PATENT SPECIFICATION

417,860

Application Date: April 6, 1933. No. 10,375/33.

Complete Left: March 24, 1934.

Complete Accepted: Oct. 8, 1934.

PROVISIONAL SPECIFICATION.

Improvements in or relating to Methods of Reproduction in Colour Photography.

I, Dr. GEOFFREY BOND HARRISON, a British Subject, of Ilford Limited, 23, Roden Street, Ilford, Essex, do hereby declare the nature of this invention to be as follows:—

This invention comprises improvements in or relating to methods of reproduction in colour photography.

The invention is principally concerned with processes of colour photography (particularly colour cinematography) of the type in which the original exposure is made through a multi-coloured screen or reseau on to a sensitised layer on the same or separate supports, and the negative image is reproduced either by contact or projection printing on a second emulsion layer (hereinafter called the copy) with which is also associated a multi-coloured screen or reseau. Even where the screen has a regular pattern (i.e. has the filter elements arranged in lines, squares, dots or the like in the form of a grid or lattice or equivalent regular pattern) and the screens on the original and copy are similar, it is in practice impossible, in superimposing the original and copy for the purpose of reproduction, to ensure accurate registration of the two screens, the patterns on which have necessarily to be very fine indeed, especially in the case of cinematograph films. Considering, for simplicity, the case of a single filter element—say a red element—in the original, it will be appreciated that if there is lack of registration between the two screens, the light transmitted by that element may not fall on, or over the whole or even part of the area of, a red filter element of the copy and in that event there will be a corresponding loss of colour value in the copy.

With a view to remedying the above defect it has been proposed (in Specification No. 374,891) to employ, for printing the copy, an optical system arranged to project simultaneously two or more rays of light from different directions through each colour element of the original, these separate rays producing corresponding separate but adjacent images of each element on the copy, disposed in a similar pattern arrangement to that of the colour screen and occupying a predetermined area thereon. By this means it is possible to ensure that each filter element of the copy will be fully illuminated by light of the appropriate colour. Other methods are also available for producing on the copy an "enlarged" image of each element of the original and thereby giving effective illumination through the copy elements by appropriately coloured light.

The above methods of compensating for lack of registration introduce the following further difficulty. Again considering the case of a single element—say a red element—in the original, the enlargement of the image of this element to a degree sufficient to ensure full illumination of a red element of the copy, means that a portion (hereinafter referred to as the overlapping portion) of the light transmitted by the red of the original will fall on an element or elements adjacent to and differing in colour from the red of the copy.

The spectral absorption characteristics of the dyes or other colouring matter constituting the filter elements of the screens may not be, however, sufficiently abrupt to ensure that the overlapping portion of the light transmitted, through, say red on the original, and falling on filters of different colour on the copy, will be fully absorbed thereby. In so far, therefore, as the overlapping light is passed by the filters of different colours of the copy on which it falls a light effect will be produced behind these filters and this will naturally result in a degradation or desaturation of the colours on the copy. This defect may be reduced by printing in succession by light passed through narrow-band filters of colours corresponding to those of the screen, e.g. filters which transmit light which is only transmitted by the corresponding set of screen elements and is absorbed by the others, but even with this expedient it is difficult to obtain filters with a sufficiently abrupt cut-off in the spectral absorption curve, to ensure that all the overlapping light will be absorbed by the copy screen elements on which it falls. Moreover the use of such narrow spectral band filters entails

[Price 1/-] Price 4s 6d

exposures of such extended duration as to be impracticable.

According to this invention the printing light is first analysed into a spectrum, the undesired portions (i.e. those portions which would be transmitted by screen filter elements of inappropriate colour) are cut out by a mask, and the residual spectrum is recombined to form the actual light by which the printing exposure is effected. By this means it is possible to ensure that where the overlapping light falls on filter elements of the copy of inappropriate colour there will be substantially complete absorption thereby, and in this way the desaturation effect previously referred to will be avoided.

The analysis of the printing light into a spectrum may be effected by any convenient optical system, for example, that employed in the known forms of spectrometer or spectroscope. Any suitable form of mask may be used, at the spectral plane, for cutting out the undesirable portions of the light. For example, a cut-out mask, with slits formed to pass only those portions which are desired, may be used, or again mirrors may be employed to reflect into combination selected portions only of the spectrum.

