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PATENT SPECIFICATION

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COMPLETE SPECIFICATION.

Process of Preparing Subtractive Multi-colour Pictures.

We, I. G. FARBENINDUSTRIE AKTIENGESELLSCHAFT, a Joint Stock Company organised according to the laws of Germany, of Frankfurt a/Main, Germany, 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 more particularly to a process of printing subtractive multi-colour pictures.

When a colour picture, taken, for instance, on a photographic film bearing microscopic refractive elements according to Berthon's known process or on a film comprising several juxtaposed partial pictures, is to be printed in contact onto a positive film composed of several layers, it appears best at first sight to choose for the positive film the sequence of the layers as is customary in the case of the known photographic tripack, namely the sequence of three emulsions sensitised to blue, to green and to red, and for the printing light the colour of the selection filters which have been utilised in taking the different colour sensations. This process, however, entails certain disadvantages and does not allow of adaptation to the requirements of the positive print to be prepared.

According to the present invention, subtractive multi-colour pictures are advantageously obtained from colour sensations made by any process in the following way:—A positive film, on which several light-sensitive layers of different sensitiveness are superposed in any succession eight on one or both sides of a support is printed in contact or by means of an optical system while choosing the printing light for the different colour sensations exclusively with regard to the properties of sensitiveness of the corresponding printing layers and giving no consideration to the colour of the light filter utilised when taking them. This process offers the advantage that the sequence of the light sensitive layers of the positive film may be adapted in any way to the requirements of the positive process.

In the case of the positive process it is, for instance, desirable to obtain the best possible definition of the pictures. As the blue-green picture is most important for obtaining a well defined picture, the sensitive layer determined for it is arranged so as to touch, when printing, the picture layer of the original and, hence, yields the sharpest print. The layers intended for the yellow picture and the purple picture then follow successively. The layer destined to yield the blue-green picture is sensitised to blue, the following layer to green and the layer destined for the purple picture is sensitised to red. When printing a lenticular film taken with a three-colour filter of the usual type having its areas arranged in the succession of red, green and blue there is used in the printing operation a filter having its areas arranged in the succession blue, red, green. With regard to the objective used in the printing process the usual conditions of its relation to the objective for taking the films are to be observed. If printing, instead of a lenticular film, a film having three juxtaposed partial colour pictures, the illumination of the partial pictures is effected in an analogous manner, that means, if the colour sensations are disposed in the succession red-blue-green, the first extract is printed with blue, the second with green and the third with red light.

The foregoing statements relative to the colours of the light filters and to the sensitiveness of the individual emulsions are only given by way of example. The primary idea of this invention is the choice of a suitable copying light and a suitable sensitiveness of the printing layers so that, while printing, a silver image is printed only in one emulsion layer of the composed printing material, said silver image corresponding to the colour sensation, likewise present in the form of a silver picture. A lenticular film comprises in each picture area records of all the colour sensations corresponding with a number of partial colour pictures required for producing the desired multi-colour picture. In exposing the film there is generally used a

three-colour filter having red, green and blue areas which may be designated, respectively, by *a*, *b* and *c*. When printing a lenticular film onto a film having no lenticular elements, which may consist, according to this invention, of three layers *d*, *e* and *f*, differently coloured and sensitised for different spectral regions (*d*, for instance, for the blue light, *e* for the red light, and *f* for the green light), each of these layers *d*, *e* and *f* may be coordinated to one of the colour sensations or the corresponding filter areas *a*, *b* and *c* in the following manner :

d (sensitised for blue) to *a*
e (sensitised for red) to *b*
f (sensitised for green) to *c*.

Now, according to this invention, the filter used in the printing process must be provided with areas of the colour to which the corresponding printing layer is sensitive. Therefore, in the present case *a* is to be replaced by a blue filter, *b* by a red filter and *c* by a green filter without regarding the colours which the corresponding parts received during the exposure. Similar conditions are to be maintained when printing the usual black and white colour sensations upon a multilayer film, the individual light sensitive emulsions of which are coloured and sensitised differently to each other.

