PATENT SPECIFICATION

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PROVISIONAL SPECIFICATION.

Improvements in or relating to Colour Photography and Projection.

We, ADAM HILGER, LIMITED, a company organised under the laws of Great Britain, and JOHN HENDRI DOWELL, British subject, both of 98, Kings Road, Camden Road, London, N.W.1, do hereby declare the nature of this invention to be as follows:—

This invention relates to colour photography and projection, more particularly to colour kinematography by the method in which two or more pictures are recorded simultaneously side by side in the space normally occupied by one picture on film of standard width.

In such cases in order to utilise as large an area of the film as possible for the purpose of getting good illumination of the projected picture, the width of each picture is in the existing systems made to run along the length of the film. In this way a comparatively greater area of the film is employed to produce pictures of standard height and width proportions, but since the accommodation of the sound track on sound films makes the picture space more nearly square, the advantage so gained is much less with this kind of film.

In such systems an image dividing prism and pair of lenses is usually employed to form the pair of pictures side by side, and the camera is either laid on its side or an optical erecting device is used to turn the picture through 90°. On projection it is also necessary to employ an optical device to turn the pictures through 90° in order that they may be erect on the screen.

It has already been proposed in colour kinematography to distort the images by reducing their width or height in such proportion that the companion images together occupy exactly one picture space on the film. This was carried out by mounting in front of the taking or projecting lens system a dioptic of two cylindrical lenses, the lens system being then a set of objectives of which each objective was associated with one colour. It is an object of the present invention to obviate parallax errors when thus distorting the images.

According to the invention an image dividing prism is combined with cylindrical and spherical lens elements designed to produce two or more identical images all taken from the same view point, the images so produced having different magnification in the horizontal and vertical directions so that one set of companion images exactly fills one picture space on the film, and the individual images are in close juxtaposition; thus the whole available area of the film is utilised. The pictures are preferably taken the right way up, and one above the other, or side by side, and optical means are provided so that the pictures so taken occupy the whole available area of the film as described above, that is, while the pictures are of standard height, the width is reduced to approximately half in the case of a two colour method, so that two pictures can be taken in the space ordinarily occupied by one. On projection the pictures are enlarged approximately twice as much in width as in height so that a picture of normal proportion is projected on the screen. In a similar way it would be possible to maintain the standard width and reduce the height on the film.

An example of an optical system according to the invention for a two colour kinematograph camera will now be described. The images may be supposed to retain their normal height and to be distorted in width. The dividing prism system comprises two prisms contacting at a vertical semi-reflecting surface set at 45° to the optical axis. The prism passing the reflected beam has an entrance face perpendicular to the optical axis, a reflecting face parallel to the semi-reflecting face and an exit face parallel to the entrance face. The other prism has a reflecting surface at an angle less than 45° to the optical axis, say at about 22½°, and an exit face perpendicular to the reflected axial ray. A mirror brings this ray parallel to the optical axis and consequently to the axial ray of the reflected beam but at a short distance sideways from it.

In front of the entrance face there is cylindrical converging lens with hori-

[*Price* 1/-]

zontal axis and behind the exit face of each prism there is a diverging cylindrical lens, also with horizontal axis. Behind each of the latter lenses is a spherical lens serving as objective.

The cylindrical, spherical and prism elements are designed so that in combination, a pair of identical images is produced free from chromatic and geometrical aberration. For the purpose of applying corrections for chromatic aberration the prism system may be constructed and arranged according to specification No. 349,107.

Alternatively with the prism system just described there may be as before in front of the entrance face a cylindrical converging lens with horizontal axis and behind the exit face of each prism a converging spherical lens. Behind each of the latter lenses there is then a cylindrical diverging lens, also with horizontal axis.