According to a feature of the invention the mask may be produced by exposing a photographic layer at the spectral plane (of the optical system used for analysing and recombining the printing light) to light transmitted through a combination or combinations of different colour filters corresponding to those of the colour screens. In this way images are produced on the photographic layer by the undesired light which has passed the filter combination, and on development the negative thus produced will constitute a mask which will cut-out with exactitude those portions of the spectrum which would be transmitted by screen filter elements of inappropriate colour. Considering the case of a two-colour screen, a composite filter comprising superimposed sheets of filter material corresponding to the two colours of the screen, would be interposed in the optical path between the source and the photographic layer and the photographic layer negative which is to form the mask would thus be exposed at the spectral plane to a spectrum of the light passed by the combined filter. The layer on development would thus produce an exact mask to eliminate the undesirable portions of the light and transmit a composite beam of light the various components of which are passed by only one of the sets of screen elements and are absorbed by the others. A suitable holder or other positioning means would be provided to ensure the negative being located in exactly the same position in the spectral plane before and after development.

Where the printing method is used in conjunction with a three-colour screen, say composed of red, green and blue filter elements, the negative to form the mask would be exposed in succession to light transmitted by the three different combinations of two different colour filters corresponding to the colours of the screen. For example, an exposure might first be made through a combination of red and green filters, a second exposure through a combination of red and blue filters, and a third exposure through a combination of blue and green filters, the filtering material in each case corresponding to that of the colour screen. It will be appreciated that, in effect, the first exposure will produce a latent spectral image on the negative of that portion of the light, which, transmitted by a red (or green) filter element of the original screen, would not be absorbed by a green (or red) filter element of the copy. Similarly, the second exposure will produce a latent spectral image of light transmitted through a combination of red and blue filter elements of the screens, and the third exposure a latent spectral image of light transmitted through a combination of blue and green filter elements of the screens. A similar procedure would be adopted in the case of a four-colour screen, and it will be seen that in every case an exact mask to eliminate the undesired portion of the spectrum can be produced. The exposures under each combination of filters need not be the same but may be varied to produce a mask which will effect any desired colour compensation in the residual beam. The invention is not limited in its application to printing from regular pattern screens; it may equally well be used in conjunction with the irregular or random type of screen or any combination of regular pattern and irregular screens.

As has been indicated, the invention has been developed principally in connection with the printing of images from one colour screen material on to another. There are, however, other useful applications of it. It may be used, for example, in the preparation of two or three colour separation negatives or positives from a colour transparency to obtain a printing light having a much more sharply defined band than could be obtained by the use of filters or for printing the colour separation negatives or positives on to colour film of any sort. Again it may be used in place of a corrective or compensating

filter in circumstances where such devices would normally be necessary, by placing a suitably shaped mask over part of the spectrum.

Considered in its more limited application, the invention may be stated as providing an analysing device for directing light of selected spectral characteristics through a colour image transparency (e.g. an image on multi-colour screen material) either for copying on to a second transparency or for viewing, for example by projection. The invention includes the method of projection or printing and also the optical apparatus for carrying that method into effect.

It will be appreciated that where reference is made to three colour screens or separation negatives or positives the same principles apply to two, three, four or more colour processes.

Dated this 6th day of April, 1933.

BOULT, WADE & TENNANT,
111 & 112, Hatton Garden, London, E.C.1,
Chartered Patent Agents.

COMPLETE SPECIFICATION.

Improvements in or relating to Colour Photography.

I, Dr. GEOFFREY BOND HARRISON, a British Subject, of Ilford Limited, 23, Roden Street, Ilford, Essex, 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 comprises improvements in or relating to colour photography and relates to processes of colour photography (particularly colour cinematography) of the type in which the original exposure is made through a multi-colour screen or reseau on to a sensitised layer on the same or a separate support. In processes of this type it is usual to make the colour transmission bands of the several colours of the screen as wide as is possible consistent with an approximate rendering of the colours in the picture in order that the exposure required for the taking of the picture may be as short as possible. In practice it is usually found necessary to make the colour transmission bands of the several screen colours so wide that they overlap to some extent.