In other cases it may be necessary, likewise, to adapt the colour of the printing light in an appropriate manner according to the requirements; this depends, for instance, upon the character of the dyes utilised for dyeing the layers of the positive film or used as light filters during the exposure. By using, for instance, as a positive film for a two colour process, a film coated on both its sides, one layer dyed green, the other red, special absorption conditions result. The green layer transmits green light, but absorbs red light. Therefore, by illuminating also the layer of the positive film, already dyed green and corresponding to the red sensation, with red light to which the corresponding colour sensation has been exposed, the effect obtained would be similar to that of the known process for making duplicates of films (printing with violet light onto emulsion layers dyed in a yellow tone), that is to say, the two partial pictures would show a very flat gradation. In order to avoid this effect, the red colour sensation yielding the positive green picture, is printed, for instance with blue or green light, and the green colour sensation yielding the positive red picture, is printed with a strongly yellow or red light.

The following is one example of a manner of carrying out the invention.

On one side of a double-sided film there is an emulsion layer, for instance one of the usual positive emulsions with an addition of Congo Pure Blue (Schultz, Farbstofftabellen 1931, Vol. 1, A. 513) or Brilliant Benzo-Fast-Green (obtainable by diazotising the azo-dyestuff from diazotised 2-naphthylamino-8-sulphonic acid and 1-amino-2-naphthalethyl ether with sodium nitrite and hydrochloric acid, isolating the intermediate product formed and adding it in admixture with water to a solution of 1-acetylamino-8-naphthol-3 : 6-disulphonic acid which has been made alkaline by addition of sodium bicarbonate and to which pyridine has been added). The emulsion is not sensitised. On the other side are two superposed layers. The bottom layer is provided with an emulsion sensitised to red by means of pinacyanol or pinacyanol blue, and as a colouring addition the dyestuff Sirius-Red Violet R (cf. Schultz, Farbstofftabellen, 7th Edn. Vol. 2, pg. 198, lines 19—23) or Sirius-Ruby B (cr. Schultz, Farbstofftabellen, 7th Edn., Vol. 2, pg. 198, lines 24—26) is employed. Over this is applied an emulsion layer sensitised to green by means of pinaflavol, erythrosine or pinaverdol, coloured with Sirius-Yellow R extra (cf. Schultz, Farbstofftabellen, 1931, page 197, line 11 to line 6 from below), or Chrysophenin G or W (Schultz, Farbstofftabellen, 1923, 6th Edition No. 304). In order to prevent the dyestuffs becoming diffused into one another, there is applied an intermediate layer consisting of hardened gelatine or containing additional substances which precipitate the dyestuffs, such as calcium salts or other lake-forming substances, between the yellow and the purple coloured emulsion layers. On this film only three partial sensations are printed, and, as is well known, the blue sensation must be printed in the yellow layer, the red sensation in the blue green layer, the green sensation in the purple layer. In the case of the film now under consideration this occurs in such a manner that on the side coloured with Brilliant Benzo Fast Green the red sensation is printed with unfiltered or blue light. On the other side the blue sensation is first printed with green light in the yellow layer, then the green sensation with red light in the purple layer. Naturally, it is also possible to print the green sensation and then the blue sensation on it. It is even possible to print both partial sensations simultaneously by means of one of the known light-dividing apparatus adapted for projecting a picture onto a film from both sides. The production of the finished film is carried out in such

a manner that the film thus illuminated is developed in the usual manner and fixed. If necessary the fixing may be omitted. Then the film is treated in a bath obtained by mixing equal parts of

SOLUTION I.

6250 cc. of water
17 gr. of iodine
33 gr. of potassium iodide
525 cc. of concentrated sulphuric acid

and

SOLUTION II.

6250 cc. of water
330 gr. of sodium sulphite
330 gr. of thiourea.

This solution has the property of destroying the dyestuff at the places where there is silver. Any silver residues still remaining are removed by means of acidified copper chloride solution and subsequent fixing. There results a coloured image which shows the original in natural colours when the partial sensations were positive.

Further, the following variations in the sequence of the colouring and sensitisation of the layers may occur.

