# N° 1073 A.D. 1915

*(Under International Convention.)*

*Date claimed for Patent under Patents and Designs Act, 1907, being date of first Foreign Application (in the United States),* 29th Jan., 1914

*Date of Application (in the United Kingdom),* 22nd Jan., 1915

*At the expiration of twelve months from the date of the first Foreign Application, the provision of Section 91 (3) (a) of the Patents and Designs Act, 1907, as to inspection of Specification, became operative*

*Accepted,* 24th Jan., 1916

COMPLETE SPECIFICATION.

## Improvements in Color Photography.

I, PERCY DOUGLAS BREWSTER, of 65, Prospect Street, East Orange, Essex County, State of New Jersey, United States of America, Manufacturer, 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 color photography and more particularly to the production of colored motion pictures or cinematograph pictures.

In my prior Application No. 3435/14 filed February 10, 1914, I have described and claimed a method of photographically reproducing colors upon a film or support coated on both sides with emulsions sensitive to light, this method, consisting in dividing the light from the object into color groups, one of which acts on the emulsion on one side of the film while the other group acts on the emulsion on the other side of the film. In one form of carrying out this method as set forth in my said prior application or patent the division of the light into color groups is effected by the film itself owing to the fact that the emulsion on one side of the film is rendered sensitive to light of one of the color groups, while the emulsion on the other side is rendered sensitive to light of another color group. As the light from the object passes through the film (the emulsion on the front side being sufficiently transparent to permit such passage of light) the color groups are separated by the selective action of the different emulsions.

Now the present invention relates to an improved method of producing colored motion pictures upon film coated with emulsion on both sides, the general object being to provide improvements in the art such that a colored motion picture may be obtained which will reproduce the object photographed with complete definition and pleasing coloring.

In accordance with the present invention, the light from the object is divided into groups at a point between the object and the emulsion surfaces of the film, and these groups of light are directed one on each side of the film to produce two photographic images thereon. The emulsion coatings on the film may be

[*Price* 6*d.*]

panchromatic, in which case each group of light passes through a color screen before acting on the emulsion, so that one group may pass through a red screen for example, while the other group may pass through a green screen. It is not essential to pass the light through color screens in this way, and if desired, the film employed may be coated with emulsion on one side which is chiefly sensitive to one color, such as green, while it is coated with emulsion on the other side which is chiefly sensitive to another color, such as red. The present method of producing positives is differentiated from that described in my prior application for patent referred to above in that the light from the object is divided into groups at a point between the object and the emulsion coatings on the film, instead of being divided in the emulsion coating, as is the case in my earlier method. My improved method is preferably carried out by means of a special camera provided with means for dividing the light from the object into groups and then directing these groups one on each side of the double-coated film. Such camera may be constructed in a great variety of ways, and a number of embodiments thereof are described hereinafter.

A further feature of my invention consists in providing improved means for printing positives from the double-coated negatives obtained in accordance with the present process, or the processes described in my said prior Patent or Application No. 3435/14. In order that my invention may be more fully understood reference will be made to the accompanying drawings in which

Fig. 1 is a sectional plan view of a camera suitable for practising my invention, and Fig. 2 is a similar view of another form, both figures being somewhat diagrammatic in character for the sake of simplicity and clearness. Figs. 3, 4 and 5 are diagrams illustrating the printing and projection of positives made by my system of color photography. Fig. 6 shows the use of a camera of the kind illustrated in Fig. 2 for the printing of positives from a negative.

The camera 10, shown in Fig. 1, is divided into two compartments or chambers, 11, 12, by a partition 13 in which is an opening to receive the film or plate 14 with its two emulsions 15, 16, facing the chambers 11, 12 respectively. In motion picture work a suitable film-gate; indicated diagrammatically at 17, is provided, through which the film is passed by suitable means. As mechanisms for such purpose are well known in the art, it is unnecessary to illustrate the same here.