Where long focus elements are used the prism passing the transmitted beam may have its exit face in the same plane as the exit face of the other prism. The two objectives and the diverging cylindrical lenses would then have their optical axes parallel. To compensate for the glass path length and to bring the images into juxtaposition the transmitted beam would then be passed through a prism of similar shape to the one passing the reflected beam, but located between the objective and the film. The relative position of cylindrical, spherical and prism elements may be arranged in such order as is most suitable to secure proper correction for aberration, the cylindrical elements being parallel or crossed. The prism element may also have spherical or cylindrical surfaces.

A lens system for projecting may consist of a pair of cylindrical or spherocylindrical elements adjusted at such a distance apart as will effect proper registration of the images on the screen, and geometrically and chromatically corrected. The unit then consists of a spherical element (such as an ordinary projecting lens) with a cylindrical element in front and behind, the cylindrical elements being either parallel or crossed.

Alternately a projection unit can be used composed entirely of cylindrical elements geometrically and chromatically corrected. It will be understood that the term "geometrical" applied to aberration and its correction includes spherical aberration in the case of spherical lenses and the corresponding aberration in the case of cylindrical lenses due to their faces being true circular cylinders.

Dated the 29th day of August, 1931.

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COMPLETE SPECIFICATION.

Improvements in or relating to Colour Photography and Projection.

We, ADAM HILGER, LIMITED, a company organised under the laws of Great Britain, and JOHN HENDRI DOWELL, British subject, both of 98, Kings Road, Camden Road, London, N.W.1, 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 colour photography and projection, more particularly to colour kinematography by the method in which two or more pictures are recorded simultaneously side by side in the space normally occupied by one picture on film of standard width.

In such cases in order to utilise as large an area of the film as possible for the purpose of getting good illumination of the projected picture, the width of each picture is in the existing systems made to run along the length of the film. In this way a comparatively greater area of the film is employed to produce pictures of standard height and width proportions, but since the accommodation of the sound track on sound films makes the picture space more nearly square, the advantage so gained is much less with this kind of film.

In such systems an image dividing prism and pair of lenses is usually employed in the camera to form the pair of pictures side by side, and the camera is either laid on its side or an optical rotating device is used to turn the picture through 90°. On projection it is also necessary to employ an optical device to turn the pictures through 90° in order that they may be erect on the screen.

It has already been proposed in colour kinematography to distort or anamorphose the images by reducing their width or height in such proportion that the companion images together occupy exactly one picture space on the film. This was

carried out by mounting in front of the taking and projecting lens systems a dioptric of two cylindrical lenses, the lens system being then a set of objectives of which each objective was associated with one colour. It is an object of the present invention to obviate parallax errors when thus anamorphosing the images.

According to the invention an image dividing prism is combined with cylindrical and spherical lens elements designed to produce two or more identical images all taken from the same view point, the images so produced having different magnification in the horizontal and vertical directions so that one set of companion images exactly fills one picture space on the film, and the individual images are in close juxtaposition; thus the whole available area of the film is utilised. The pictures are preferably taken the right way up, and one above the other, or side by side, and optical means are provided so that the pictures so taken occupy the whole available area of the film as described above, that is, while the pictures are of standard height, the width is reduced to approximately half in the case of a two colour method, so that two pictures can be taken in the space ordinarily occupied by one. On projection the pictures would then have to be enlarged approximately twice as much in width as in height so that a picture of normal proportions is projected on the screen. In a similar way it would be possible to maintain the standard width and reduce the height on the film. The objective system which is used for projection according to the invention comprises in combination a pair of cylindrical lens elements with a spherical lens element between them. The cylindrical lens elements in one construction have crossed axes and are then both convergent or both divergent; in an alternative construction the axes are parallel and then one element should be convergent and one divergent. Such a system may also be used in the camera with or without the image-dividing prisms.

Some examples of optical systems according to the invention are shown diagrammatically in the accompanying drawings in which

Figure 1 is an image-dividing and anamorphosing system for a two-colour kinematograph camera;

Figure 2 shows a similar system which is more suitable for long focus elements;

Figure 3 is a projecting system in which a cylindrical anamorphoser is combined with a spherical imaging system;

Figures 4, 5 and 6 are further alternative lens arrangements suitable for camera's or projectors.

