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A. H. J. DE L. SAINT GENIES
DEVICES FOR MAKING EXPOSURES
ON LENTICULAR FILMS
Filed Feb. 10, 1940

Serial No.
318,344
3 Sheets-Sheet 1

Fig. 1

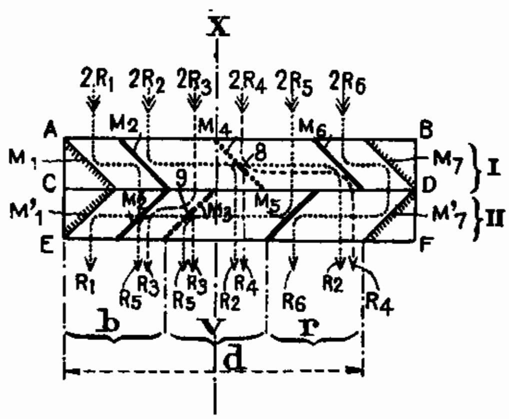

Fig. 2

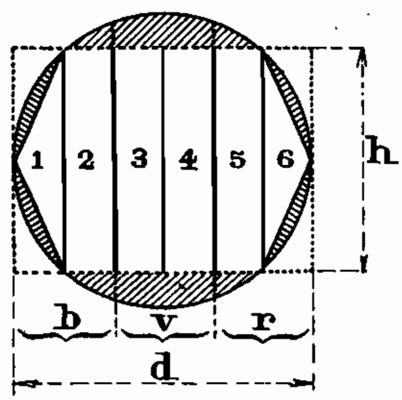

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Fig. 3

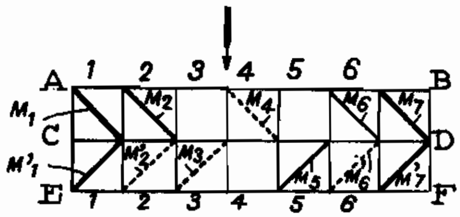

Fig. 4

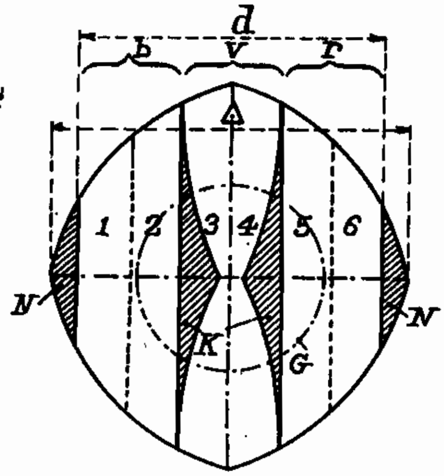

Fig. 5

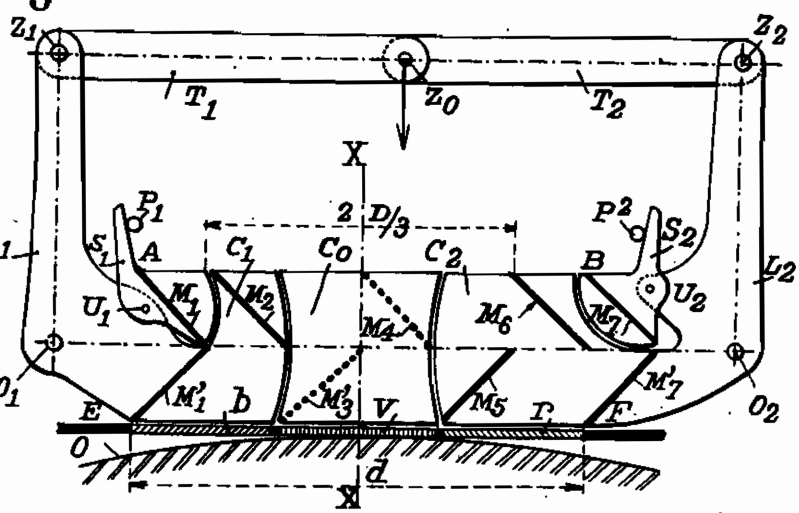

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Fig. 6

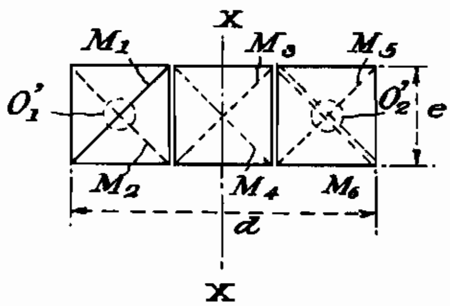
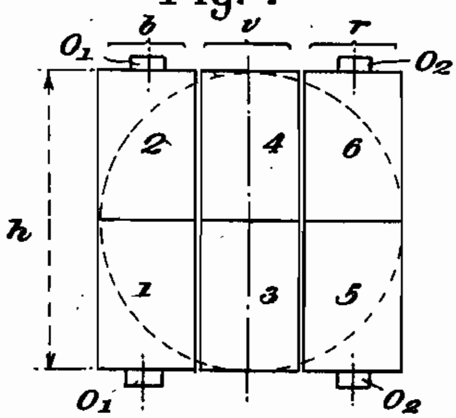