Photographs of this type may be reproduced on similar multi-colour screen material or they may be reproduced by preparing a series of colour separation records each corresponding to one of the part-records produced by the colours of the screen and then combining these colour separation records to form a single picture in colour.

When multi-colour screen material is used for the making of copies, it is found, in order to reduce the opacity of the screen as much as possible so as to get bright copies, desirable that the colour transmissions of the several screen colours should also be as wide as possible and should overlap to some extent. In practice it is impossible when using screens with very small elements to superimpose the original and copy materials for the purpose of reproduction sufficiently accurately to ensure exact registration of the elements of the two screens. The patterns on the screens have necessarily to be very fine indeed, especially in the case of cinematograph films. In these circumstances it is found that the overlapping parts of the colour transmission bands of the screen colours result in degradation of the colours of the copy since, considering for simplicity the case of a single colour element in the original—say a red element—if there is lack of registration between the two screens the light transmitted by that element cannot fall wholly, and may not fall in part, on the area of a red element of the copy but will fall at least in part on an element of different colour. If the red element falls on an element of the copy material which has a component of colour transmission which overlaps the transmission of the red element, then this common component will affect the sensitive material behind the element on the copy and will produce a false colour record.

This effect also occurs if a diffused or duplicated image of each element of the original is produced on the copy during printing as has been suggested in order to ensure that each element of the original falls on at least one element of corresponding colour in the copy. Various methods of producing such a diffused or duplicated image have been proposed, for example in specification No. 374,891.

Similarly, when the original colour-screen record is printed on to plain material to form colour separation records using for each record light of colour corresponding to the colour of one of the screen

elements, then these separation records are not accurate copies of the original records formed behind the screen elements of the several colours of the master screen since the printing light which should only be transmitted by screen elements of one colour is also partly transmitted by screen elements of another colour.

A further reason why it is desirable that the colour transmission bands of the screen elements of the copy material should be as wide as possible, is that it is necessary that the finished record should transmit the maximum possible amount of light in order to obtain adequate illumination of the screen on which the picture is being shown. In the reproduction of such pictures, however, if ordinary white light is used it is found that further colour degradation occurs due to the overlapping transmission bands of the screen elements since, taking for example a part of the picture which should be devoid of green but should contain red and violet, the red and blue-violet elements will each transmit a portion of green.

It has already been proposed in such processes to use light containing colour components transmitted by the several colours of the screen and containing no components which would be transmitted by any two or more superposed screen elements of different colours.

It has also been proposed to obtain such light by analysing a beam of light containing colours transmitted by all the screen elements into a spectrum, and interposing in the spectrum a mask having a number of narrow slits at the wavelengths corresponding to approximately the centres of the transmission bands of the screen elements.

The present invention relates to a method of obtaining light containing colour components transmitted by one or more colours of the screen and containing substantially no colour components which would be transmitted by any two or more superposed screen elements of different colour as described above, and more particularly to a method of producing a mask for use in selecting from a beam of light, light of the desired composition.

The invention accordingly provides the method of preparing a mask for use in eliminating from a beam of light composed of various wavelengths and analysed into a spectrum those wavelengths which would be passed by each of any two or more differently coloured elements of a multi-colour screen which comprises the steps of passing a beam of light containing wavelengths which would be passed by two or more differently coloured elements of the screen (e.g. white light) through filtering means the transmission band of which is substantially the same as that of the said two or more differently coloured elements when superposed and analysing the beam transmitted by the filtering means into a spectrum and photographing the spectrum (preferably on a panchromatic emulsion) to form the mask.

When the mask is to be used for the selection of light to be employed in connection with a screen having more than two colours the steps of passing light through filtering means, of analysing the beam transmitted thereby into a spectrum, and photographing the spectrum are preferably repeated using filtering means having a transmission band which is the same as that of a different set of two or more differently coloured elements of the colour screen.

