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COMPLETE SPECIFICATION.

Optical Appliances for Two Colour Heliochromy.

We, FRANK TWYMAN, Manager of Adam Hilger Limited, of 75A, Camden Road, London, N., Scientific Instrument Makers, JOHN SHARP HIGHAM, The Corner, Birkdale, Lancashire, Cotton Manufacturer, and HAROLD WORKMAN, of 12, University Gardens, Kelvinside, Glasgow, North Britain, Engineer, 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:—

The present invention relates to two colour cameras, and more especially to two colour cinematograph cameras, in which a branch is separated from the entering beam of light, by reflection in a partially transmitting and partially reflecting compound prism block (hereinafter called "compound prism block"), the direct beam passing through one objective (hereinafter called "direct lens"), while the branch beam reflected in the block is again reflected by a reflecting prism (hereinafter called "reflecting prism") fitted at the side of the compound prism block so that the axes of the direct beam and the branch beam are brought into parallelism and the branch beam traverses a second objective (hereinafter called "side lens"). Such a device is used in association with colour screens appropriate to the two colour system and the system produces two images simultaneously on one receiving plane or surface, both images being produced from the same point (aspect) of view.

The object of the present invention is to provide a more efficient taking system of the class described in which equality of size on the part of the two images may be realised for objects at all distances from the camera or through any shorter range of distances from the camera through which it is desired to use the system.

To this end the present invention comprises a combined lens and prism system of the class described in which "optically paired" lenses are used and the direct lens is set or adjusted nearer to the common focal plane than the side lens by a distance which causes equally sized images to be formed by the two lenses of an object close to the camera, or by such a lesser distance as will cause substantially equally sized images to be formed by the two lenses of objects at the shortest distance from the camera at which it is intended to use the system and in which a plane parallel block of glass or other suitable medium is fitted between the side lens and the common focal plane so as to cause the image produced by the side lens to be set back so much as to bring this image to a sharp focus on the same plane as that on which the image produced by the direct lens is sharply focussed.

By "optically paired" lenses is meant lenses which have been so selected or adjusted that when placed in correct position between an object and the focal plane on which its image is to be produced they give sharp images of the object of equal size on that plane, and provided the above condition is maintained such lenses need not necessarily be otherwise identical.

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Such pairing is preferably done under the conditions under which it is intended to use the lenses.

In applying this invention the prism arrangement in front of the lenses for dividing the light between them is preferably of the improved form described in British Patent No. 16,810 of 1915, *viz.*, a form in which the compound prism block in front of the direct lens is decentred relatively to the axis of that lens in a direction away from the axis of the side lens, and has a plain flat glass extension or *ajutage* on that side of it with aspect towards the produced axis of the side lens into which extension or *ajutage* the transmission reflection surface does not intrude and with which extension or *ajutage* the reflecting prism is optically integral.

In the embodiment which is hereinafter described in detail with reference to the appended drawing the prism system is formed so as to cause the reflecting surface of the reflecting prism to meet the extended portion of the compound prism block some distance back from the front face or face with aspect towards the scene of the compound prism block. But the hereinabove defined improved form of prism system may be one in which the co-operating reflecting surfaces of the compound prism block and its companion reflecting prism are made parallel to each other but inclined at an angle greater than 45 degrees to the axes produced of the lenses so as to cause the reflected marginal ray from the front edge of the first reflecting surface to substantially skim the front face of the compound prism block. Both the foregoing specific arrangements under the preferred form of prism system will be found described and figured in the Specification and drawings of the before recited British Patent No. 16,810 of 1915.

With regard to the optically paired lenses combined with the prism system, the direct lens is mounted or adjusted and set nearer to the common focal plane than the side lens by a distance which renders virtually or optically equal the paths of the direct beam and the doubly reflected branch beam as traced and measured in each case from the front face of the compound prism block, *i.e.*, that face by which the light enters the system, to the optical centre of the corresponding lens, and by this means equally sized images or substantially equal sized images are produced by the two lenses of objects at all distances from the camera. Alternatively the nearer mounting or adjusting and setting of the direct lens to the common focal plane may be by a somewhat lesser distance than that indicated above, and in such cases the direct lens is set or adjusted nearer to the common focal plane by such a lesser distance than that defined as will cause equally sized images or substantially equal sized images to be produced by the two lenses of objects within a given range of distance from the camera through which it is desired to use the system.

The plane parallel block of glass behind the side lens is made of such a thickness in relation to its refractive index that the image formed by the side lens is brought to a sharp focus on the same plane as that formed by the direct lens and this thickness is preferably adjusted for an image formed by light of the colour of the taking filter used with the side lens and this filter is preferably the red one.

The arrangement according to the present invention of the combined lens and prism system including the plane parallel block of glass behind the side lens conduces to the optical parts forming the system being so conjoined or rigidly fixed together that the system becomes integral with a single focussing mount whereby all the parts move together as a unit in focussing, and the arrangement is preferably so mounted. For a description and illustration of such a mounting, reference may be made to British Patent No. 16,812/1915.