Fig. 7



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ALIEN PROPERTY CUSTODIAN

DEVICES FOR MAKING EXPOSURES ON LENTICULAR FILMS

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Application filed February 10, 1940

The present invention relates to combined optical blending and dispersing devices for effecting exposures on lenticular films as used for example in three colour photography.

The distinct image points formed by the juxtaposed bands of the colour filter in colour cinematography on lenticular film result in the recording on the film of monochrome images which are not strictly coincident except at the parts representing the plane of the photographed object which is exactly in focus.

Instead of in a blurring of the image, the lack of coincidence, which is the more pronounced the further the object is removed from the plane of sharp definition, shows itself, on projection of the original lenticular films or of copies thereof, in the production of coloured fringes, and these latter are the more pronounced the greater the aperture and the greater the focal length of the camera lens used for making the exposures.

To overcome this drawback inherent in making exposures in colour on lenticular films, various means have already been proposed utilizing mirrors or prisms, either to give to two of the colour bands of the filter, or to three of them, the breadth of one of these bands as image point base, or by blending each of the image points partially with the other two.

In the first case, there is achieved the dispersion of the relatively narrow beam of light striking the entry lens, and its distribution over the entire breadth of the filter, but this result is obtained at the cost of a considerable reduction in the light yield of the lens.

In the second case, the beams striking the lens are blended over the breadth of the filter, but owing to the reflecting surfaces used being strictly parallel, it will be understood that focussing can only be effected for the plane of infinity of the object photographed, and it is consequently necessary to add to the device, in front of the lens, a large aperture system of variable focal length which enables any other plane of the object to be sharply focussed by throwing such plane back to infinity by collimation.

Apart from the very considerable complication implied in the use of a collimating system for this purpose, which has to have a wide aperture and be perfectly corrected, it will be understood that the light yield of the assembly is also seriously affected by the number of glasses of which this collimating system is composed.

The present invention has for its object to provide a combined dispersing and blending device for the beams of light, of high luminous efficiency and capable of allowing the camera to be sharply focussed on any plane of the object photographed.

The principal characteristics of the invention are the following:

(1) The division of each of the three coloured bands of the filter into two segments of equal width, which determines six segments having in all the same superficial area as the pupil of entry of the camera lens;

(2) The provision of totally or partially reflecting facets projecting normally to the plane of the filter in such a manner that each coloured band may be completely covered by the projection of merely two facets which may if desired occupy two superposed tiers and baffle each other as between one tier and the other;

(3) Such distribution of the beams that after incidence on one of the facets, they emerge either through one only, or through two, or at the most through three of the six segments of the pupil of entry of the camera lens;

(4) Paths of beams, which, by virtue of this division and the baffle arrangement, are as short and symmetrical as possible, while the device itself is as small as possible in depth, so that, with a minimum of reflections as set forth above under (3), maximum light yield is secured;

(5) Division of the combined blending and dispersing device into a plurality of bodies articulated relatively to each other, rendering it possible to dispense with the provision in front of the device, of a system for collimating the focussing plane (a system which is generally inseparable from light beam blending devices equipped with totally or partially reflecting facets), and consequently enabling the handling of the device to be simplified while at the same time achieving the novel improvement in light yield.

Preferred embodiments of the invention are shown, by way of example only, in the accompanying drawings, in which:

Fig. 1 shows, in diagrammatic section, an embodiment of the combined blending and dispersing device according to the invention.

Fig. 2 shows the entry pupil of the camera lens.

Fig. 3 represents a modification of the embodiment shown in Fig. 1.

Fig. 4 is a modification of Fig. 2.

Fig. 5 shows an arrangement constituting a deformable dispersing and blending device.

Figs. 6 and 7 show a simplified modification of the device illustrated in Fig. 5.