The invention includes the method of taking or reproducing (either by projection on to a screen or by photographic printing) a coloured photograph of the multi-colour screen type wherein the colour composition of the taking, reproducing or printing light is selected by analysing into a spectrum a beam of light containing colours corresponding to the colours of the screen together with colours which are common to two or more colours of the screen and cutting out from the spectrum the colours which are common to two colours of the screen by means of a mask prepared by the method described above interposed in the spectrum.

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

Figure 1 represents the colour transmission bands of a three-colour screen,

Figure 2 is a diagram illustrating one method of preparing a beam of light of the desired composition,

Figure 3 is a diagram illustrating an alternative method of obtaining light of the desired composition,

Figure 4 is a diagram illustrating the preparation of the mask, and

Figure 5 is a mask for use in the methods as shown in Figures 2 and 3.

Like reference numerals indicate like parts throughout the several Figures of the drawings.

In Figure 1 the curve A—C represents the spectral transmission band of the red elements of a three-colour master screen, B—E the spectral transmission band of the green elements of the screen and D—F the spectral transmission band of the blue-violet elements.

It will be seen that the red and green transmissions overlap at B—C and the green and blue-violet transmissions over-

lap at D—E. Assuming in this example that the master record is being copied on to three-colour screen material and that the transmission of the screen elements of the copy material is similar to that of the master material, then it will be seen that if, during printing, a red element of the master screen falls over a green element of the copy screen a component of the printing light (if ordinary white light is being used) will be passed by both screen elements at BHC and will affect the sensitised material behind the green element of the copy thus producing a false colour effect. Similarly if a green element of the master record falls on a blue-violet element of the copy, then a component of the printing light will pass through both screen elements at DIE and produce a false record. The same of course applies if a blue-violet element of the master falls on a green element of the copy or a green element of the master falls on the red element of the copy.

If, however, the components of colour B—C, D—E are omitted from the light used for printing, then these false effects will not occur.

One way of obtaining light from which these components have been eliminated is shown in Figure 2 in which a beam of parallel white light G^1—G^2 is analysed into a pure spectrum by means of a prism 1 and lens 2. The different colours of the spectrum are brought to real foci at 3 and the colours are recombined into a beam of light by means of the lens 4. Placed in the plane of the spectrum at 3 is a mask 6 which has two opaque portions 7 and 8. These opaque portions correspond in position in the spectrum to the colours B—C and D—E in Figure 1 and thus these colours are absorbed by the mask, and the reassembled light leaving the lens 4 contains no components of colour corresponding to the portions B—C and D—E, and may be used for printing as indicated at 9.

An alternative method of securing light of the desired composition is shown in Figure 3. In this method the light is analysed into a pure spectrum at 3, the undesired colours are absorbed by a mask 6 in the manner described above in relation to Figure 2 and the light is arranged to fall on the material placed in the plane 10 at the focus of the lens 2.

An example of the method of preparing a mask for use in either of the above methods is shown in Figure 4. In this case a beam of parallel white light G^1—G^2 is passed through a pair of filters 11 and 12, one of which has a colour transmission corresponding to the red elements of the colour screen (i.e. A—C in Figure 1) and the other to the green elements of the screen (i.e. B—E in Figure 1). The light leaving the filters therefore corresponds to the component of colour common to the red and green elements (i.e. the part BHC in Figure 1). This light is analysed into its components by means of a prism 1 and the components are brought to real foci at 3 by means of the lens 2. A sensitised photographic plate is placed at 3 and is exposed to the part spectrum thus formed at that plane. The operation is then repeated on the same photographic plate using filters at 11 and 12 corresponding to the green and blue-violet elements of the screen.

The photographic plate is then developed producing a mask as shown in Figure 5 having two black banks 7 and 8 corresponding to the portions B—C and D—E in Figure 1. The prism 1 and lens 2 used in this operation of preparing the mask are conveniently those used in the final printing process.

The light obtained by the method illustrated in Figure 2 may of course be used for projecting a multi-colour screen transparency on to a viewing screen, resulting in more accurate reproduction as explained above.