A desirable embodiment of the invention in which equal sized images are formed by both lenses of objects at all distances from the camera is illustrated by Fig. 1. A is the compound prism block of which the cemented diagonal or hypotenuse B is made partially reflective as a whole, or wholly reflective in

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lines or areas according to any well known system or mode. Thus the coating of the plane B may be by the deposition all over of a thin partially reflecting and partially transmitting layer of silver, platinum or other suitable metal or substance, or the coating may be a fully reflecting metallic coating in lines or small areas, evenly distributed over the whole reflecting surface, either of these devices allowing an appropriate or desirable apportionment of light so that any required proportion of light entering the compound prism block A may be deflected from the original direct course through that lens which is covered by the compound prism block. The reflected beam which emerges from that side of the compound prism block contiguous to the reflecting prism D is received by the above mentioned reflecting prism D, and is again reflected so that the axis of the reflected beam shall be brought into parallelism with the axis of the original beam. The hypotenuse of the reflecting prism D may, if considered desirable, be silvered. In the path of the direct beam, after having passed through the compound prism block A, is an objective F being the direct lens, and in the path of the twice reflected beam is a second objective G being the side lens which should be optically similar to or form a pair with the direct lens F, the direct lens F being set or adjusted back in relation to the side lens G, to such a distance as will wholly correct or bring into parity the sizes of the images produced by the two lenses for objects at all distances from the camera. Behind the side lens G, is a block of plane parallel glass I of such thickness and density as will cause the image of this lens to be brought to a focus at H on the same plane as the image formed on the surface E in the undeflected beam, or alternatively this block may be a composite of glass and a liquid or plastic medium retained by the glass, or of any suitable highly refractive material.

In the particular case given by way of example the lenses or objectives F and G are lenses adjusted to form a pair, the focus being $2\frac{1}{4}$ inches, the apertures being F 3.5 and the distance between the axes or "centres" $1\frac{3}{16}$ inches. The compound prism block and reflecting prism in front of the objectives are of glass having a refractive index of 1.53 and the glass block I has a refractive index of 1.65.

In this particular case the reflecting surfaces in the compound prism block and the reflecting prism are at an angle of 45° to the produced axes of the lenses and the direct lens is set or adjusted nearer to the common focal plane than the side lens by a distance which if arrived at by calculation is equal to $\frac{d}{u}$ where u denotes the index of refraction from air to the glass used for the prisms, (in the particular case 1.53) and d denotes the distance between the axes of the lenses, (in the particular case $1\frac{3}{16}$ inches).

The thickness or distance from front to back of the plane parallel glass block I is equal if arrived at by calculation to $x \frac{u}{u-1}$ where x denotes the distance the direct lens is set or adjusted nearer to the common focal plane than the side lens, this being found as above stated, and u denotes the index of refraction from air to the glass used in the plane parallel glass block (in this particular case 1.65).

This last mentioned refractive index should preferably be that for light of the average colour used to form the image through the side lens and as before stated this image is preferably formed through the red filter.

Whilst the rules given for arriving at the distances hereinabove referred to by calculation will ordinarily be used in carrying out the invention, the distances so formed may be checked and finally adjusted by trial and observations; alternatively they may be found or adjusted by trial and observation.

In cases in which it is only desired to produce substantially equal sized images through both lenses of objects within a selected range of distance from the

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camera through which it is intended to use the system, the aforesaid nearer setting or adjusting of the direct lens will be by a somewhat lesser distance as hereinabove defined than in the instance described in detail with reference to the drawing and the plane parallel glass block I will be correspondingly adjusted so as to bring the image formed by the side lens G to a sharp focus on the same plane as that of the image produced by the direct lens F. 5

Colour screens appropriate for two colour heliochromy must be placed in the separated light paths in accordance with the known principles of two colour heliochromy which are now common knowledge and are explained in works or articles on heliochromy, and the required screens may be interposed anywhere in the paths of the branch beams; but as hereinabove stated the image formed by the side lens is preferably taken through the red filter. 10

By a combined lens and prism system substantially as herein described is realised a practical means of using lenses of large aperture and of short focal length for producing simultaneously exposed pairs of images in the branch of heliochromy concerned from substantially the same point of view, and of equal size or approximately equal size for objects at all distances from the camera or within the range of distance through which it is desired to use the system, such images being brought to a sharp focus on the same plane. 15

It has already been suggested in a three colour camera with three lenses and a light dividing reflecting plate system in front of such lenses to set one of such lenses back closer to the common focal plane relatively to the other two and to introduce parallel blocks of glass or equivalent liquid medium behind the second mentioned two lenses with the object of placing the three equal sized images on the same focal plane. Such an arrangement however will not produce images of the quality to be desired in the branch of colour photography specially referred to herein, the achievement of which is an object of the present invention. 20 25

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:— 30

1. A combined lens and prism system of the class described in which optically paired lenses are used and the direct lens is set or adjusted nearer to the common focal plane than the side lens by a distance which causes equally sized images to be formed by the two lenses of an object close to the camera, or by such a lesser distance as will cause substantially equally sized images to be formed by the two lenses of objects at the shortest distance from the camera at which it is intended to use the system and in which a plane parallel block of glass or other suitable medium is fitted between the side lens and the common focal plane so as to cause the image produced by the side lens to be set back so much as to bring this image to a sharp focus on the same plane as that on which the image produced by the direct lens is sharply focussed. 35 40

2. A combined lens and prism system as claimed in Claim 1 hereof, in which the compound prism block with its reflecting prism is of the improved form herein defined.

3. A combined lens and prism system as claimed in Claim 1 or Claim 2 hereof, in which the optical parts forming the system are so conjoined or rigidly fixed together that the system becomes integral with a single focussing mount whereby all the parts move together in focussing. 45

4 The herein described improvements in a combined lens and prism system of the class defined substantially as set forth or illustrated. 50

Dated this 29th day of November, 1915.

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ERRATUM.

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Page 3, lines 51 and 52, for " observations " read " observation. "

PATENT OFFICE,

May 17th, 1917.

Fig. 1.