Fig. 1 represents, solely by way of example, an embodiment of the optical device according to the invention. This device consists for example of two glass plates having parallel faces and denoted by I and II, in each tier of which are inserted reflecting facets, and disposed in such a manner, for example, that the plane EF lies in the plane of the pupil of entry of the objective with which the exposures are made.

The disposition and arrangement of this optical member are based on the following considerations:—

Fig. 2 is assumed to represent the division of the pupil of entry into six parallel segments, preferably of equal breadth, numbered 1 to 6, their direction being that of the three colour bands of the filter associated with the camera lens.

It may be estimated that, roughly speaking, the superficial area of the segments 1 and 6 is half that of each of the remaining segments 2, 3, 4 and 5.

It is assumed that each of the three points of view taken in the pupil of entry represents the area of two of these neighbouring segments, and that it is a case of causing the same quantity of light flux to traverse each of the three groups of segments of the pupil of entry, composed respectively of these segments 1 and 2, 3 and 4, and 5 and 6, as if the optical system shown in Fig. 1 were non-existent. For this purpose, when R is the flux traversing one of the segments 1 and 6, and 2R that traversing each of the four others, giving a total of 10R for the useful incident flux, it is necessary that the three groups enumerated above be finally traversed, respectively, as follows:— Group 1+2 by 3R, group 3+4 by 4R, and group 5+6 by 3R, giving a total of 10R.

Referring to Fig. 1, it will be seen that this result is duly achieved when it is assumed, for example, that the facets shown in full lines are totally reflecting, while those shown in dotted lines are partially reflecting, for instance merely semi-reflecting.

On top of the six facets M_1—M_6 are superposed on the facets M_1 and M_2 of tier I, the facets M'_1 and M'_2 of tier II, these being symmetrical with respect to the plane of separation CD between these two tiers. Two further facets M_7 and M'_7 are also disposed, symmetrically with respect to said plane CD, like M_1 and M'_1 but have their projection on the plane EF outside the pupil of diameter d while being tangential to this pupil. All these facets, superposed on top of the six first-mentioned, have the height h measured normally to the plane of the drawing.

Owing to the difference between the areas of the segments 1 and 6 and those of the four other segments (Fig. 2), dominant image points may become formed in the blend of the three groups of image points. To counteract this, the distribution of the beams in their blend may be modified, for example by rendering a fraction 8 and 9 of the facets M_3 and M_4 totally reflecting.

Fig. 3 represents in section a blending and dispersing device according to the invention in which the distribution of the beams presents a high degree of symmetry.

In this symmetrical distribution of the beams, given by way of example, the differences of path are slight and negligible, owing to the small total thickness of the two superposed tiers, amounting to half that obtained without the baffling arrangement of the facets (rendered possible by the division of the surface of incidence into six segments), and also owing to the principle according to which a beam divided at incidence does not traverse all the segments of the emergent face but only one, two, or at the most three of these six segments.

In Fig. 4 is indicated in outline a filter having the contour of a curvilinear lozenge, known for giving the diaphragm corresponding to the maximum useful aperture of a camera lens. In order to ensure the most correct use possible of the pupil of entry furnished by this diaphragm, in combination with the combined blending and dispersing device according to the invention, the diameter of this diaphragm, measured perpendicularly to the direction of the coloured bands, is reduced to a value d which is less by about $\frac{1}{8}$ than the diameter T, by eliminating the corners N.

In this way, and at the cost of an insignificant sacrifice of luminosity of this diaphragm, the disparities between the mean values of the respective heights of the segments 1, 2, and 3 (and correspondingly of 4, 5 and 6) is diminished, while at the same time a substantial improvement is effected in the efficiency of this filter when used with a combined blending and dispersing device according to the invention, of the type shown by way of example in Fig. 3.

It will readily be understood, for example, that the fluxes incident on the segments 3 and 4 of the face AB would be reduced to a considerable extent, with reference to the fraction emerging therefrom through the segments 1 and 6, if this precaution were not taken.

It is assumed that the lozenge shape with truncated corners delimits, without varying, the emergent face EF of the device, whereas there may be utilized a circular diaphragm of variable diameter, an iris diaphragm for example, in the plane of the incident face AB, centred on the axis of the camera lens. For this purpose it is necessary that the ratio between the flux emerging through the central band, on the one hand, and that emerging through one of the side bands of the lozenge-shaped filter, on the other hand, remain substantially constant when the diameter of the diaphragm varies.

It is known that when a three colour filter comprises three bands of the same breadth occupying the pupil of entry of maximum useful aperture, it is necessary to obscure the central coloured band of this filter relatively to the neighbouring bands, on account of its greater height.