The two lenses 18, 19, are preferably as nearly as possible of the same focal length and are preferably at equal distances from the plane of the film or plate 14. Rays of light from the object (not shown) are received by the lens 18 and are projected thereby against reflectors 20 and 21 in succession and finally are brought to suitable focus upon the sensitive coating 15 of the film or plate 14. Similarly the lens 19, with the help of the interposed reflectors 22, 23, 24, projects an image upon the emulsion 16, which image may be, in general, substantially congruent with that on the emulsion 15, subject only to the unavoidable separation of the images due to the thickness of the plate or film 14. To produce congruence, it is evident that the number of reflectors in the case of one image (either one) must be even and in the other odd. By using three reflectors in chamber 12, instead of one, it is possible to keep the lenses 18, 19, close together, thus diminishing the stereoscopic effect incident to the use of two lenses side by side or one above the other.

As explained in my co-pending application above referred to, the emulsions 15, 16, are intended to be affected by light of different colors or groups of colors, for example the first by red, orange, and yellow, and the other by yellow-green, green, blue and violet. For this purpose each emulsion may, by well understood methods, be made sensitive to light of its own color or group of colors and relatively insensitive or "blind", to light of the other color or group. As an additional precaution, suitably colored ray filters, as 25, 26, may be used, each being colored to cut out the rays of undesired color or colors. Both emulsions may be sensitive to all colors; or one sensitive to one or more of the colors down

to and including, say, green, and greenish yellow, of the spectrum, and the other to one or more of the remaining colors; suitable filters being used in each case to screen out undesired rays. If necessary or desirable the green-sensitive emulsion may be suitably stained or colored to prevent the passage through it of material amounts of rays of the color or colors to which it is sensitive, to reduce or even eliminate action by such rays upon the other emulsion. If the two emulsions are not equal in "speed" I prefer to place the film with the slower emulsion facing the chamber having the smaller number of reflectors, as less light is lost therein by reflection.

In photographing near objects the stereoscopic or parallax effect of the two lenses may be too great to give the desired degree of similarity of the two images. I therefore prefer to employ a camera with one lens instead of two, as in Fig. 2 for example. Here the rays from the lens 27 strike a transparent reflector 28 combined with a ray filter 29 (preferably behind the reflector, as shown), so that part of the light is reflected to the mirror 30, and thence to the emulsion 15 and another part, with undesirable rays screened out by the filter 29, is thrown upon the emulsion 16 by the reflectors 31, 32, 33. A filter 34 may be used, say in front of the lens, to cut off or reduce the amount of rays which should not go to either emulsion and somewhere in the path of the light which strikes the emulsion 15 may be placed a filter, as 34*a*, to screen out rays which should not go to that particular emulsion; the corresponding function for emulsion 16 being performed by filter 29, which, as stated, is preferably combined with the light dividing mirror 28 and arranged at the back thereof.

If the filter 34 (in front of the lens or between the lens and the transparent mirror) is omitted, two filters may be used, in rear of the mirror just mentioned. In such case, using a film whose "green-sensitive" emulsion is substantially or wholly insensitive to red and orange, the filter in the path of the rays which include red would be designed to eliminate or materially diminish the rays above, say, yellow-green of the spectrum, while the other filter, in the path of the rays which include green, would be designed to cut off the ultra-violet rays and diminish the violet (and possibly the blue) so as to give on that side of the film a substantially orthochromatic rendering of those colors. The advantage of this scheme is that the light projected upon the red-sensitive emulsion (which is usually slower than the other) has to pass through but one filter and hence suffers less loss than would be the case if it had to pass through two filters, as in Fig. 2, for example. In each camera the reflectors used may be made of any suitable material, and if they are silvered glass plates the silvering is preferably on the front surface to eliminate double reflection.

In both cameras the distances of the reflectors from each other, from the lens, and from the focal plane, and the angles which they made with each other and with the focal plane and the optical axis of the lens, are of course important conditions to the securement of the desired focus of the image and the desired registration thereof. The reflectors may therefore be permanently fixed in their proper positions; or as many as necessary may be adjustable, at least to a certain degree, so that their positions can be corrected at a later stage of manufacture or after the camera is otherwise completed. As indicative of this possibility and to avoid complicating and confusing the drawing, only one reflector in each camera is shown as adjustable, for example, the reflector 24 in Fig. 1. For this purpose the reflector is mounted on a stem 35 by means of a universal joint provided with adjusting screws 36 by which the reflector may be turned on the pivot 37. Similar screws (not shown) are provided to turn the reflector on the pivot 38. The stem itself is slidable in the support 39 to shift the reflector toward and from the film 14.

