

March 11, 1941.

K. BAUER

2,234,665

OPTICAL PRISM

Filed Aug. 26, 1937

Fig. 1.

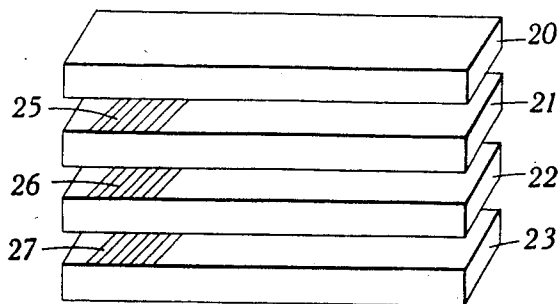


Fig. 5.

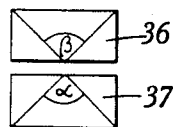


Fig. 6.

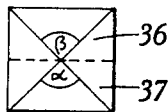


Fig. 2.

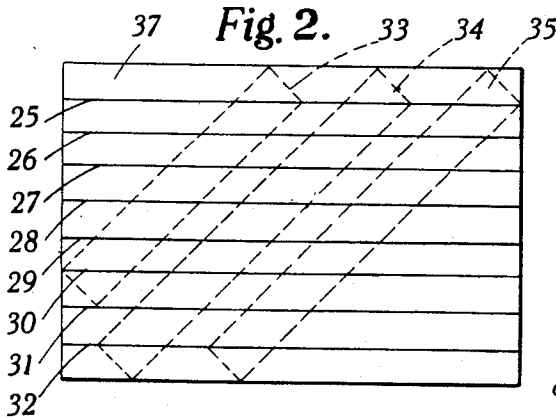


Fig. 3.

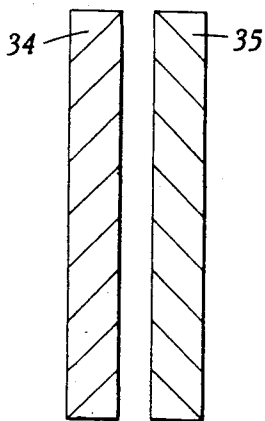


Fig. 4.

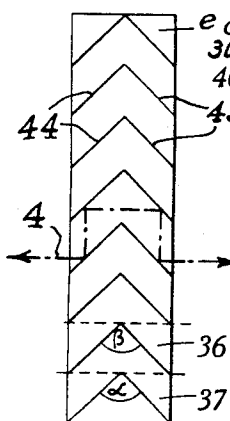


Fig. 7.

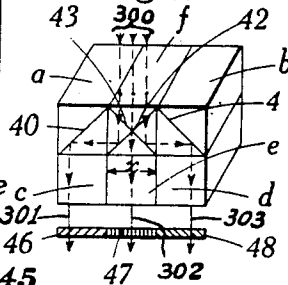
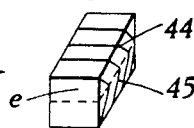


Fig. 8.



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2,234,665

OPTICAL PRISM

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Application August 26, 1937, Serial No. 160,984
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4 Claims. (Cl. 88—1)

My invention relates to an optical system and more particularly to an optical system for use in taking and reproducing of colored images, for example in connection with color photography, color cinematography, color television and color printing.

In taking colored images, for example in color cinematography, it has been suggested taking a plurality, for example, three of color separation images in black and white. In reproducing the color separation images are combined into one colored picture. In taking the color separation images, it is generally necessary to divide the light beam into several partial light beams and, in reproducing, to recombine the partial light beams emanating from the color separation images into one light beam, the dividing and recombining being effected in known manner by means of mirrors and prisms. If more than two color separation images are used and if they have to be provided arranged in a common plane, the paths of the partial light beams have different lengths, as a consequence of which it was impossible, without employing complicated means, to make the color separation images coincide completely, for example when projected, so that the super-imposed images showed a certain amount of parallax.