Referring to figure 1, the image-dividing system comprises the two prisms 1 and 2 separated by a semi-reflecting surface 3 set at an angle of approximately 45° to the optical axis. The prism 1 has an entrance face 4 perpendicular to the optical axis and a totally reflecting face 5 parallel to the face 3. The light reflected at this surface passes out by an exit face 6 parallel to the entrance face 4. The prism 2 has a reflecting surface 7 set at an angle of about $22\frac{1}{2}°$ to the optical axis and the ray transmitted through the semi-reflecting surface 3 is reflected at the surface 7 to pass out through the exit surface 8. To bring this ray parallel to the one reflected at the surface 3 and to rectify it as regards left and right a mirror or other suitable reflecting means 9 is arranged parallel to the reflecting surface 7. The two rays then fall side by side on the film at 10 and 11. The angular settings of the reflecting surfaces may be varied within wide limits.

In combination with the beam dividing system there is an anamorphosing system comprising the cylindrical converging lens 12 with horizontal axis in front of the entrance face 4 and a pair of similar diverging cylindrical lenses 13 and 14 also with horizontal axes and located near the exit faces 6 and 8 respectively. The focal lengths of the lenses 12, 13 and 14 and their separations are such that parallel light entering the lens 12 is still parallel after passing out of the lenses 13 and 14 but the magnification is different in different azimuths to produce the required alterations of dimensions of the image on the film.

The third element in the combination is a pair of spherical lenses 15, 16 each associated with one of the divided beams of light and located between the lenses 13 and 14 respectively and the film 10, 11. The optical combination built up of these three elements forms the image-dividing anamorphosing and producing system.

The dimensions of the various elements are so related to each other that a pair of identical images is produced at 10 and 11, and moreover the various elements are so corrected that these images are free from chromatic and geometrical aberration. For the purpose of applying corrections for chromatic aberration the prism system is preferably arranged as described in patent specification No. 349,107. The term " geometrical aberration " used here and elsewhere in this specification includes spherical aberration of the spherical lens elements and the corresponding aberration of cylindrical lens elements due to their

surfaces being ground as true circular cylinders. The drawing indicates lenses and prisms in the conventional way as single pieces of glass, but it is clear that the corrections referred to will necessitate the building up of these elements in most cases of separate glasses having different optical qualities.

The embodiment just described was intended for comparatively short focus lenses and where lenses of rather longer focal length are suitable it may be found convenient to interchange the lenses 13 and 15 and the lenses 14 and 16, that is to say the spherical imaging lenses would come between the positive and negative cylindrical lenses.

For longer focus lenses still the alternative arrangement shown in figure 2 is more suitable. Prism 1 has faces 3, 4, 5 and 6 as described in connection with figure 1, but the prism equivalent to 2 is in effect divided into two parts 17 and 18. The prism 17 has an exit face 19 in the same plane as the exit face 6 of prism 1. The transmitted beam emerges therefore parallel to the reflected beam, and to compensate for the shorter path length through the prism 17 the prism 18 is added which takes the place of the extended part of prism 2 in figure 1 and of the mirror 8. It will be seen from the figure that the prism 18 has two parallel reflecting surfaces 20 and 21 so that the companion images are brought side by side on to the film at 10 and 11 as before.

The cylindrical and spherical lens elements may be arranged as desired in relation to the prism elements 1, 17, and 18, the arrangement shown in the drawing being the alternative arrangement of figure 1, namely with the spherical lens elements 15 and 16 between the cylindrical lens elements 12 and 13 and 14 respectively. Where the location of these elements is not governed by the requirements regarding focal length, they should be arranged in the manner best calculated to secure proper correction for the various aberrations. The cylindrical elements although shown with parallel axes may, of course, have crossed axes, examples of which are described hereinafter.

In a further modification the prism element is itself provided with spherical or cylindrical surfaces in place of plane entrance or exit faces or both. The purpose of these faces would be to assist either the image-forming properties of the complete system or the corrections for aberrations.