Any suitable shutter may be used with either camera but as such devices are well known it is unnecessary to illustrate the same herein.

After exposure, the film is chemically treated (developed and fixed) in the usual way. I then have two negative images of the same object which are in

suitable register with each other, one produced by light of one color or group of colors, and the other produced by light of another color or group. For example, suppose the object photographed is a vertical cylinder lighted from one side and bearing circumferential bands of red, green and white, and that one emulsion is sensitive to green only and the other to red only. Then the image on the red-sensitive emulsion would show the red band with correct gradation, would be wholly or almost transparent throughout the green band, and would show the white band by a deposit with a correct scale of gradation and of about the same density as in the case of the red band. On the other hand, the green sensitive emulsion would show the green band by a deposit with a correct scale of gradation, would be almost or entirely blank in the red band, and would show the white band with a correct scale and about the same density as the green band. By a transmitted light the two images would combine and exhibit a single or unitary (negative) image with substantially correct gradation and tone-rendering throughout. The two images may therefore be said to be complementary, more or less, in gradation. Instead of "fixing" the negative images they may be converted into positives by reversal by a combination of the well-known ozobrome and cinatype methods of coloring in which the film is treated with a fericyanide and a bromide which hardens the gelatine of the emulsion when the silver is present, which is ozobrome practise. The film is then treated with a dye that is adapted to go into or color the unhardened portions of the gelatine. Any of the pinatype dyes, such as cochineal or dinal pure blue C.H., are suitable for this purpose.

By this method reversal is secured and a black and white negative is converted into a color positive.

In case it is desired to convert a black and white positive into a color positive, the film may be treated with the fericyanide and bromide solutions and then colored by plasters carrying the color pigments, as is carried out in the ozobrome process.

A third method is the traube method, in which the silver is converted into silver iodide, cleared in sodium bisulphite, dyed in basic dyes, such as malachite green, aeromines saffranin, and finally the silver dissolved out by hypo or cyanide of potassium.

Quite a wide variation is permitted in the filters used, the red varying from a deep orange red for portraiture, to quite a yellowish red for scenery and the green from a yellowish to a bluish green. It is preferable that the two filters should be nearly complementary to each other. For example the Wratten-Wainwright filter No. 25 (Atlas of Absorption, Spectra C.E.K. Messrs. Longmans, Green & Co., London, 1909) may be used for red and No. 60 for the green.

It is far more necessary that the negative images should be colored with strictly complementary colors than that the positive images should be so, but it is otherwise immaterial with what colors the negatives are colored. The positives may be colored with malachite green on one side and saffranin or one of the rhodamins on the other with the addition, preferably of some yellow, such as auramin to reduce the excess blue.

The colors chosen depend somewhat upon the color effects desired in the unitary image. For example, if a good rendering of the natural colors of the object is desired, one may be colored green or blue-green, and the other red or orange-red. It is not necessary, in all cases, to have the two colors strictly complementary. If the film is to be used as a negative, it is of course fixed after development. After fixation the negative images are suitably colored with two distinct colors, preferably belonging to the two groups referred to. For example one image may be stained green or blue-green and the other red or orange-red, the blank portions of the emulsion being left uncolored. Any number of positives can now be printed from the negative, as by contact in the usual way. The positive film also is coated on both sides, one emulsion being preferably sensitive to a group of colors above and including, say, green of the

spectrum, and the other to a group below and including, say, orange, and each being by preference practically inert to colors other than those of its own group. If desired or necessary, the printing light may have its ultra-violet, and some of the violet, or other undesirable rays, screened out by a suitable filter, for example one of a pale yellowish color. In positive printing as by contact, for example, it is evident that the light which acts upon the emulsion on the rear of the positive must pass through the front emulsion. This means that the front emulsion must be transparent enough to permit the given printing light to pass in sufficient amounts to give the desired effect on the rear emulsion or coating. Imperfect transparency, and difference in printing speed, may be compensated for in various ways. For example, if the red-sensitive emulsion is slower and is behind, and the front (green-sensitive) emulsion is imperfectly transparent, exposure to white or green printing light may be long enough to give the desired effect on the front (green-sensitive) emulsion and then continued with red, orange-red or orange, for example, thereby securing the necessary effect on the rear emulsion without materially affecting the green-sensitive emulsion; the desired colors of the printing light being secured preferably by means of suitable filters. I prefer to effect the printing by two differently colored lights, preferably those corresponding to the colors with which the negative images are colored or stained. In any case the light effects on the two emulsions can be made equal, or to any desired degree unequal, by varying the exposure of one or both emulsions, either in duration or in the intensity of the light used, or both.

