PATENT SPECIFICATION

Application Date: Feb. 21, 1936. No. 30467/37. 475,784

(Divided out of No. 475,786.)

Complete Specification Left: Feb. 22, 1937.

Complete Specification Accepted: Nov. 22, 1937.

PROVISIONAL SPECIFICATION

Improvements in and relating to Colour Photography

We, KODAK LIMITED, a Company registered under the Laws of Great Britain, of Kodak House, Kingsway, London, W.C.2, and RAYMOND EDWIN CROWTHER, a British Subject, of 41, Belmont Road, Bushey, Hertfordshire, do hereby declare the nature of this invention which has been communicated to us by Eastman Kodak Company, a Company organised under the laws of the State of New Jersey, United States of America, of 343, State Street, Rochester, New York, United States of America, to be as follows:—

This invention relates to improvements in colour photography.

In the Specification of our co-pending application No. 27765/35 (Serial No. 468,560), we have described a sensitive element especially a film having a single support carrying a plurality of emulsion layers sensitized to different colours, of which layers one at least is uncoloured while one at least is coloured with a colouring matter adapted to be decolourised and/or removed selectively in either the exposed or unexposed areas. There might be, for example, two, three or four emulsion layers and all might be upon the same side of the support or they might be distributed between both sides of the support, e.g. one on each side, one on one side and two on the other, two on each side or three on one side and one on the other. In the said Specification we have also described a method of producing coloured photographic records, especially natural colour pictures, by exposing a sensitive element having a plurality of differentially colour sensitive layers, one at least of which is essentially uncoloured and one at least of which is coloured, and by producing coloured images in the uncoloured layer or layers by "colour production" and in the coloured layer or layers by "colour suppression" (in the sense in which these terms are defined in the aforesaid Specification).

The present invention relates, for one part, to methods of processing elements of the kind described, and for another part to new or improved methods of processing photographic elements having a plurality of differentially colour-sensitized layers on a single support by operations of "colour production" without "colour suppression." In the last case, the differentially colour sensitized emulsion layers are essentially uncoloured; that is to say, they do not contain colour which appears as any part of the coloured image produced therein. In this aspect the present invention may be applied to the processing of the photographic elements having three differentially colour sensitized layers described in prior Specifications Nos. 440,032 and 440,089.

The present invention is concerned with photographic elements having three gelatino-silver halide layers on a single support either containing superimposed image records of three colours covering substantially the whole of the visible spectrum or selectively sensitized to colours covering substantially the whole of the visible spectrum. In addition to such three gelatino-silver halide layers the photographic element may carry a lower layer of panchromatic emulsion dyed black and/or an anti-halation layer and/or layers of clear gelatine situated between any of the gelatino-silver halide emulsion layers, which clear gelatine layers may contain decolourable colouring matter to serve as a screen for the under layer or layers.

The gelatino-silver halide emulsion layers may be superimposed on the same side of the support or may be distributed as between the front and rear sides of the support. In all cases the emulsion layers may be described as inseparable from one another or from the support and the methods of processing employed in the present invention do not require their separation from one another or from the support. The different layers may be successively coated by normal methods. In all cases in which the green and red sensitized emulsions have a relatively important sensitivity to blue light the layer first hit by incident light is sensitive to blue (i.e. insensitive to red or green) and it may contain decolourable yellow colouring matter to prevent access of blue light to

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the red sensitized and green sensitized layers therebeyond. Alternatively or in addition a decolourable yellow filter layer may be present between the layer sensitive to blue and the other layers as described and claimed in our Patent Specifications Nos. 444,198 and 441,325.

In greater particularity the present invention is concerned with subtractive colour photographic elements such as films and especially motion picture films in which a transparent carrier of material such as celluoid or cellulose acetate is used. The invention is, however, applicable to the production of still pictures and the final colour photograph produced may be on paper or other carrier. For the printing elements, however, and elements to be used for projection or to be viewed by transmitted light a transparent carrier is required.

It will be convenient here to define some of the terms to be employed in the description which follows.

" Colour Suppression " and " Colour Formation." These terms have the meaning ascribed to them in the Specification of co-pending Application 27765/35 (Serial No. 468,560).

" Negative Processing." Operations performed upon gelatino-silver halide emulsion layers containing light images whereby greatest opacity is produced in the areas most affected by the light.