1) The sequence of the yellow and purple layers can be exchanged. The purple layer is then not sensitised. Illumination is as follows: the green sensation with blue light in the purple layer, the blue sensation with red light in the yellow layer, the red sensation as above with blue light in the blue green layer.

2) First side coloured purple. Second side: bottom layer blue-green, top layer yellow. The printing occurs as follows:— the green sensation with blue light in the purple layer; the blue sensation with red light in the red-sensitive yellow layer; the red sensation with green light in the green-sensitive blue-green layer.

3) Arrangement of layers as in No. 2, except that the succession of the emulsion layer dyed bluish green and that dyed yellow is changed. The green sensation is printed, as above, with blue light in the purple layer, the red sensation with blue light in the blue green layer, the blue sensation with green light in the green-sensitive yellow layer.

The arrangement wherein partial sensations are not used but a lenticular screen process is used for printing is fundamentally the same. The printing itself is carried out either in contact or by optical means, in that in each particular case the opening of the illuminating device corresponding to a certain partial colour image is provided with the filter according to the above description, that is, for instance, first of all there is used the said film in which on one side there is the blue-green layer and on the other side the purple layer and the yellow layer one above the other. The yellow layer is brought into contact with the lenticular film, layer against layer. This film is illuminated with a light source, the size and position of which corresponds to that of the virtual filter plane on the original exposure of the lenticular film. At the place where the blue filter was located at the original exposure, a green filter is now inserted. The other parts of the printing apparatus are darkened. In this manner the blue sensation is brought into the green-sensitive layer. Then the place where there was a green filter at the original exposure, is covered with a red filter and now—while covering the other parts of the filter—the green sensation is copied in the red-sensitive purple layer. With such a film coated on both sides—in order to register the images—the red sensation must be printed by optical means from the other side, and in the optical apparatus there is inserted a screen which, according to the position and size of the original, corresponds to the position and size of the virtual filter image at the original exposure. The objective used must, naturally, represent the original in natural size on the film to be copied. According to the invention all the operations named above for the partial sensations can be carried out in exactly the same manner with different filters with a lenticular film.

The invention is illustrated by the accompanying diagrammatic drawing, in which:—

Figs. 1, 2 and 3 show the manner in which the single colour sensations are printed.

Fig. 4 indicates in cross section a multilayer film showing the picture in natural colours.

The same reference characters are used through the different Figs. to indicate the same or analogous parts.

In Figs. 1—3, A is the object to be photographed. For the sake of greater clarity it is shown in the form of a band with green, red and blue colour areas *g*, *r* and *b*. B_1, B_2 and B_3 are the negatives on which the red, blue and green colour strips taken through a light filter of analogous colour, are recorded. C_1, C_2 and C_3 are the corresponding positives either obtained by a print from the negative or by reversal of the negative. These positives and negatives may be made on a photographic plate or on a film. In the negatives B_1, B_2 and B_3 the recorded colour sensations are indicated by corresponding blackenings and in the positives C_1, C_2 and C_3 by corresponding white

fields, these pictures being the usual black and white silver pictures.

These colour sensations now are printed in succession through distinct light filters D_1, D_2 and D_3 upon the multi-layer film E. This multi-layer film E comprises an emulsion carrier E_1 which may be, for instance, a usual nitrocellulose film. This emulsion carrier E_1 carries on its front a bluish-green coloured light sensitive emulsion E_2 which is sensitised for the blue light rays and an intermediate light sensitive emulsion layer E_3 which is yellow coloured and sensitised for the green light rays. On its back, the carrier E_1 is coated with a purple coloured emulsion layer E_4 sensitised for the red light rays.

In Figs. 1—3 the colour for which the single light sensitive emulsions of E are sensitised, is indicated by a corresponding hatching; this indication of sensitiveness, however, must not be confounded with the colour in which the layers are dyed (see Fig. 4).