One object of my invention is to provide an optical system, by means of which the above mentioned disadvantages encountered with the use of more than two color separation images are avoided.

A further object of my invention consists in providing an optical system comprising a light divider wherein the length of the partial beams emanating from the light divider is equalized.

Still another object of my invention is to provide an optical system with plane entrance and exit surfaces, which has a light divider dividing the light into two outer partial beams and one inner partial beam and has compensating means in the path of the inner partial beam, whereby the length of the path of the inner partial beam is increased to the length of the outer partial beams without ultimate change of its direction and the three partial beams leaving the exit surface are in alignment with each other.

In order to carry out my invention into practice, I provide an optical system of solid transparent material comprising a light divider having outer plane entrance and exit surfaces, inner partially reflecting and inner totally reflecting plane surfaces arranged in such a way as to divide and direct a light beam entering the

said entrance surface into three parallel beams leaving the plane exit surface, the inner partial beams of said three partial beams passing through said partially reflecting surface, the two outer partial beams being reflected by said totally reflecting surfaces, the length of the path of the inner partial beam through said divider being shorter than the length of the path of the outer partial beams between said entrance and said exit surfaces, the path of the outer partial beams being straight after the reflection of said totally reflecting surfaces, and means for equalizing the lengths of said partial beams, said equalizing means comprising a compensator cooperatively associated and forming a unitary structure with said divider and arranged in series relationship with the path of the inner partial beam, said compensator having at least two rows of parallel equally spaced totally reflecting surfaces, the reflecting surfaces of the first row being inclined to the direction of the inner partial beam entering the compensator, the reflecting surfaces of the second of said rows being equally inclined, but in the opposite direction to the direction of the inner partial beam entering the compensator, said two rows being in series relationship with respect to the direction of the inner partial beam, and each reflecting surface of said two rows extending between the path of the outer partial beams reflected by the totally reflecting surfaces of the divider, whereby the length of the path of said inner partial beam is increased without ultimate change of its direction and the three partial beams leaving the exit surface are in alignment with each other.

The above objects as well as others not particularly pointed out will appear from the following description with reference to the accompanying drawing in which:

Figs. 1-6 illustrate steps in the method of manufacturing prisms for use in my optical system,

Fig. 7 shows an optical system according to my invention, and

Fig. 8 is a perspective detail view of the compensating element of the optical system.

Referring now to the drawing, Fig. 7 illustrates an embodiment of my optical system of solid transparent material for the purpose of three color photography and cinematography. The optical system comprises six prisms, *a*, *b*, *c*, *d*, *e* and *f*, which are cemented together or brought in any other suitable way into optical contact.

Preferably, the prism or compensator *e* provided with two rows of parallel equally spaced totally reflecting surfaces or mirrors 44, 45 (see

Fig. 8) inclined to each other at 90° is manufactured in the following manner:

As best shown in Fig. 1, plane parallel plates 20, 21, 22, 23, the thickness of which is equal to the distance between two consecutive mirrors of one row of the prism *e*, are covered with reflecting surfaces indicated by 25, 26, 27. The plates are placed one above the other and cemented together so that a unit 37 is formed as illustrated diagrammatically in Fig. 2 in which the reflecting surfaces are indicated by the numerals 25—32. Parts 33, 34, 35 are cut or ground out of the unit 37 in such a manner that the cut or ground surfaces are inclined to the reflecting surfaces at a suitable angle. In the embodiment illustrated this angle is chosen as 45° .

For making the prism *e* shown in Fig. 8, two of the parts, e. g. 34 and 35, are positioned as shown in Fig. 3 and are brought together into optical contact to form finally the prism *e* diagrammatically illustrated in Fig. 4. The parts 34 and 35 can be brought together either by holding them in contact in a suitable frame or by cementing same together.

