Second Edition.]

PATENT SPECIFICATION

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COMPLETE SPECIFICATION.

Improvements in Optical Systems for Photographic or Projection Apparatus.

I, LUCIEN HENRI ROUX, a Citizen of the Republic of France, of 16, Avenue Victor Hugo, Vanves (Seine), France, 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 optical systems for cinematograph or other colour photography or projection apparatus. One known method of natural colour photography involves producing a plurality of identical monochrome (for example, red, blue and green) images of the object. Various forms of photographic apparatus based on this principle are already known. They are composed of two optical systems, the former of which is a single primary object lens giving a real image of the object, in the plane of which image is placed a converging lens which directs the rays coming from the primary object lens on to a second optical system formed of a group of identical secondary objective lenses all situated in one plane and whose number equals that of the monochromatic images which it is desired to obtain; thus the secondary images are all formed in one plane in which is placed a sensitised surface, e.g. a film or plate.

Such an arrangement presents certain difficulties. For example the plane of the sensitised surface is conjugate with a certain plane in the object field of the secondary objectives. The result is that on the sensitised surface, sufficient sharpness will be exhibited only by images from a volume or zone of the object field which is contained between two extremely close planes, whose distance apart is at the most equal to double the focal depth (distance from the focus within which each image of a point object does not exceed a given tolerance) of the secondary objectives (about 1/10 mm.). For practical purposes therefore, this volume would be a plane which itself is conjugate with a certain volume in the object field of the anterior objective which volume, under the best working conditions, that is to say when focussing to infinity, would lie between infinity and the hyperfocal length (minimum distance at which said objective, focussed to infinity, will give a sufficiently sharp image).

Thus on the sensitised surface there would be a sharp image only of the space enclosed between the hyperfocal length of the anterior objective A and infinity: all which lies on the near side of this limit would only give a sharp image behind the sensitised plate. The projection of photographs taken under these conditions in black will result merely in blurring, That of photographs taken in colours on the other hand will give quite useless images.

Moreover, with these known arrangements there is a residual parallax due to the fact that the beam which traverses each secondary objective has first of all passed through a circular peripheral region, in the anterior objective, which is the image of this secondary objective given by the interposed optical system and not through a common region which would be the centre of the anterior objective.

The arrangement which is the subject of the present invention aims at remedying these deficiencies; it is characterised, in the case of photographic apparatus, by the fact that a lens, which projects to infinity the image formed by the principal objective, is placed in front of the secondary objectives and in immediate proximity to these objectives, the focus of this lens being in the plane of the real image formed by the principal objective. As will be hereinafter explained the elements of the optical system arranged in the manner stated can be employed in projection apparatus, the direction of projection being the opposite of that defined for the case of photographic apparatus.

Embodiments of the invention will now be described, by way of example, with reference to the accompanying diagrammatic drawings, in which:—

Fig. 1 represents a diagrammatic section of the optical system employed for photographing an object;

Figs. 2, 3 and 4 represent various alternative arrangements of the secondary optical system;

Figs. 5, 6 and 7 represent the corresponding arrangements of the images upon a cinematograph film; and

Fig. 8 represents a diagrammatic section of a projection system.

In Fig. 1, the single entrance pupil is an objective lens of suitable focal length, which forms the objective A and produces a plane image B of the object. In the plane B, is placed a diaphragm so as to limit the field, and a field lens D so as to reduce the divergence of the light beam after formation of the image B; the said field lens D is not however absolutely necessary. Another lens E the focus of which is situated in the plane B is placed immediately in front of a group of secondary objective lenses F^1 F^2 of suitable equal focal lengths. Each of these secondary lenses produces from B a new image G_1 or G_2 in the single plane of their foci, the said images being identical with B and with each other as a result of the focal lengths of lenses F^1 and F^2 being equal.

There are thus obtained as many images of the photographed object as there have been employed secondary objectives such as F^1 and F^2, all these images being identical as to form and size since they are simultaneous photographs of a single image.

In order to reproduce the colours according to a multichrome process, it is further necessary that each image G be formed through a suitable coloured filter. For that purpose, a suitable coloured screen is conveniently placed in front or at the rear of each secondary objective F^1, F^2. It is to be understood that the said screen may have curved faces or plane faces which may or may not be parallel to one another, or may constitute the whole or a part of the lenses of the said objectives F^1, F^2.

The introduction of lens E in front of the secondary objectives F ensures, as indicated above, a double advantage:

While in the known arrangements the secondary objectives F give multiple secondary images of the single image formed by the anterior objective A serving as object for these objectives F, in the arrangement which is the subject of the invention the image formed by A is reprojected to infinity by lens E and it is the image given by this lens E which acts as object for the secondary objectives F. The sharpness of the focussing is determined, in the known arrangements, by the focal depth of the secondary objectives and, in the arrangement of the present invention, by the focal depth of the lens E. The focal depth, for a given aperture, can be shown to be proportional to the focal length, so that the focal depth which is effective to determine the sharpness of focussing is, by the invention, increased in the ratio $\frac{\text{focal length of E}}{\text{focal length of F}}$, a ratio which in practice is between 2 and 2.5, this resulting in a considerable improvement in the focussing.

Further, the presence of the lens, E practically eliminates parallax. Since the image from the objective A reprojected to infinity by said lens E has (the reprojected rays being parallel) the same aspect in relation to each of the secondary objectives, the latter give images without parallax defects.

According to requirements, if it is desired to produce two, three, or four colour records on, say a cinematograph film, the objectives F^1, F^2 may be arranged as indicated in Figs. 2, 3 or 4. Similar arrangements of colour record images result, Figs. 5, 6 and 7. Any one of these groups of colour records will give an image of the object in colours, if the constituent records forming the group are projected in superposition.