An example of an optical group for projecting purposes is shown in figure 3. Here the companion images 10, 11 on the film are to be projected together on to the screen 22. The optical system shown in this figure comprises two similar sets of lenses, and each of these sets comprises a spherical converging lens 23 with a cylindrical diverging lens 24 between it and the film and a cylindrical converging lens 25 between it and the screen. The cylindrical lenses are shown with parallel axes but they may also have crossed axes. The whole combination will, of course, be suitably corrected for the various aberrations, not necessarily by each lens being corrected for itself. As in the case of the taking lenses it is clear that if the cylindrical lenses have crossed axes they will have a certain imaging power in both directions and this will modify the power of the spherical lens element to be used for any given conditions. It is also obvious that the lens separations will have some effect on the effective focal lengths in the different planes considered.

Figure 4 shows a lens arrangement which is alternative to the arrangement in figure 3, the magnification ratio being in the opposite direction. In this case as before a converging spherical lens element 23 is located between the two cylindrical lens elements, but the converging element 26 is placed between the spherical element 23 and the film 10, the diverging element 27 being towards the screen or the object being photographed. This particular arrangement is shown in a purely diagrammatic form and it is clear that it may be duplicated as shown in figure 3 for the purpose of projection or it may be combined with image-dividing prisms as shown in figures 1 and 2 for the purpose of taking photographs.

Figure 5 shows an alternative arrangement in which the effect of separations between the lens elements is taken account of in that both cylindrical lens elements are of the same type. For exhibiting the arrangement in the figure one cylindrical lens element has been rotated through 90°, but in the actual construction of this embodiment the cylindrical lens axes are at right angles. The spherical lens 23 is located between two diverging cylindrical lenses 28 and 29; thus in the one plane the lens 29 has no effect and the effective image-forming combination is the lens group 23 and 28. In the plane at right angles to this the lens 28 is not effective and the image-forming lens group is 23 and 29. In both planes the image is brought to a focus at the film 10, or alternatively the image on the film 10 is brought to focus on the projection screen (not shown), but owing to the difference in effective focal length the magnification is different in the two directions. With an arrangement of this kind it is quite easy

to obtain a ratio of effective focal lengths in the two planes at right angles of 2 : 1.

Figure 6 shows a somewhat similar arrangement but in this case both the cylindrical lenses 30 and 31 are of the converging type. This arrangement in contrast to that of figure 5 is generally suitable for only moderate differences of magnification in the two directions.

While it comes within the scope of the invention to use an ordinary projecting lens as the spherical element in the various combinations described, it has been found preferable to design the complete combination for each case without any reference to the separate use of the spherical element as an independent projecting lens. A further modification within the scope of the invention is to combine a spherical and cylindrical element in such a way that at least one lens has a spherical face on one side and a cylindrical face on the other. Further, the prism element may in any case be provided with either spherical or cylindrical surfaces as indicated above for one particular case. There are thus provided a considerable number and variety of surfaces by the curvature, orientation and location of which the desired corrections may be made.

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. For colour photography an objective system comprising in combination image dividing prisms and cylindrical lens elements with crossed axes giving different magnification in different azimuths.

2. For colour photography an objective system comprising in combination a spherical lens element, cylindrical lens elements having parallel axes and so arranged in relation to the spherical element that different magnification is obtained in different azimuths, and image dividing prisms located between the imaging elements, those imaging elements between the image dividing means and the sensitive surface being duplicated for the separated images.

3. For colour photography an objective system giving different magnification in different azimuths comprising in combination an image dividing prism system and spherical and cylindrical lens elements, the latter having crossed axes.

4. For colour photography an objective system comprising in combination image dividing prisms having reflecting dividing surfaces, cylindrical lens elements with parallel axes and a spherical lens element so arranged that different magnification is obtained in different azimuths.

5. For colour photography or projection an objective system giving different magnification in different azimuths comprising a pair of diverging cylindrical lens elements with crossed axes with a spherical lens element between them.