After exposure the positive is developed and fixed in the usual manner. It then has two positive images which are complementary in gradation, and also orthochromatically if the proper course was taken to that end. As in the case of the negative, the two positive images exhibit by transmitted light a single or unitary image. To produce the desired color effects the positive images are now stained or colored, for example in the same manner as in the case of the positive produced by the reversal of the negative described above.

In the completed positive, (and in the negative as well), the two images are separated by the transparent support on which the emulsions are coated. Hence when the positive is projected by divergent rays, as in Fig. 3, in which A designates the nodal point of the projecting lens and B, C, D, divergent rays, two positive images which are perfectly "congruent" with respect to parallel transmitted rays will not give on the screen an image which is unitary throughout. Thus in Fig. 3, two points $D^1$, $D^{11}$, in the path of the axial ray D will be projected together as a single point on the screen. But if the two images are absolutely congruent, that is, in perfect register to rays parallel to the axial ray D, the rays B and C through points $B^1$ and $C^1$ in the one image will find different points, $B^{11}$ and $C^{11}$ respectively, in their paths through the other image. Hence in the image on the screen the definition may be good in the center but will fall off progressively toward the margin. In other words, the image on the screen will not be "unitary" but will consist of two overlapping images. To avoid this, the image that is next to the point A must be of decreasing size, from center to margin, relatively to the other image, the relative difference in size being so graduated that a ray passing through a point as $B^1$, in the rear image, will find in its path the corresponding point in the front image. The two images will then be in "suitable register" for that particular projecting lens. Such "registry" can be produced in printing the positive, as for example by the following procedure: In Fig. 4, E designates a negative with congruent images, through which passes a pencil of parallel rays F, G, H, I, J, to the lens K, which refracts the rays through the nodal point $A^1$ and projects a unitary negative image upon the positive S. The two positive images are therefore produced by rays $F^1$—$G^1$—$H^1$—$I^1$—$J^1$ diverging from $A^1$. If now we remove the source of parallel rays, F, G, H, I, J, and the lens K and negative E, and reverse the direction of the rays $F^1$—$G^1$—$H^1$—$I^1$—$J^1$, there will

be projected on a screen arranged at the right of $A^1$ and at the proper distance therefrom a "unitary" positive image; understanding of course, that the exposed positive has been developed, *etc.*, and replaced in the exact position that it occupied during the printing exposure. In short, if the positive is to be projected upon a screen, the printing of the positive from a negative having congruent images is effected by projection, with divergent rays; then in subsequent projection of the positive, the projecting rays must converge through the positive with the same angularity as the divergent printing rays.

On the other hand, if the negative images are suitably different in size the positive may be printed by contact. Thus in Fig. 5, the divergence or relative angularity of the printing rays, as L, M, N, is such that corresponding points, as P—$P^1$, Q—$Q^1$, R—$R^1$, in the negative $E^1$ are in the paths of the rays from the emission point $A^{11}$, thereby making the positions of the images of these points in the positive $S^1$ correspond with the positions of the points in the negative. Then if the projecting rays pass through the completed positive with the same relative angularity as the printing rays the image on the screen will be defined with the desired sharpness. Where the negative is exposed by the method specifically described in my Application 3435 of 1914, in which the rays reach the emulsion on the rear of the film by passing through the emulsion on the front the negative images will be of the different sizes suitable for contact printing by the method illustrated in Fig. 5. Negatives of the same kind can be made in various ways with the cameras illustrated herein. For example, by one of the lenses in Fig. 1 having a slightly shorter focal length than the other, or by adjusting one or more of the reflectors, or by positioning the film. Thus, moving the film toward one or the other set of reflectors in either camera will make the image on one side of the film differ slightly in size from the other, with the centers of the two images still in alignment. Such adjustment may, however, impair the focus if the focal length and aperture of the lens are too great. Advantage may also be taken of the fact that rays of different colors are brought to focus at different distances from a non-achromatic lens, the rule being, as is well known, that the higher the color in the spectrum the nearer to the lens is its focal plane. Hence if the corrections of the lens or lenses used are not such as to produce perfect "achromatism" but will permit the blue or green image, for example, to be formed in a plane nearer the lens than the red or orange image, for example, adjustment of the reflectors or the film as explained above can be made in either camera without materially impairing the definition of the images. For this purpose the two mirrors 32, 33, Fig. 2, are mounted on a slide 40 in guides 41 by means of a screw 42 so that the focal plane of the rays from the two mirrors can be shifted toward or from the plane of the emulsion 16 until exact coincidence of the two planes is obtained. Fig. 2 also illustrates convenient means for varying the angularity of the reflectors 32, 33. Thus mirror 32 can be turned on the axis 43 by a worm 44 and mirror 33 can be turned on the axis 45 by a worm 46.