It goes without saying that the invention is not restricted to the number and arrangement of the objectives F_1, F_2 and the images G_1 G_2 shown in the diagrams.

The same optical system, modified as shown in Fig. 8, may be employed conveniently for colour projection purposes.

The film K carrying the colour records G_1, G_2 is illuminated by a source of light H, placed behind a condenser I, and a plurality of smaller secondary condensers J_1, J_2 are located close to the condenser I between the latter and the film K, the number of the secondary condensers J_1, J_2 being equal to the number of secondary objectives F_1, F_2. Each of the condensers J_1, J_2 concentrates a portion of the light issuing from the main condenser I upon the corresponding objective F_1, F_2 through the corresponding colour record G_1, G_2. A group comprising a source of light and a concave mirror, or any other convenient device, may be substituted for the group comprising the source of light H and the condenser I.

As to the other parts of the arrangement, the path of the light through them is the reverse of that traversed by the light during the taking of the photographs.

The presence of the lens E in the projection apparatus permits of working with the same spacing of the centres of the secondary objectives F as was employed in the photography apparatus and therefore obviates any necessity for adjusting said objectives. If the lens E were not provided, it would be necessary to make

these objectives adjustable to enable the exact superimposal of the images in the plane of the lens D. The provision of the lens E has the further advantage of avoiding an optical system of inconvenient length.

The positive film may be colourless, the colours being obtained on the screen by employing, in front or at the rear of each objective F_1, F_2, the same coloured filter which was employed for the photography. Also, the filters may be dispensed with and in this case the records on the film would be painted respectively with the colour of the corresponding screen interposed for the photography.

It is clear that modifications may be made in the above described apparatus without departing from the scope of the invention. In particular curved mirrors may be used in lieu of the whole or a portion of the objective lenses, a vessel containing coloured liquid in lieu of the coloured filters and photographic plates instead of the film.

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

1. Apparatus for cinematograph or other colour photography of the kind in which a first objective gives a real image of which several secondary objectives then give their several individual images which may be superimposed and are all situated in one plane, characterised by the fact that a lens, projecting to infinity the image formed by the principal objective, is placed in front of the secondary objectives and in close proximity to these objectives, the focus of this lens being in the plane of the real image given by the principal objective.

2. Apparatus for cinematograph or other colour projection, comprising the elements of an optical system arranged as claimed in Claim 1, the direction of projection being the reverse of that defined in said claim for the purposes of photography.

Dated this 4th day of March, 1932.

For the Applicant,
RAWORTH, MOSS & COOK,
75, Victoria Street, London, S.W. 1,
Chartered Patent Agents.

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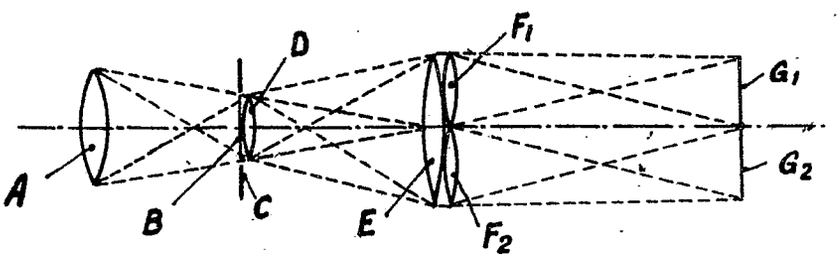
2nd Edition

Fig. 1



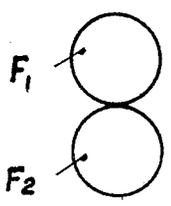


Fig. 2

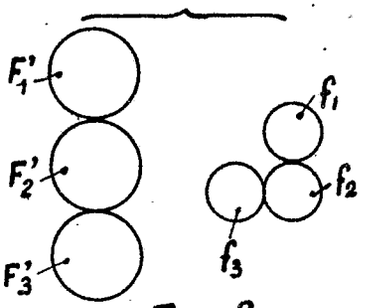


Fig. 3

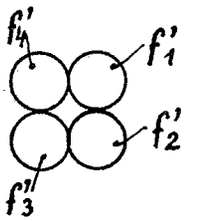


Fig. 4

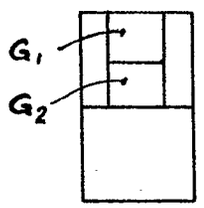


Fig. 5

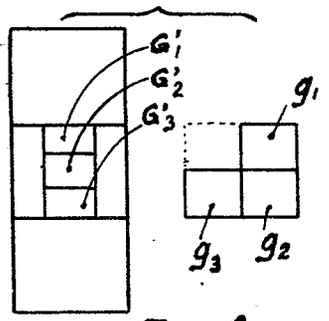


Fig. 6

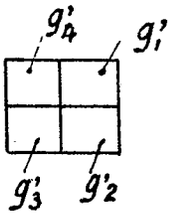


Fig. 7

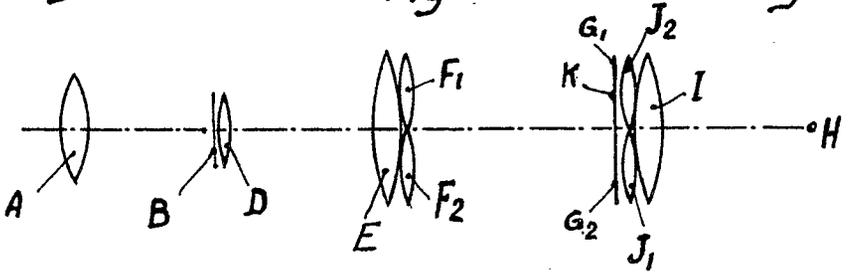


Fig. 8

Malby & Sons, Photo-Lith.