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# PATENT SPECIFICATION

*Application Date, Apr. 11, 1917. No. 5087/17.*
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COMPLETE SPECIFICATION.

## Improvements in Light Dividing Means for Optical Apparatus.

We, DANIEL FROST COMSTOCK, Scientist, of 1407, Beacon Street, in the Town of Brookline, County of Norfolk, Commonwealth of Massachusetts, United States of America, and the TECHNICOLOR MOTION PICTURE CORPORATION, a corporation organized under the laws of the State of Maine, and having an usual place of business at Boston, in the County of Suffolk, State of Massachusetts, United States of America, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to an optical instrument for dividing a beam of light so as to transmit part of the beam and to deflect part of the beam without impressing upon either the deflected or the transmitted light any color disturbance, or diffusion disturbance, or diffraction disturbance, of practical magnitude.

The invention comprises a partly transparent and partly reflecting surface, hereinafter termed a grid, capable of use instead of the half-silvered surfaces, reflecting diffraction and other similar gratings, Nicholl prisms and other light dividing means heretofore known, all of which disturb either the transmitted or reflected light by interference, diffraction or color phenomena.

It is old for instance in Patent No. 10,617 of 1897 to provide double images for the measurement of angles by means of a telescope and light dividing means comprising a mirror divided into a number of reflecting and transparent sections.

The light dividing surface of the present invention is characterized by distinct areas of transmission and areas of reflection mutually so arranged as to prevent the formation of cumulative diffraction spectra.

The invention may be used for dividing a beam of light into parts for many purposes, as for example, in connection with an image-forming optical train for photography where it is desired to split or divide the image bearing beam of light into undistorted parts to form simultaneous images of an object field from the same point of view, the two images having relatively constant or the same luminous intensity, distribution of intensity, dimensions and color.

In the accompanying drawings:

Figure 1 is a diagram of photographic apparatus including the invention;
Figure 2 is a diagram of the device used for observing superposed images;
Figure 3 is a greatly enlarged face view of a fragment of the grid;
Figure 4 is a section through the grid;

[*Price 6d.*]

Figure 5 illustrates diagrammatically certain interference phenomena avoided by the invention;

Figure 6 is an explanatory diagram of the image region of a lens.

Figure 1 illustrates in diagram a photographic lens L and a sensitive film $f$ upon which it is proposed to form simultaneously at separated positions I, $I^1$, like images of the object field of the lens L. Such arrangement may be used for taking motion pictures enabling the simultaneous taking of two pictures of the same scene from the same point of view on the same film.

Behind the lens are arranged prisms $p^1$, $p^2$, having plane, totally reflecting surfaces $T^1$, $T^2$, and meeting faces in the plane $y$ inclined at an angle of 45° to the optical axis of the lens. A prism $p^3$, having a totally reflecting surface $T^3$, adjoins prism $p^2$, and a parallel faced transparent block $p^4$ adjoins the prism $p^1$. The image beam from the lens L will have optically equal paths from any point in the plane $y$ to the image spaces I, $I^1$, on the film $f$. The light dividing means is located in the plane $g$ to reflect part of the light through prism $p$, and thence through block $p^4$ to the picture space $I^1$ on the film, and to transmit part of the light through prism $p^2$, thence through prism $p^3$ to the picture space I on the film.

This light dividing means consists of a grid G in the plane $g$. The grid G is characterized by irregularly shaped, oriented, or positioned, unobstructed transmission areas $r$ of a size separately perceptible to unaided vision, but so small as to occur in a relatively large number in the area of the grid normally included in the optical path. Reflection area or areas $s$ occupy the remainder of the field. The total reflecting area (symbolized by A) bears a relation to the total transmission area (symbolized by R which may be stated as $R = \frac{A}{K}$ where K is a constant expressing the numerical relation between the amount of light incident and the amount of light reflected by a continuous reflecting surface of the same kind as the reflecting areas. The values A and R may be varied as desired to vary the intensity of the respective images. Thus, the total reflecting area may be enough larger than the total transmission area to compensate for the loss of light by reflection when images of equal intensity are to be formed.