Instead of the contact method of printing from "non-congruent" or different sized negative images, as in Fig. 5, the negative images (properly different in size) can be projected upon opposite sides of the positive by the method illustrated in Fig. 6. Here the rays converging through the negative $E^{11}$, carried by a suitable support 47, are received by the lens 48 of a camera 49 similar to that shown in Fig. 2. After passing the lens the rays are divided by the transparent reflector 50 and are reflected by the mirrors 51, 52, 53, 54 to the opposite sides of the positive film $S^{11}$. One or more filters, not shown, may be interposed at appropriate points to screen out undesired rays.

If desired, the positive film, after the images have been suitably colored, may be passed through a yellow dye-bath to stain or tint the emulsions, particularly the transparent portions thereof, a light yellow. This color, combining with blue or green in one or the other images, sometimes improves the color rendering of green objects, such as foliage for example.

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. In a method of photographically reproducing objects in color, dividing the light from the object to be photographed into light groups at a point between said object and emulsion coatings on each side of the photographic film or support, which light groups are then directed one on each side of said film, or support, for the purpose specified.

2. In color photography employing a film coated on both sides with sensitized emulsion, dividing the light from the object being photographed into two light groups at a point between said object and the film, and directing said light groups each through a color filter of different color one on each side of the film, for the purpose specified.

3. In a method of color photography, dividing the light from the object being photographed into light groups at a point between said object and the emulsion coatings on the film, and directing said light groups on opposite sides of said film, which film is coated on one side with emulsion chiefly sensitive to light of one color group and on the other side with emulsion chiefly sensitive to light of another color group, for the purpose specified.

4. A camera for color photography provided with means for dividing the light from the object into two light groups which act on opposite sides of a double coated film, color screens of different color being interposed (if desired) one in the path of each light group between the film and the light-dividing means, for the purpose specified.

5. A camera for color photography comprising means for supporting in position for exposure a film sensitized on both sides, and optical means for projecting upon opposite sides of a film so supported independent images of the same object centrally congruent but differing in size, for the purpose specified.

6. A camera for color photography comprising light-reflecting means disposed in position to divide the light from the object into two light groups which act on opposite sides of a double coated film, for the purpose specified.

7. A camera for color photography comprising a pair of lenses, and means for supporting a double-sensitized film so arranged that the light from one lens acts upon the emulsion coating on one side of the film while the light from the other lens acts upon the emulsion coating on the other side of the film, color screens of different colors being interposed between the object and the film, for the purpose specified.

8. A camera for color photography provided with a light dividing and reflecting member so arranged that the light from the object strikes against said member, which reflects a portion of the light and allows a portion to pass through it, said reflected portion being directed to reflecting surfaces against one side of a double coated film while the portion of light transmitted through said member is directed by reflecting surfaces against the other side of said film, for the purpose specified.

9. A method of printing a color positive upon a double-coated film from a negative having the images on each side thereof colored differently, consisting in illuminating the said color negative, projecting the images by means of a lens into a camera containing the positive film, the light passing through the negative being divided into two groups by light-dividing means, which groups act one on each side of the positive, either with or without the interposition of color screens, depending upon whether the emulsions on the positive film are color-selective, for the purpose specified.

10. A method of printing a color positive having images on opposite sides thereof one larger than the other from a negative having differently colored images of the same size on each side thereof, said method consisting in passing parallel rays through the negative and causing said rays to act on the positive at diverging angles, for the purpose specified.