6. For colour photography or projection an objective system giving different magnification in different azimuths comprising a pair of converging cylindrical lens elements with crossed axes with a spherical lens element between them.

7. For colour photography or projection an objective system giveng different magnification in different azimuths comprising a pair of cylindrical lens elements with parallel axes with a spherical lens element between them.

8. An objective system as claimed in any of Claims 1 to 4, in which one or more of the required curved (cylindrical or spherical) surfaces is worked at a suitable location on the image dividing prisms.

9. An objective system as claimed in Claim 2, 3 or 4, in which at least one lens element has a cylindrical face on one side and a spherical face on the other.

10. An objective system as claimed in any of the preceding claims corrected for geometrical aberration.

11. Objective systems substantially as shown on the accompanying drawings and as described with reference thereto.

Dated the 29th day of June, 1932.
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Fig. 1.

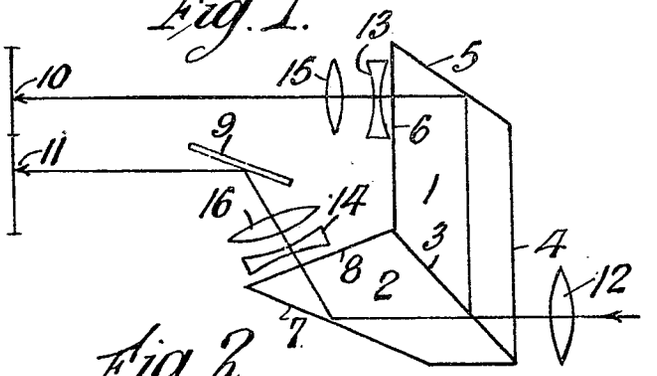


Fig. 2.

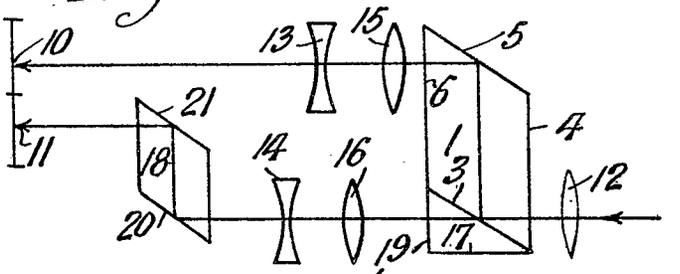


Fig. 3.

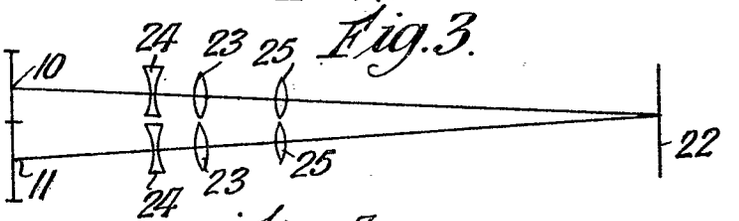


Fig. 4.

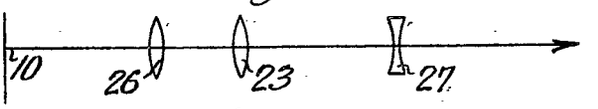


Fig. 5.

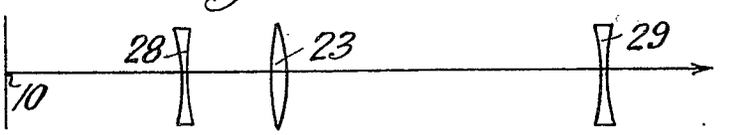
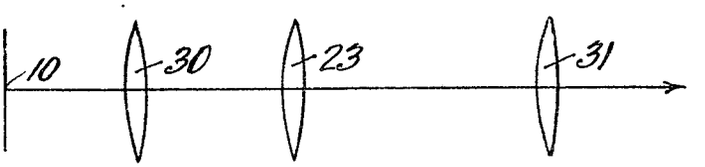


Fig. 6.



Malby & Sons, Photo-Litho.