As seen from Fig. 1, the positive C_1 on which the red colour sensation of the original A is registered, is printed through a blue light filter upon the multi-layer film E, whereby a corresponding record is imprinted on the emulsion layer E_2, sensitised to the light passing the filter D_1. In the second phase of printing, the positive blue sensation C_2 is printed through the green light filter D_2 and thus, an exposure is effected in order to record the blue sensation on the yellow coloured intermediate layer E_3 sensitised for the green light waves passing the filter D_2. In the third phase of printing, the positive picture C_3, being the green sensation of the original, is printed through the red colour filter D_3 upon the rear coacting E_4 sensitised for the red light rays, so as to produce a corresponding record on this purple coloured layer.

The sequence of these three printing operations, obviously, can be altered since each manipulation is independent of the other. After development, the multi-layer E shows the silver images indicated in Fig. 3 by blackenings of the corresponding field in the different layers. The red part of the original thus is printed upon the front layer E_2 being coloured bluish-green; the blue part of the original is recorded as a silver image on the yellow coloured intermediate layer E_3 while a silver image of the green parts is shown on the purple coloured emulsion E_4 situated on the rear side of the film E_1.

Now, the silver pictures are bleached out, whereat the silver particles deposited in the three emulsions, are transformed by chemical means into a compound destroying the dye incorporated into the said layers in such a degree as metallic silver is present on the different places of the print, so that finally the silver images in the different layers are replaced by transparent uncoloured areas of the emulsion carrier. This fact is illustrated in Fig. 4 showing white spaces on those places on which the dye is destroyed by the action of the silver compound formed during the bleaching process. When projecting the transparency onto a screen, the white field indicated in Fig. 4 by *g* reproduces a green picture of the original as the yellow colouration of the layer E_3 and the bluish-green colouration of the layer E_2 yield green. The area *r* appears red, since red results from the yellow of the layer E_3 and the purple of E_4. The purple of the layer E_4 and the bluish-green colouration of the layer E_2 form a blue area at *b*. Thus, the original A is reproduced in its true colours by the multi-layer film E illustrated in Fig. 4.

Various modifications of the process illustrated in the foregoing paragraphs are possible. Thus, for instance, the invention is not limited to the use of positive colour sensations or to the bleaching-out process described. It is likewise possible to employ a printing material, the individual emulsion layers of which are only sensitised for different wave lengths showing, however, no distinct colouration. In this case, the layers may be dyed after printing and developing. Although the invention has been illustrated by a preferred example, the broader scope of it is a printing process in which the sensation of a distinct colour is printed through a light filter the colour of which does not correspond to the colour to which the sensation corresponds, upon a light sensitive emulsion of a multi-layer film which likewise is sensitised for light rays of another colour. It is not necessary that the spectral region of the printing light and that to which the printing layer is sensitised, be completely identical; thus, for instance, the spectral region of the light sensitive layer may be smaller than that of the copying light. The principle of the invention resides in the fact that in every case by a suitable selection of the sensitiveness and colouration of the single light sensitive emulsions of the printing material and by a correspondingly adjusted composition of the printing light, the effect is obtained that, while printing one colour sensation only one layer provided on the printing material records a corresponding picture, the other layers remaining unaffected.

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. In a process of preparing subtractive multi-colour pictures the step which comprises printing the single colour sensations of the original obtained by a photographic process successively upon a positive film bearing several superposed light sensitive layers of different sensitiveness to colours and adapting the printing light in the different printing operations only to the sensitiveness of the individual printing layer on which the individual colour sensation is to be recorded without regard to the colour of the light filter used during exposure of the peculiar colour sensation.

2. A process according to Claim 1, which comprises printing red, blue and green colour sensations onto a film provided with three emulsion layers, of which two layers are arranged on the one side and the third layer on the other side of the support, and of which the first layer is dyed bluish green and sensitised to blue, the second layer, arranged between the first layer and the support, is dyed yellow and sensitised to green, and the third layer is dyed purple and sensitised to red, the red sensation being printed with blue light onto the layer dyed bluish green, the blue sensation being printed with green light onto the layer dyed yellow and the green sensation being printed with red light onto the layer dyed purple.

3. Subtractive multi-colour pictures obtained by the process covered by Claim 1 or Claim 2.

Dated this 24th day of December, 1930.

ABEL & IMRAY,
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ERRATUM

SPECIFICATION No. 375,338 [Second Edition].