The mirrors 44 of the first row of mirrors thus formed in the prism *e* are parallel and equally spaced and so are the mirrors 45 of the second row of mirrors. The inner edges of the inclined reflecting surfaces or mirrors 44, 45 of the two rows are contiguous, the angles between said inclined mirrors of said two rows are 90° , and said mirrors of said two rows are symmetrically arranged about the straight plane bisecting said angle of 90° . The dash and dotted line 4 shown in Fig. 4 indicates the path through the prism of a light ray impinging normally on the prism. The light ray is reflected four times as illustrated. The light ray emerges from the prism in the same direction as it was incident. It will be easily appreciated that the length of the path of the light ray within the prism is twice the length it would be if no mirrors were provided in the prism, i. e. the length of the path of the light ray is increased without ultimate change of its direction.

Preferably, the prism *f* provided with two partially reflecting and partially transparent plane surfaces 42, 43 (see Fig. 7) diagonally crossing each other is manufactured in the following manner:

The plane parallel plates 20, 21, 22, 23 shown in Fig. 1 are covered with partially reflecting and partially transparent surfaces 25, 26, 27. Then, a prism shown in Fig. 4 is produced in the same manner as described above in connection with the manufacture of the compensator *e*. In this case, however, the prism to be used for the prism *f* has partially reflecting and partially transparent surfaces. Now, parts 36 and 37 (Fig. 4) are severed from the prism and are brought together into optical contact (see Figs. 5 and 6) so that the vertices of the angles α and β touch each other and finally crossed mirrors as diagrammatically shown in Fig. 6 are formed. The parts 36 and 37 are brought together in any suitable way, for example, by cementing, or by means of a frame.

As best shown in Fig. 7, a light beam 300 entering the entrance surface of a prism *f* thus formed with crossed partially reflecting and partially transparent plane surfaces 42, 43 is divided into three parallel beams 301, 302 and 303.

The optical system shown in Fig. 7 comprises

a light divider having outer plane entrance and exit surfaces and includes the six prisms *a*, *b*, *c*, *d*, *e* and *f* cooperatively associated with each other. The optical system has the shape of a cube and the prisms have the shape of rectangular parallelepipeds having one square section. The six prisms are arranged in two series, one series above the other. The first series contains the first prism *a*, the second prism *f* and the third prism *b*; the second prism *f* is arranged between the first and third prisms and has the entrance surface of the optical system. The second series contains the fourth prism *c*, the fifth prism or compensator *e* and the sixth prism *d*; the fifth prism *e* is arranged between the fourth and sixth prisms, and the fourth, fifth and sixth prisms have the exit surface of the optical system. The first prism *a* is arranged above the fourth prism *c*, the second prism *f* is arranged above the fifth prism *e*, and the third prism *b* is arranged above the sixth prism *d*. The prism *a* is provided in one diagonal plane with a totally reflecting mirror 40. The prism *b* is provided with a similar mirror 41 which is inclined at 90° to the mirror 40. The prism *f* is provided diagonally with two mirrors 42 and 43 which cross each other at right angles and which are partially reflecting and partially transparent. The prisms *c* and *d* are formed of simple transparent blocks without mirrors, while the prism or compensator *e* is provided with two rows of reflecting surfaces or mirrors 44, 45 (see Fig. 8) inclined to each other at 90° . Each reflecting surface of said two rows extends between the prisms *c* and *d*.

In taking a three color photograph the incident light beam has generally to be divided into three partial light beams each of which produces a color separation image. For this purpose, the optical system illustrated in Fig. 7 is positioned in a suitable taking camera in such a way that the incident light beam 300 impinges on the upper surface of the prism *f*. In said prism *f* the light beam is divided into two outer partial beams 301 and 303 and one inner partial beam 302.

The outer partial beam 301 is reflected to the left in Fig. 7 by the partially reflecting mirror 42 and enters the first prism *a*. It then impinges on the mirror 40 and is reflected downwards, passes through the fourth prism *c* and emerges from the lower surface thereof. The path of the outer partial beam 301 is straight after the reflection by the mirror 40.