The form and distribution of the respective reflecting and transmission areas are important to the result. The grid G, best illustrated in Figs. 3 and 4, may be formed on a surface, for instance of the prism $p^1$, by coating the reflecting areas $s$ with a dense bright deposit such as silver. The Brashear or the Rochelle salts precipitating methods may be used. The deposit is removed or prevented from being formed at the parts $r$ of the surface thus providing unobstructed light transmission areas.

The light transmission areas $r$ of the grid G are irregular polygonal figures having straight or irregularly curved joint boundaries oriented and scattered at random on the field. The remainder of the field is the reflecting area $s$. The object of this mutual arrangement of reflecting and transmission areas is to avoid any systematic or recurrent series of parallel boundaries between the reflection and transmission areas which would result in cumulative diffraction spectra.

The cumulative disturbances caused by light dividing surfaces having reflection and transmission areas bounded by parallel lines or other regularly recurring boundaries will be explained by reference to the diagrams of Fig. 5.

The diagram I (Fig. 5) illustrates the image of a narrow bright vertical line viewed through a series of narrow vertical openings assumed to be transmission areas of a light dividing surface. In that case the image $x$ in the direct line of vision is broadened by diffraction as is well known and on either side of the central image $x$ dark and bright diffraction bands of different orders $a$, $a^1$, $b$, $b^1$, *etc.*, appear, being wider or narrower and more or less displaced from $x$ as the narrow vertical openings are narrowed or widened; and brighter as they increase in number.

If the object is a bright point the appearance shown in diagram III results. If the bright point is viewed through a round hole instead of a slit, a similar series of bands concentric with a central bright image is formed (not shown). If a number of parallel series of slits at angles to each other are used, additional diffraction spectra result of the kind shown in diagrams I or III. The amount of light diffracted away from the direct path depends upon the number of openings in the grid, and increases as they increase, while the distribution of this lost light depends upon the geometrical distribution of the edges between the transmission and reflection spaces. Any such systematic and cumulative diffraction figures are avoided by the form and distribution of the transmission and reflection areas of the grid G of the present invention, the diffraction effect of the many openings reducing to that of a single opening *r*.

For such uses as photography the broadening effect of diffraction caused by a single opening *r* is within the expected definition losses usual to the apparatus employed, such as halation in the sensitive coat of the film *f* errors of lens surface, *etc.*

The effect of the grid G is illustrated conventionally in diagrams II and IV, Fig. 5. Diagram II illustrates greatly magnified, the image at *f*, Fig. 1, of an artificial star, grid G being removed. Diagram IV shows the image of the star when the grid G is in place, similarly magnified.

The amount of the broadening of the image by diffraction caused by an opening *r* depends upon its size. The openings *r* must occur in the field of the lens with which they are used of such a size and in such frequency as not to form separate shadows. Referring to Fig. 6, if an obstruction $s^1$ is placed as shown, the point $f^1$ on the film *f* can receive no light from any part of the aperture of the lens L. If this obstruction is at $s^2$ then part only of the source of illumination of the point $f^1$ is obscured. If, now, there are a number of evenly distributed obstacles $s^2$ near the lens, the loss of light on film *f* is not local but general and there is no local shadow on *f*. The reflectors *s* of the grid G are obstacles analogous to the screen $s^2$ in Fig. 6, and their permitted size is that at which they do not form separate shadows on the film *f*.

In practice, for a lens of $2^3/_4$ inches [70 mm.] principal focus and 1 inch [25.4 mm.] aperture, a grid averaging 16 openings to the lineal inch [6.3 openings to the linear centimeter] is recommended. The reflection area may be continuous or discontinuous but it is recommended that it be continuous as shown to enable better retension on the prism surface.

For protection of the grid and to cause transmission of light striking the transmission surfaces at such angle that it would otherwise be reflected, the transmission surfaces are coated with an optical cement of greater density than the atmosphere, such as Canada balsam, filling the transmission openings *r*, and joining the two transparent prisms $p^1$ and $p^2$ between which the grid is enclosed.

In Fig. 2 is illustrated a use for the grid G, suggestive of other uses, a lens being employed behind the grid as an objective through which to view objects *o* and $o^1$ whose images are superposed upon each other. Obviously in range finders, surveying instruments, goniometers and the like, the device is useful to enable superposition of images.