Page 1, line 41, *for* " eight " *read* " either "

THE PATENT OFFICE,
11*th September*, 1935.

2nd Edition

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

Fig. 1

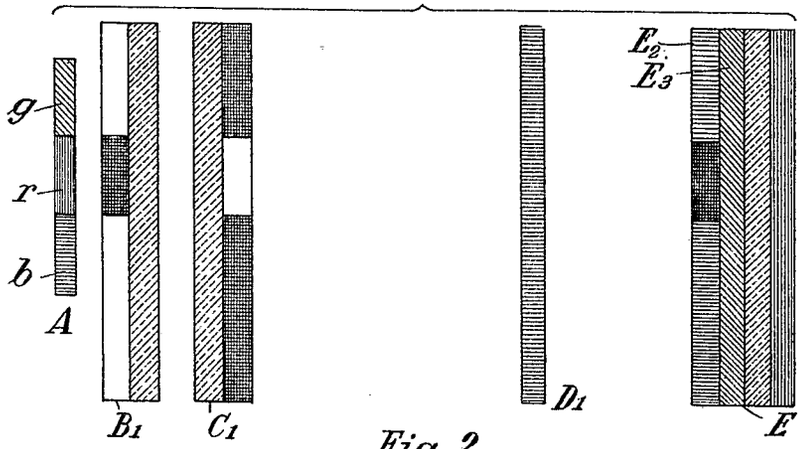


Fig. 2

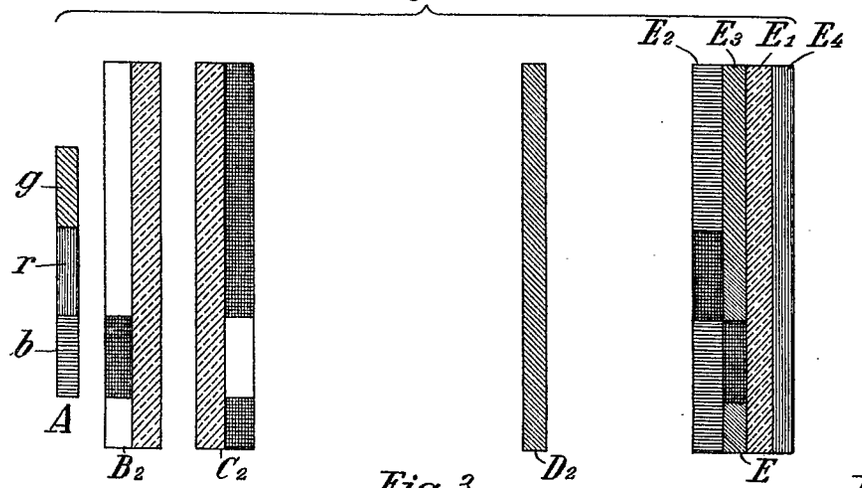


Fig. 3

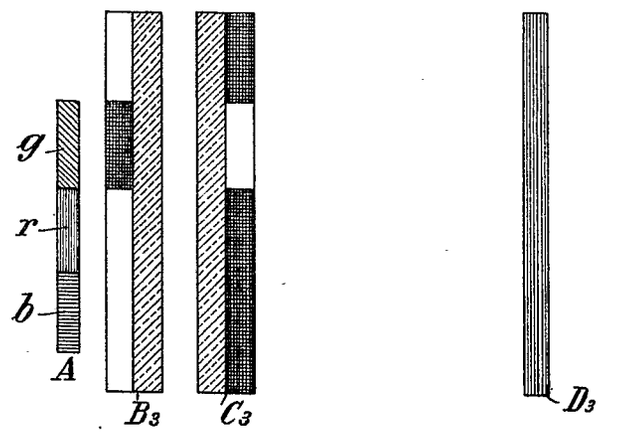
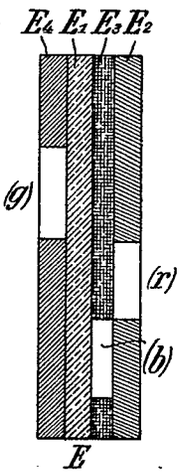


Fig. 4



Malby & Sons, Photo-Lith.