while in Fig. 4 the position of the blinds is such as to afford an effective light transmitting area equal to approximately three-quarters the maximum light transmitting area available in Fig. 5.

From inspection of Figs. 1 to 5 inclusive it will be clear that the blinds serve to modify the angles alpha and beta respectively subtended by the effective light transmitting areas A and B without altering their ratios.

In actual practice either rigid or roller blinds may be employed for accomplishing the results illustrated in Figs. 1 to 5 inclusive. It will be equally obvious that the particular manner of mounting and operating the blinds is a subordinate feature which may be taken care of in various ways, the important consideration being actuation of the blinds in such a way that the angles alpha and beta will be modified without altering their ratios.

In the construction shown in Figs. 6 and 7 the blinds 9 and 10 are mounted on suitable rollers located in suitable bearings 11 and 12 provided above and below the glazed opening of the skylight. The blind 9 is attached by cords 13 to winding drums 14 fixed to an operating shaft 15. The blind 10 is similarly attached by cords 16 to winding drums 17 on the same shaft. The relative diameters of the two sets of winding drums to which the blinds are attached are predetermined so that the blinds will function in the desired manner to modify the angles alpha and beta without changing their ratios. Any suitable provision may be made for manual or power actuation of the shaft 15.

From the foregoing description it will be seen that the present invention provides, in a novel manner, for the illumination of both walls C and D with daylight that is of suitable quality (i. e. sunless white light); is at a constant intensity (for example, twelve foot candles of illumination); is directed to fall on the walls C and D at a suitable angle (approximately thirty to forty degrees from the horizontal), and is distributed with an adequate degree of uniformity over the pictures indicated at 8 and 8a.

The location of the mirror 7 together with its supporting structure 9a provides for a shaded area over the floor between the walls C and D, so that reflection of the images of observers in the glasses or varnished surfaces of the pictures is reduced to a minimum.

In the present drawings I have shown inner glazing X and X' through which the light beams E and F are respectively transmitted to the walls C and D, but it will be understood that this inner glazing is not always essential and may be dispensed with in certain cases.

Having thus described what I now consider to be the preferred embodiment of this invention, it will be understood that various desired modifications may be resorted to within the scope and spirit of the appended claims. For example, in the case of museums, exhibition rooms, studios, workshops, laboratories or other enclosures the working plane to be illuminated may be horizontal (floors, tables, benches, cases, etc.) whereas, in the preferred embodiment described herein, the working plane (the walls) is vertical. As the scope of this invention applies equally in either case, the word "wall" as used in the appended claims is intended to be interpreted broadly to cover any working plane whatever.

Having thus described my invention, what I claim is:—

1. A lighting system comprising, in combination, an enclosure provided with a skylight aperture facing the north sky, and a reflector so arranged within the enclosure as to reflect the image of the whole skylight aperture towards one area of said enclosure while permitting a

direct beam of light to pass from part of the skylight aperture to another area of said enclosure.

2. A lighting system as claimed in claim 1 in which the skylight aperture is at a predetermined rake appropriate for the exclusion of sunlight during desired hours of use at a given latitude.

3. A lighting system as claimed in claim 1 characterized by the fact that substantially equal illumination of both areas is provided for by due apportionment of the ratio of the whole skylight aperture used in reflection to that part of said aperture which furnishes a direct flux of light to the second mentioned area.

4. A lighting system as claimed in claim 1 in which the solid angles, respectively subtended by the whole and the said part of the skylight aperture, are predetermined so that the angle of the beam reflected onto the first mentioned area is greater than the angle of the direct beam in the proportion of the amount of the absorption coefficient of the reflecting surface.

5. A lighting system as claimed in claim 1 including means for varying the solid angles, respectively subtended by the whole and the said part of the skylight aperture, to compensate for variations of brightness of the sky at the different angles to the horizontal corresponding to the angular direction of the reflected and direct beams.

6. A lighting system comprising, in combination, an enclosure provided with a skylight of the "saw-tooth" or "weaver beam" type having its glazed light transmitting opening facing in a northerly direction at a rake appropriate for the exclusion of sunlight during desired hours of use at a given latitude and a reflector so arranged within the enclosure as to reflect the image of the whole skylight opening towards one area of said enclosure while permitting a direct beam of light to pass from part of the skylight to another area of said enclosure.

7. A lighting system comprising an enclosure provided with a skylight aperture facing in a northerly direction and set at a predetermined angle in the vertical plane appropriate for the exclusion of sunlight during desired hours of use at a given latitude, a reflector so arranged within the enclosure as to reflect the image of the whole skylight onto the north wall of said enclosure while permitting a direct beam of light to pass from part of the skylight to the south wall of said enclosure, said system being further characterized in that differences of the angles of incidence of the beams at corresponding points of observation on the two walls are compensated for by relative proportioning of the solid angles respectively subtended by the whole and the said part of the skylight opening.

8. A picture gallery comprising an enclosure provided with a skylight aperture facing the north sky at a rake appropriate for the exclusion of sunlight during desired hours of use at a given latitude, and a reflector arranged within the enclosure to reflect the image of the whole skylight onto the north wall of said enclosure while permitting a direct beam of light to pass from part of the skylight to a wall opposite the first mentioned wall, the solid angles, respectively subtended by the whole and the said part of the skylight aperture being predetermined so that the angle of the beam reflected onto the north wall is greater than the angle of the direct beam in the proportion of the amount of the absorption coefficient of the reflecting surface so that substantially equal illumination of both walls is obtained.

9. A picture gallery as claimed in claim 8 including means arranged to provide a shaded floor area lying between said walls.

10. A picture gallery as claimed in claim 8 including a supporting structure for the reflector arranged to provide a shaded area over the floor between said walls.

11. A system of lighting comprising, in combination, an enclosure provided with a skylight arranged to admit a direct flux of light towards one wall of said enclosure, reflecting means so arranged within the enclosure as to reflect the image of the whole light transmitting area of the skylight onto the wall opposite said first mentioned wall, while admitting a direct flux of light from a part of the light transmitting area of the skylight to said first mentioned wall and means for varying the total effective light transmitting area of the skylight while maintaining the same apportionment of the ratio of the whole light transmitting area used in reflection to that portion of said area which furnishes a direct flux of light.

12. A system of lighting comprising, in combination, an enclosure provided with a skylight of the "saw-tooth" or "weaver beam" type having its glazed light transmitting opening facing in a northerly direction and set at an angle in the vertical plane appropriate for the exclusion of sunlight during desired hours of use at a given latitude and a reflector so arranged within the enclosure as to reflect the image of the whole skylight towards one part of said enclosure while permitting a direct beam of light to pass from part of the skylight to another part of said enclosure.

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