When it is desired to prepare a series of colour separation records from a master colour screen record then the mask 6 used at 3 in either of the methods illustrated in Figures 2—3 is such as to transmit only light of colour transmitted by one of the screen elements and having no component corresponding to any of the other screen elements. Thus to prepare a separation record corresponding to the red elements the portion *b*—*f* of the mask shown in Figure 5 (corresponding to the band B—F in Figure 1) would be opaque. Similarly, to produce a green separation record the portions of the mask *a*—*c*, *d*—*f* would be opaque. The method of preparing these masks is similar to that described above in connection with Figure 4, except that to produce, for example a mask for use in preparation of the red record, the plate is exposed first with a filter 11 corresponding to the green elements of the screen in position alone and subsequently with a filter corresponding to the blue-violet elements of the screen in position alone.

Although the above examples have been described in connection with a three-colour screen, the invention may of course equally well be applied to screens having any number of colours, for example two or four colour screens. The invention is also equally applicable to regular or irregular screens.

Colour compensation in the residual beam may be effected by modifying a

mask prepared by the method described herein while still retaining its general characteristics as previously defined. Thus for example if the red in the finished picture is found to predominate the mask used may be only partly transparent over the red portion of the spectrum, or the transparent area in the red region may be reduced in size. Again it is not necessary that the whole of the light passed by combinations of two or more elements of the screen should be entirely eliminated. In some cases better results may be obtained by using a partly transparent mask which transmits a proportion of the common light. Again in order to be able to obtain an artificial illumination equivalent to, for example, daylight (e.g. for use in illuminating subjects for the purpose of photographing them by the colour screen process) a mask as described above may be used, the transparent area of which has been so shaded off or otherwise varied that the spectrum colours are passed in approximately the same proportion as in daylight.

In addition to the colour degradation produced during reproduction of a colour screen record due to the overlapping transmission bands of the screen elements a certain amount of degradation occurs, from the same cause, during the taking step. It is found that the accuracy of the master record may be improved, in circumstances where it is possible, if the subject is illuminated during taking by light which contains substantially no component of colour transmitted by any two screen elements of different colour. Such light may, for example, be produced by the method described with reference to Figure 2.

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. The method of preparing a mask for use in eliminating from a beam of light composed of various wave-lengths and analysed into a spectrum those wave-lengths which would be passed by each of any two or more differently coloured elements of a multi-colour screen which comprises the steps of passing a beam of light containing wave-lengths which would be passed by two or more differently coloured elements of the screen (e.g. white light) through filtering means the transmission band of which is substantially the same as that of the said two or more differently coloured elements when superposed and analysing the beam transmitted by the filtering means into a spectrum and photographing the spectrum (preferably on a panchromatic emulsion) to form the mask.

2. The method according to claim 1 wherein the steps of passing light through filtering means, of analysing the beam transmitted thereby into a spectrum and photographing the spectrum are repeated using filtering means having a transmission band which is the same as that of a different set of two or more differently coloured elements of the colour screen.

3. The method of taking or reproducing (either by projection on to a screen or by photographic printing) a coloured photograph of the multi-colour screen type wherein the colour composition of the reproducing or printing light is selected by analysing into a spectrum a beam of light containing colours corresponding to the colours of the screen together with colours which are common to two or more colours of the screen and cutting out from the spectrum the colours which are common to two colours of the screen by means of a mask prepared by the method according to claim 1 or claim 2 interposed in the spectrum.

4. For directing light of selected spectral characteristics through a coloured image transparency on multi-colour screen material either for copying or for viewing (for example by projection) an analysing device comprising an optical system (e.g. in the form of a spectrometer) for analysing the light into a spectrum combined with a mask prepared by the method according to claim 1 or claim 2 located in the analysed beam.

5. The method of preparing a mask for use in eliminating various wave-lengths from a beam of light substantially as herein described.

Dated this 24th day of March, 1934.

BOULT, WADE & TENNANT,
111/112, Hatton Garden, London, E.C. 1,
Chartered Patent Agents.

Redhill: Printed for His Majesty's Stationery Office, by Love & Malcomson, Ltd.—1934.

Fig. 1.