The other outer partial beam 303 is reflected to the right in Fig. 7 by the partially reflecting mirror 43 of the prism *f* and enters the third prism *b*. It then impinges on the mirror 41 and is reflected downwards, passes through the sixth prism *d* and emerges from the lower surface thereof. The path of the outer partial beam 303 is straight after the reflection by the mirror 41 and parallel to the path of the first outer partial beam 301.

The inner partial beam 302 passes downwards through the partially transparent mirrors 42 and 43 of the prism *f* and enters the compensator *e* having its reflecting surfaces 44, 45 inclined to the direction of the inner partial beam 302. It then impinges on the mirrors 44 and is reflected by the mirrors 44 and 45, whereby the length of its path is increased without ultimate change of its direction, so that the inner partial beam 302 finally emerges from the lower surface of

the prism *e* in a direction parallel to the direction of the two outer partial beams 301 and 303.

If the partial prism *c* were not provided with the rows of mirrors, obviously the path of the inner partial beam 302 would be shorter by the distance *x* than the paths of the outer light beams 301 and 303. However, by providing the prism or compensator *e* with the two rows of mirrors 44, 45, this is corrected since the path of the inner partial light beam 302 is doubled without altering its direction so that it is increased exactly by the missing length *x*. Thus the lengths of the three partial beams 301, 302, 303 is equalized, and all three paths of the partial light beams through the optical system have equal lengths.

In the paths of the three partial light beams 301, 302, 303 color filters may be provided in known manner, e. g. a red filter 46, a green filter 47 and a blue filter 48. The filters may be secured rigidly on the lower surfaces of the prisms *c*, *e* and *b* respectively.

If it is intended to combine three light beams into one as is required in many additive color processes, the optical system described above may be used, its action here, however, being reversed. In this case the light path is reversed. The three black and white color separation images are projected respectively on to the lower surfaces of the prisms *c*, *e* and *d*, if desired or necessary through suitable color filters. The three partial light beams produced are combined in the optical system into a single light beam in a similar but reverse way to that above described.

It is obvious that the optical system can be subdivided into prisms in numerous ways other than that illustrated, without altering its action. For example, some of the prisms shown can be combined or subdivided; for instance, the prism *e* could be subdivided into two partial prisms as indicated by the dash line in Fig. 8.

Although a preferred embodiment of my optical system has been described and illustrated, it will be apparent that numerous modifications and variations are possible within the scope of the invention. For instance, prisms embodying the invention can be easily constructed for taking and reproducing colored images using more than three color separation images. Again, the prisms having several rows of reflecting surfaces can be used in every case where it is essential to increase by a certain amount the path of light rays within an optically transparent body. Furthermore, the optical system can be used in every case in which a light beam has to be split or several light beams have to be combined (in which case the prisms act as a beam-combining prism), while maintaining equal the paths of all partial light beams within the prism.

The specific embodiment described and illustrated must be understood not to limit in any manner the scope of the invention as defined in the appended claims.

What I claim is:

1. An optical system of solid transparent material comprising a light divider having outer plane entrance and exit surfaces, inner partially reflecting and inner totally reflecting plane surfaces arranged in such a way as to divide and direct a light beam entering the said entrance surface into three parallel beams leaving the plane exit surface, the inner partial beam of said three partial beams passing through said partially reflecting surface, the two outer partial