11. The improved methods and apparatus for color photography substantially as described with reference to the accompanying drawings, for the purpose specified.

12. A motion picture film, positive or negative, made in accordance with the method herein described for the purpose specified.

Dated this 22nd day of January, 1915.

For the Applicant:

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Chartered Patent Agents,
55/56, Chancery Lane, London, W.C.

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BREWSTER'S COMPLETE SPECIFICATION.

(2 SHEETS)

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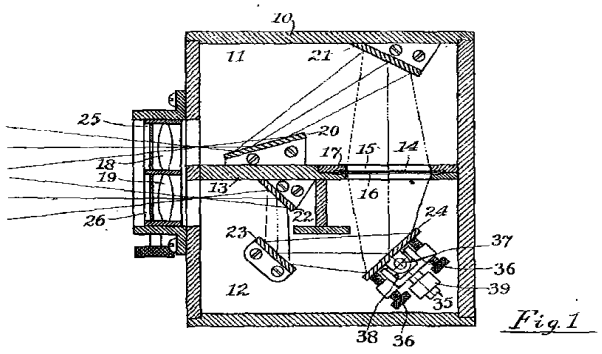


Fig. 1

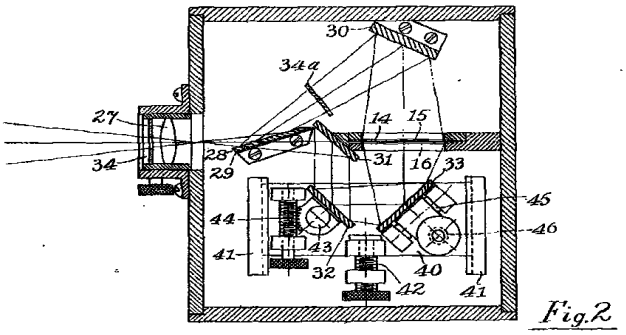


Fig. 2

SHEET 2.

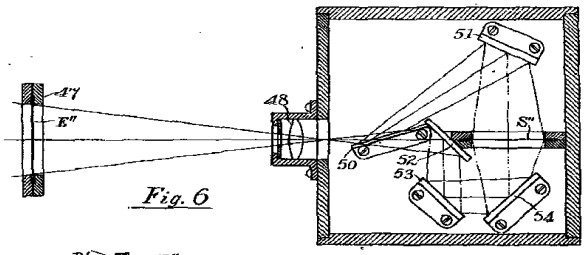


Fig. 6

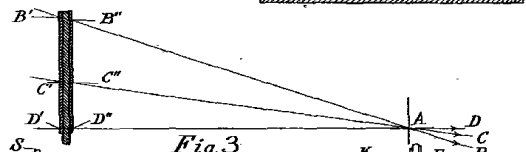


Fig. 3

Fig. 4

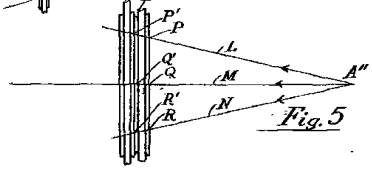


Fig. 5

[This Drawing is a reproduction of the Original on a reduced scale.]