Having now particularly described and ascertained the nature of our said invention and in what manner the same is to be performed, we declare that what we claim is:—

1. Light dividing means comprising an optical surface having thereat distinct areas of transmission and areas of reflection, said areas being mutually arranged and adapted to prevent the formation of cumulative diffraction spectra.

2. Light dividing means according to Claim 1, further characterized in that the reflection and transmission areas have joint boundaries lying in a number of different distinct directions.

3. Light dividing means according to Claim 1, or Claim 2, further characterized in that the reflection and transmission areas respectively differ among themselves in size or shape or both.

4. Light dividing means of the kind claimed in Claim 1, or Claim 2, or Claim 3, further characterized in that the reflection or transmission areas are polygonal and are irregularly arranged or distributed at random with respect to each other.

5. Light dividing means as claimed in Claim 1, characterized in that said reflecting and transmission areas are held between two transparent bodies which are united one to the other through said openings by a substance having an optical density higher than the atmosphere.

Dated the 11th day of April, 1917.

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Chartered Patent Agents.

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Fig. 1.

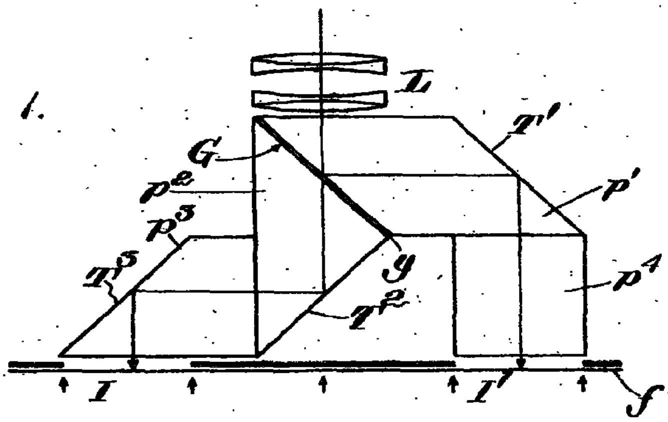



Fig. 2.

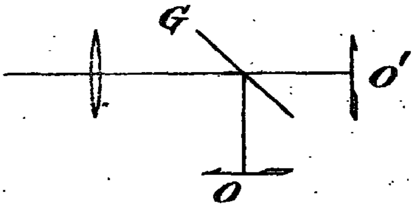



Fig. 3.

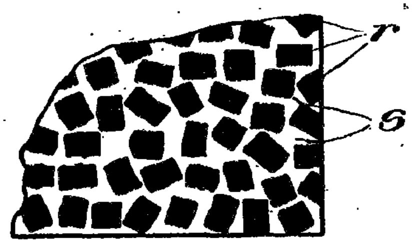
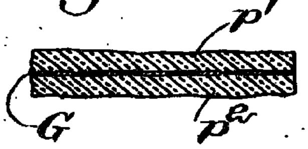



Fig. 4.



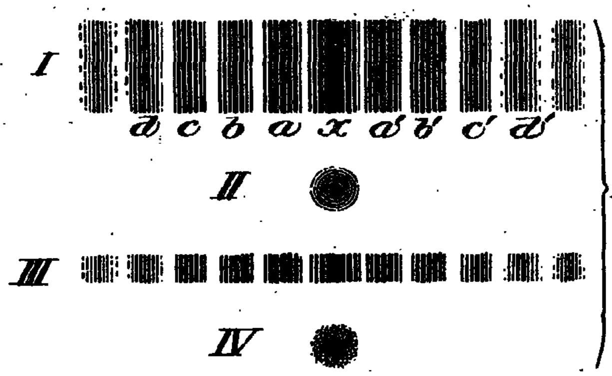
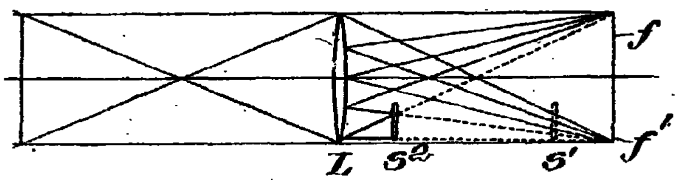




Fig. 5.

Fig. 6.






Malby & Sons, Photo-Litho.