This greater degree of opacity could not however in practice be imparted to it in the present device without effecting variation of the ratio between the fluxes discussed above when the diameter of an iris diaphragm placed in the plane of incidence AB of the device is caused to vary.

Calculation shows indeed that the ratio between the flux emerging from the central band of the filter and that emerging from one of the side bands varies with the aperture of the iris diaphragm disposed in front of the blending and dispersing device, in the vicinity of its surface of incidence AB, in a different manner according to the degree of reflection taken for the partially reflecting facets of the device. There are consequently represented in this Fig. 2 what might quite simply be masks K associated with the central band, providing the screening effect referred to above, as desirable, in the event for example of the facets M_3 and M_4 being semi-reflecting and the facets M'_3 and M'_4 dispensed with, in order that, when the filter is of the kind which is balanced at full aperture, this equilibrium is automatically maintained whatever be the diameter of the diaphragm G susceptible of variation between full aperture and d/n, n being any number which may possibly be greater or smaller than the number 3.

Fig. 5 shows an embodiment of the invention which allows of focussing on to any plane of the object photographed, by deformation of the device having reflecting facets.

It will be noted that the normal focussing procedure by extending the objective O, to effect focussing to any plane other than infinity, produces on the filter correct focussing of the image for those of the light rays proceeding from said plane, which traverse the objective O without having undergone reflection in the dispersing-blending device. For all the remaining rays, which undergo such reflection, on the other hand, there occurs disturbance in the construction of the image on the film, except for certain incident rays, particularly such, for example in the case of the arrangements shown in Figs. 1 and 3, in consequence of an even number of reflections, as those incident on the facets M_1 or M_8, and which emerge from the device through the segments 1 or 6 of the same number as these facets.

To correct the direction, on emergence from the device, of all other reflected beams, it would have to be possible to turn the reflecting facets through a certain angle in such conditions that only these beams are correctly readjusted. This is allowed for (see Fig. 5) by the articulation of the bodies C_1 and C_2 of the device relatively to the body C_0 assumed to be fixed with the objective O and, respectively, on these bodies C_1 and C_2, as shown in this figure, by the supplementary articulation of the facets M_1 and M_7.

If 2 $d/3$ be the deviation between the mid-points of the groups of viewpoints furnished by the bodies C_1 and C_2, it will be seen that the beams of light are correctly conducted if the rotation of these articulated facets takes place in the appropriate sense and symmetrically with reference to the axis XX of the objective O, as a function of the parallax relative to the base 2 $d/3$, of any selected point in the focal plane of the object. If α be the angular extent of this parallax relatively to the base 2 $d/3$, it will be understood that beams emerging from the device, after having undergone reflection twice in one direction or the other between the central body C_0 and one of the side bodies on such facets (spaced apart by the amount $d/3$), will appear, if these facets are parallel, to proceed from a point located at the distance $d/3$ from the object point in the focal plane of the object photographed. After having traversed the objective O, these beams will thus form on the film an image distinct from that formed by the beams which traverse this objective without undergoing reflection. But it will also be understood that these two images will coincide if the beams emerging from the device after having undergone reflection on the facets the deviation between which is $d/3$, are alone deflected through an angle of $\alpha/2$ by a rotation of the side bodies through $\alpha/4$ about the fixed axes O_1 and O_2 of the objective O. In effect, the beams will appear, like those which are not reflected, to proceed from the object point itself.

Likewise, it will be understood that a rotation through half this angle, that is to say through $\alpha/8$, for the facets M_1 and M_7, will suffice to rectify the emergence of beams undergoing, in the bodies C_1 and C_2 to reflection on the facets at a distance of only $d/6$, in such a manner as to cause these beams to form the same image as those considered above.

The invention finally contemplates rendering this adjustment automatic by arranging for it to be effected in dependence on the extension of the objective lens, if, for example, the articulation point Z_0 of connecting rods T_1 and T_2 be fixed on the camera, and connecting rods articulated at Z_1 and Z_2 to levers L_1 and L_2 pivoted in their turn at O_1 and O_2 on the mounting of the objective be of such length relatively to the length of the said levers (measured between the axes) and form such angles that, on rotation of the side bodies, the deformation of the device is caused to follow substantially the law of parallax variation, on variation of the plane selected for focussing.

Instead of levers and connecting rods it may of course be preferred to employ a system of cams for effecting this control. It is also possible to serve this purpose approximatively by making the device out of translucent elastic material in one piece, and causing this device to become bent or curved by any suitable control means.