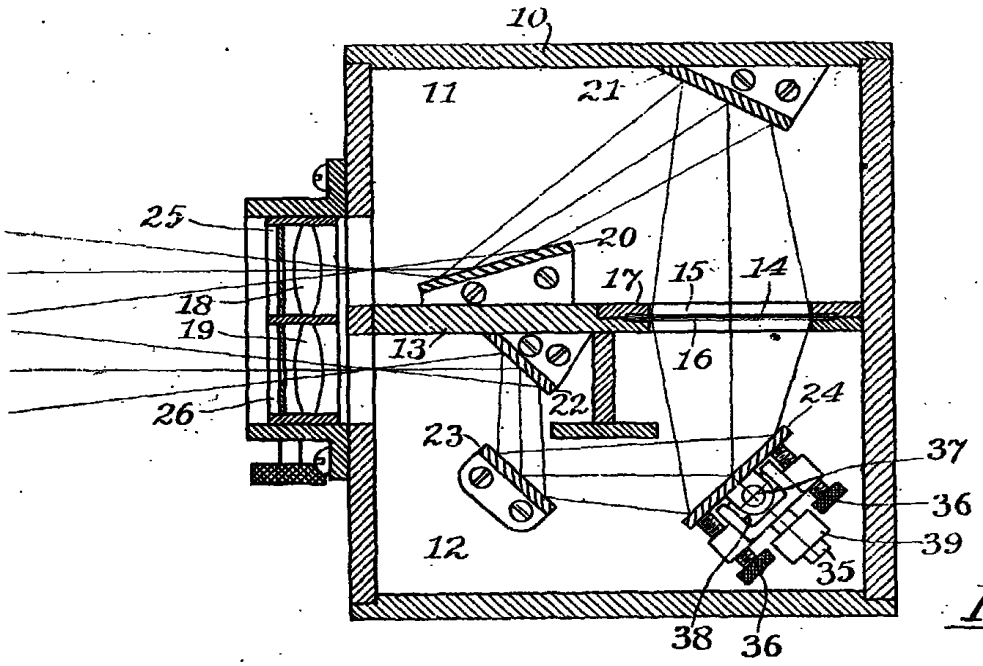


Fig. 1

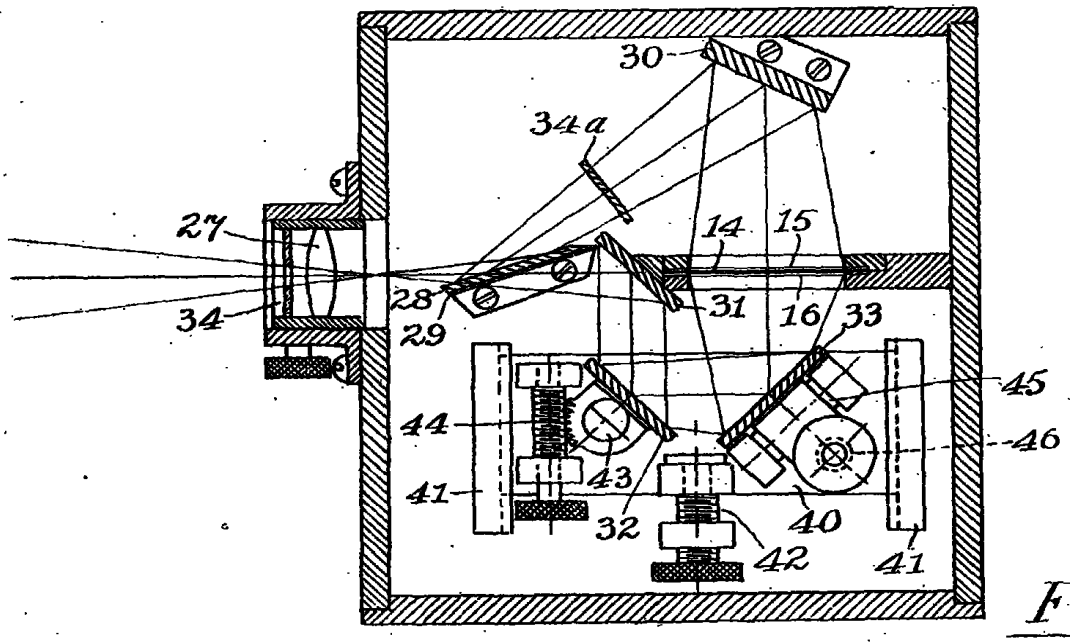


Fig. 2

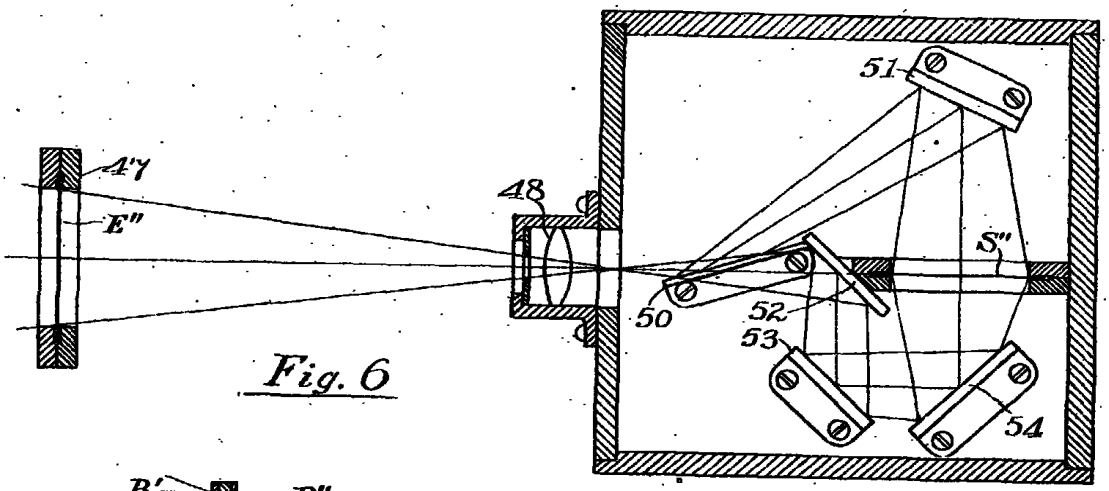


Fig. 6