beams being reflected by said totally reflecting surfaces, the length of the path of the inner partial beam through said divider being shorter than the length of the path of the outer partial beams between said entrance and said exit surfaces, the path of the outer partial beams being straight after the reflection of said totally reflecting surfaces, and means for equalizing the lengths of said partial beams, said equalizing means comprising a compensator cooperatively associated and forming a unitary structure with said divider and arranged in series relationship with the path of the inner partial beam, said compensator having at least two rows of parallel equally spaced totally reflecting surfaces, the reflecting surfaces of the first row being inclined to the direction of the inner partial beam entering the compensator, the reflecting surfaces of the second of said rows being equally inclined, but in the opposite direction to the direction of the inner partial beam entering the compensator, said two rows being in series relationship with respect to the direction of the inner partial beam, and each reflecting surface of said two rows extending between the path of the outer partial beams reflected by the totally reflecting surfaces of the divider, whereby the length of the path of said inner partial beam is increased without ultimate change of its direction and the three partial beams leaving the exit surface are in alignment with each other.

2. An optical system as claimed in claim 1, the linear edges of the inclined reflecting surfaces of the two rows of the compensator being contiguous, the angles between said inclined reflecting surfaces of said two rows being symmetrically arranged about the straight plane bisecting said angle of 90°.

3. An optical system of solid transparent material comprising a light divider having outer plane entrance and exit surfaces and including six prisms cooperatively associated with each other, said six prisms being arranged in two series, one series above the other, the first series containing the first, second and third prism, the second prism having said entrance surface and being arranged between said first and third prisms, the second series containing the fourth, fifth and sixth prism, the fourth and sixth prisms being formed of simple transparent blocks, the first and third prisms being arranged above the fourth and sixth prisms respectively and the second prism being arranged above the fifth prism, the second prism having two partially reflecting and partially transparent plane surfaces diagonally crossing each other so as to divide a light beam entering said entrance surface into three partial beams, the first and third prism having each an inclined totally reflecting surface, the totally reflecting surfaces of the first and third prisms being inclined at 90° to each other so as to direct the first and third partial beams emanating from the second prism through the fourth and sixth prisms into paths parallel with the second and inner partial beam emanating from the second prism, the length of the path of said inner partial beam through said divider being shorter than the length of the path of the outer first and third partial beams between the said entrance and exit surfaces, the path of the outer partial beams being straight after the reflection by said totally reflecting surfaces of the first and third prisms, and means for equalizing the length of said partial beams comprising a compensator

cooperatively associated and forming a unitary structure with said divider and arranged in series relationship with the path of the second and inner partial beam, said compensator including
5 the fifth prism having at least two rows of parallel equally spaced reflecting surfaces, the said reflecting surfaces of the first row being inclined to the direction of the second and inner partial beam entering the fifth prism, the said reflecting
10 surfaces of the second of said rows being equally inclined, but in the opposite direction to the direction of the second and inner partial beam entering the fifth prism, said two rows being in series relationship with respect to the direction
15 of the second and inner partial beam, and each

reflecting surface of said two rows extending between said fourth and sixth prism, whereby the length of the path of said inner partial beam is increased without ultimate change of its direction and the three partial beams leaving the exit
5 surface are in alignment with each other.

4. An optical system as claimed in claim 3, the inner edges of the inclined reflecting surfaces of the two rows of the fifth prism being contiguous, the angles between said inclined reflecting surfaces of said two rows being 90°, and said reflecting surfaces of said two rows being symmetrically arranged about the straight plane bisecting said angle of 90°.

KARL BAUER. 15

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CERTIFICATE OF CORRECTION.

Patent No. 2,234,665.

March 11, 1941.

KARL BAUER.

It is hereby certified that the name of the assignee in the above numbered patent was erroneously described and specified as "Alfred Doeschner" whereas said name should have been described and specified as --Alfred Daeschner--, as shown by the record of assignments in this office; and that the said Letters Patent should be read with this correction therein that the same may conform to the record of the case in the Patent Office.

Signed and sealed this 29th day of April, A. D. 1941.

(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.

CERTIFICATE OF CORRECTION.

Patent No. 2,234,665.

March 11, 1941.

KARL BAUER.

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(Seal)

Henry Van Arsdale,
Acting Commissioner of Patents.