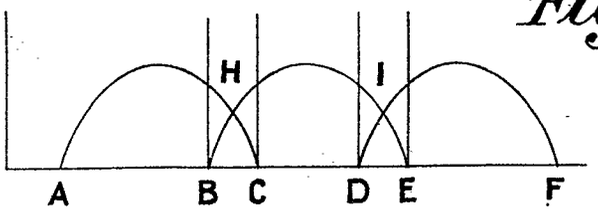


Fig. 2.

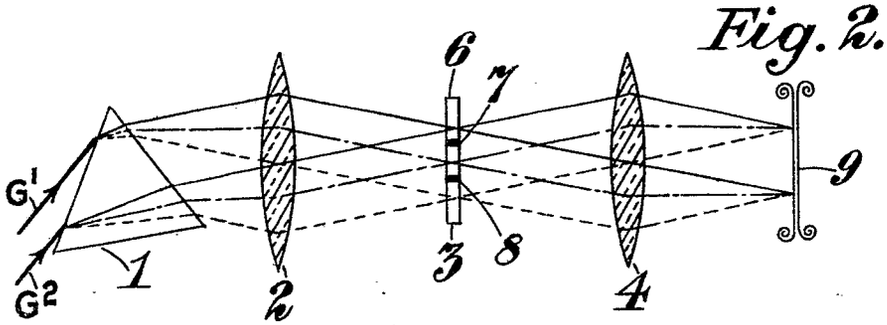


Fig. 4.

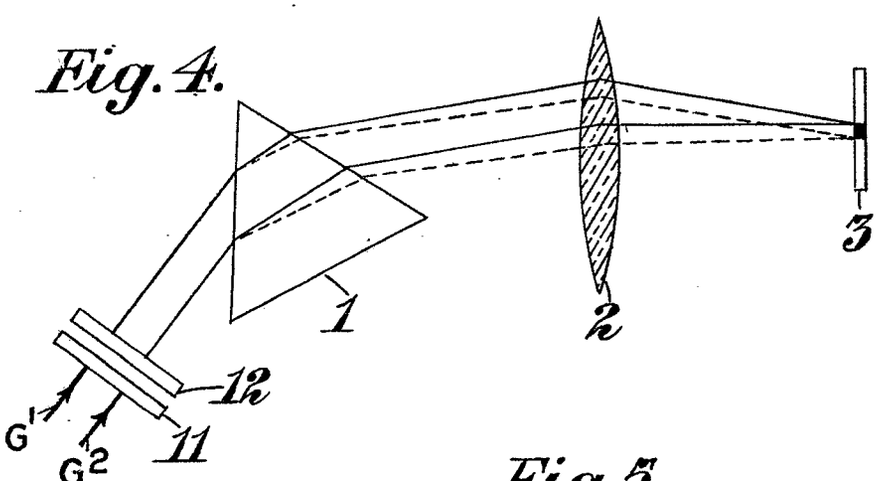


Fig. 5.

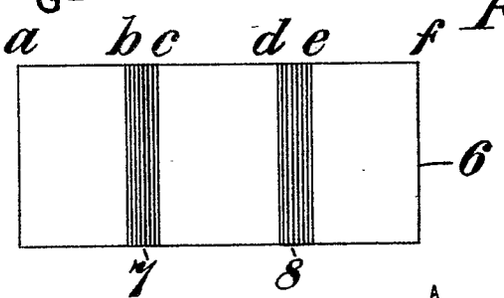
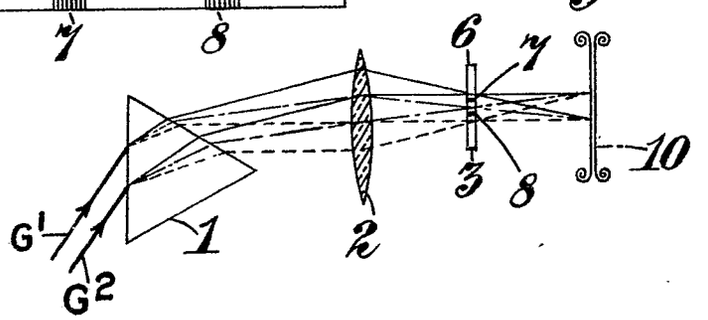


Fig. 3.



Malby & Sons, Photo-Lith.