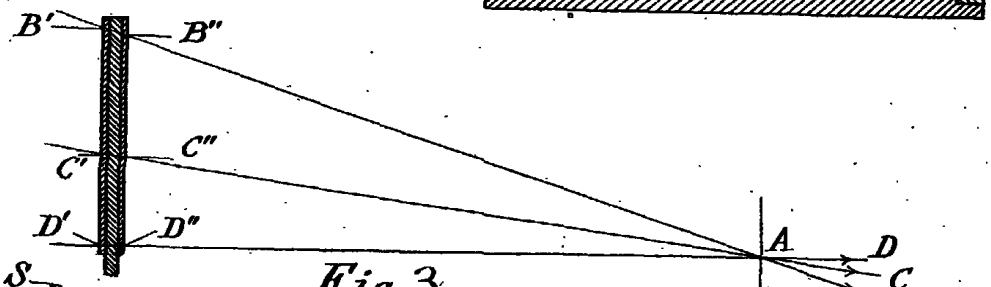


Fig. 3

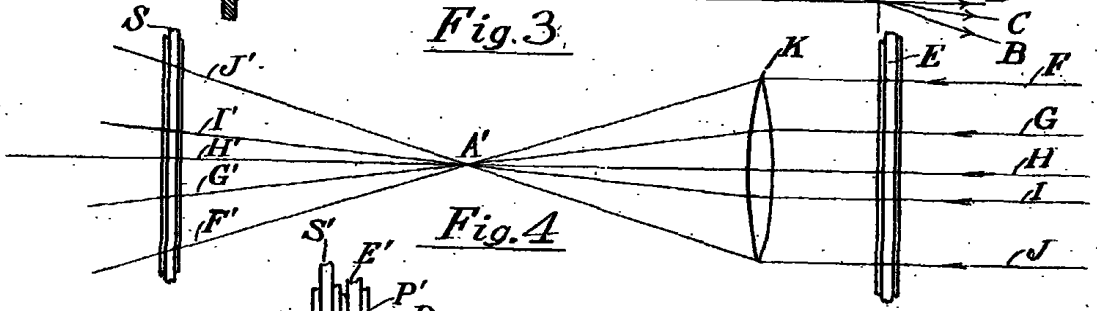


Fig. 4

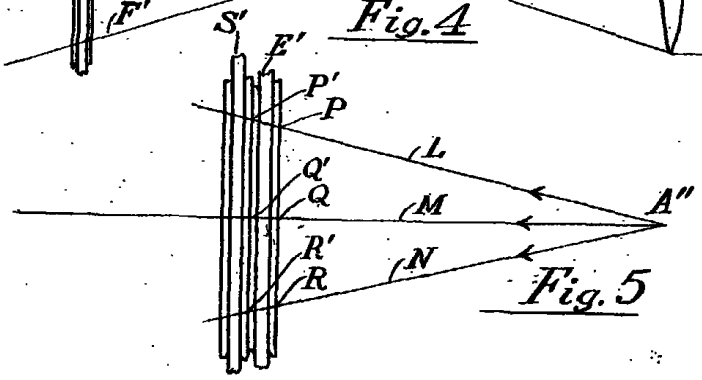


Fig. 5

Malby&Sons, Photo-Litho.