" Positive Processing." Operations performed upon gelatino-silver halide emulsion layers containing light images whereby greatest translucency is produced in the areas most affected by the light.

" Negative Colour Suppression." That form of colour suppression wherein the colour is most destroyed in the areas least affected by light. One form of negative processing.

" Positive Colour Suppression." That form of colour suppression wherein the colour is most destroyed in the areas most affected by light. One form of positive processing.

" Colour Record." A gelatino-silver halide emulsion layer containing an image representing one only of the three primary colours, red, green and blue, of the original object. The image may be negative or positive or may be latent.

" Three Colour Record." An element having three colour records superimposed on a single support.

" Processing to Colour " or " Colour Processing." The operation of converting the images in one or more colour records into substantially clear, transparent coloured images.

" Subtractive Colour Record." A colour record in which the image representing a primary colour has been colour processed to the colour complementary to one of the three primary colours (herein termed a minus colour).

" Subtractive Three Colour Record." An element having superimposed on a single support three colour records the images in each of which have been respectively colour processed to the colours complementary to the three primary colours. Although the image representing any one primary colour exists in one one colour record, it will be apparent that, in accordance with the principles of the subtractive process, the colour which is transmitted by that record is contributed by the subtractive effect of the minus colours in the other records.

" True Colour Record." A subtractive colour record in which the image representing a primary colour has been colour processed to the colour complementary to that primary colour. In conformity with the foregoing definition of " colour record " this may be negative or positive.

" False Colour Record." A subtractive colour record in which the image representing a primary colour has been colour processed to the colour complementary to another primary colour.

" True Three Colour Record." A subtractive three colour record in which each colour record is a true colour record. In confomity with the foregoing definitions, it may be a true three colour negative in which case it transmits a negative picture of the original object in colours complementary to the colours of the original object or a true three colour positive in which case it transmits a positive picture of the original object in the true colours of the original object. A true three colour positive is referred to herein as a " Natural Colour Picture."

" False Three Colour Record." A subtractive three colour record in which two at least of the colour records are false colour records.

" Essentially uncoloured." A layer is said to be essentially uncoloured when it does not contain any colour which persists after colour processing. Such a layer must therefore be processed to colour by colour production.

As already stated we may employ a sensitive photographic element of the kind described in Application No. 468,560 which can be exposed in the camera or printed upon from a subtractive three colour record by means of white light. It has hitherto been a disadvantage of the colour suppression process that it has required, for the exposure of one layer at least, the use of light outside the visible

spectrum, e.g. infra-red light. This has rendered the use of coloured layers impracticable for the camera material and inconvenient for the printing material.

It is an object of the invention to provide subtractive colour processing operations involving printing by means of white light from a false three colour record. It is a further object of the invention to produce false three colour records from photographic elements exposed in the camera or printed with the aid of white light. The avoidance of colour filters for the exposure light in such printing is rendered possible by printing from subtractive colour records instead of printing from black and white records.

One form of sensitive element employed in the present invention has inseparably coated on a single support three gelatino-silver halide emulsion layers of which the one first hit by incident light is sensitive only to blue and is essentially uncoloured but adapted to be processed to colour by colour production while the other two layers are sensitized to red and green respectively and are adapted to be processed to colour by colour suppression, preferably positive colour suppression, the colour to be suppressed in the layer next beyond the blue being yellow (minus blue). The layers may all be coated on one side of the support or one may be on one side and two on the other. There may be, in addition to the three selectively colour sensitized layers, a layer of panchromatic emulsion dyed black and situated furthest from the blue sensitive layer. Since the image in this layer will be processed in all cases to a faint black image, positive or negative as may be required to assist in getting better colour saturation in the finished record, it can be disregarded in discussing the colour processing. Where the selectively colour sensitized layer beneath the yellow layer is sensitized to green this is preferably coloured minus red and accordingly the colour record constituted by the upper blue sensitive layer has to be processed to minus green; where the selectively colour sensitized layer beneath the yellow layer is sensitized to red this is preferably coloured minus green and accordingly the colour record constituted by the upper blue sensitive layer has to be processed to minus red. If positive colour suppression is employed for the lower layers, the upper layer must be subjected to a colour formation process involving positive processing. The colour of one or more of the colour records may be changed, after processing to colour, if desired or necessary.