If the embodiment of the invention is of the kind illustrated in Fig. 5, the three bodies will preferably have cylindrical separation surfaces and have interposed between them a substantially non-volatile liquid the refractive index of which is very close to that of the substance of which the device is made, such as for example liquid Canada balsam, castor oil, or glycerine.

Rotation of the facets M_1 and M_7 is permitted, in the case of the embodiment shown in Fig. 5 for example, by supplementarily pivoting the facets M_1 and M_7, at U_1 and U_2, on the levers L_1 and L_2, respectively, pertaining to the mounting for the two articulated side bodies C_1 and C_2. This rotary adjustment is controlled, when these levers are moved by extension of the lens O in the course of focussing, with consequent adjustment of the lens relatively to the fixed point of articulation on the camera, for example by the abutment of fingers such as S_1 and S_2 against blocks P_1 and P_2 secured for example to the lens mounting; these fingers, which are secured to the articulated mountings of the facets M_1 and M_7, are of suitable profile.

It will be understood that if the facets M'_2 and M'_6 are held in position on the device shown in Fig. 5, in the manner indicated in Fig. 3, it would also be necessary to make these facets articulated like the facets M_1 and M_7 on the mountings L_1 and L_2 of the side bodies C_1 and C_2. It is in fact necessary, on the one hand, that the fractions of each of the beams incident on the segments 1 and 6 of the surface AB, which are also reflected by each of the facets M'_2 and M'_6, shall not undergo any deflection on emergence from the device, because these fractions, emerging through segments of the face EF denoted by the same indices 1 and 6 as those of the entry face, are comprised in the "direct flux". On the other hand, it is also necessary, and at the same time, that the fractions of beams striking these facets M'_2 and M'_6 and coming by reflection on the facets M_3 and M_4, and which emerge through the segments 2 and 5 of the face EF, be deflected through the angle corresponding to the deviation $d/6$ which exists only between the points of incidence and emergence of the rays of these fractions of beams. Finally, this articulation of the facets M'_2 and M'_6 has no effect upon the fractions of these same beams which traverse them and emerge through the segments 1 and 6 of the face EF, nor on those which emerge through the segments 2 and 5 of the face EF and derived from beams incident on the segments 1 and 6 of the face AB. Thus, these various fractions only undergo, respectively, as has been seen above to be necessary, deviations imposed by rotation of the facets M_1 and M_7 regulated on the one hand for the spreading to the extent of $d/6$ extant between the points of incidence and emergence of the first of these fractions of beams, and by rotation of the bodies C_1 and C_2 regulated on the other hand for the spreading to the extent of $d/3$ established between the points of incidence and emergence of the second of these fractions of beams.

According to the mode of construction indicated by Brewster in his U. S. Patent No. 1,277,040/1918, and for the purpose of substituting metallized mirrors which are totally or partially reflecting, for the prismatic elements of a beam dividing or dispersing device, the separation surfaces of articulated bodies may also be immersed together with the whole of the device, in a tank containing liquid of such composition that its refractive index renders absolutely invisible the glass of the mirrors of which only the metallized surface reflects. For this purpose it is known to employ aqueous solutions of iodo-mercuriate of barium, potassium, or sodium, the refractive index of which may attain the figure 1.7.

Figs. 6 and 7 represent, in section and in plan view respectively, a device in which the six segments of the diaphragm (assumed to be circular) delimiting the filter, are divided into two groups of three separated by a diameter lying transversally of the bands *b*, *v*, *r* of this three color filter, and in which the odd and even facets cross each other at 90°. These facets occupy for example the entire thickness *e* of the device, which is equal to the thickness of the two superposed tiers of the preceding devices, and, for example, the facets M_2 and M_5 are 66% reflecting, the facets M_3 and M_4 50% reflecting, and the facets M_1 and M_6 100% reflecting. All are symmetrical again in respect of the paths of rays in the two groups of facets, but a substantial fraction of the incident beams is lost by the totally reflecting facets.

The efficiency of the device and the distribution of the beams between the central and side segments may be very considerably improved by making them all of the same maximum height H/2, which increases the parts reflected by the side facets and destined to traverse the segments covered over by the other facets.

In these latter combinations, it is sufficient for the facets to be divided up between three bodies C_0, C_1, C_2, in order to ensure, by articulation about the axes O_1 O'_1, O_2 O'_2, correct focussing simultaneously with extension of the lens. It is also sufficient for the dividing surfaces between the three bodies to be plane, with very slight spacing in the case of lenses in which *d* is relatively small, since the rotation of the two side bodies is also very limited.

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