The processing of such an element, which is claimed in our co-pending Application No. 5227/36, results in a false three colour record. However, this record may be printed with white light upon sensitive material having three differentially colour sensitized layers for obtaining further subtractive three colour records which may, by the choice of suitable printing material and appropriate colour processing, be true three colour records and even natural colour pictures.

The first false three colour record may, alternatively, be printed upon a photographic element having substantially uncoloured layers such as that described in prior Patent Specifications Nos. 440,032, 440,089 or 447,092, and the element then processed to a subtractive three colour record in appropriate minus colours. In this way, by processing the images in the layers respectively to the colours complementary to the primary colours of which they are records, a true three colour record can be obtained by one printing, as will appear more clearly from the examples given hereinafter. If the first false three colour record has been obtained by positive processing, then positive processing of the printed record to appropriate minus colours will yield a natural colour picture. If, on the other hand the first false three colour record has been obtained by negative processing, then negative processing of the printed record to appropriate minus colours will give a natural colour picture. Indeed, it may be generally stated that the true three colour record will be a natural colour picture whenever the number of negative processing steps, if any, involved in its production is even; if the number is odd, a true three colour negative will result.

It is also possible to obtain a natural colour picture in one printing by employing as the printing material a sensitive material resembling the exposure material but in which the sensitivities of the lower two layers, ie. the red and green sensitized layers, are interchanged and the colours to which the top (blue sensitive layer) and bottom colour records are processed are interchanged, as will appear more clearly from the examples given hereinafter.

In all those cases in which the colour suppression process is employed, it will be apparent that the coloured layers are capable of transmitting the light to which they are sensitive and, in the case of the yellow layer, the colour to which the under layer is sensitive.

The invention also includes the step of obtaining a subtractive three colour record, which may be a true three colour record or a false three colour record, from a photographic element having inseparably coated on a single support three

colour records which consists in processing one colour record to the minus colour of the primary colour recorded by one of the other colour records and then processing the other colour records respectively to the minus colours of the other two primary colours. Thus each colour record may be processed respectively to the minus colour of the primary colour of which one of the others is a record, (no two layers being processed to the same minus colour), and consequently none of them is processed to the minus colour of the primary colour of which it is itself a record. Alternatively, one colour record may be processed to the minus colour of the primary colour of which it is a record and the other two colour records are then processed each to the minus colour of the primary colour of which the other is a record.

The colour records which are processed to minus colours in the above methods may be obtained by exposure of a photographic element having inseparably coated on a single support three gelatino-silver halide emulsion layers respectively sensitized to red, green and blue, in a camera or by printing upon such an element from another subtractive three colour record.

The invention includes methods of producing a true three colour record from a false three colour record with the aid of white light.

According to one of these methods a subtractive three colour record in which one colour record is processed to the minus colour of the primary colour of which it is a record while each of the remaining colour records is processed to the minus colour of the primary colour of which the other is a record, is printed with white light upon a photographic element having inseparably coated upon a single support three gelatino-silver halide emulsion layers respectively sensitized to red, green and blue and the resulting latent images are processed to produce colour records in the minus colours of the primary colours by which the colour records giving rise to these images were produced in the subtractive three colour record from which they were printed. As before, if negative processing is employed at all, a true three colour negative or a natural colour picture will result according as the number of negative processings is odd or even.

The colour processing in the above methods may be accomplished by colour suppression or colour formation, the latter method being employed in all cases for the images in an uncoloured sensitive layer. If positive colour suppression is employed to process the coloured layer or layers in an element, positive colour formation must be employed for the essentially uncoloured layer or layers in that element. Thus, in proceeding with the aid of colour forming developers, which is the preferred method, the images may first be reversed and the reversed images processed to colour by the methods adopted in Specifications Nos. 447,092, 440,032 or 440,089 with appropriate modification of the colour forming developers employed.

The invention will be understood more clearly by the following brief description of some suitable photographic elements (materials) and their manner of use. For the colouring of the colour records positive processing is, for convenience, assumed.

Sensitivity order of the layers.	Colours of the layers. (Decolourable where the silver image develops).	Colour of the positive colour records.
1. Blue	Essentially uncoloured	Minus Red
Green	Minus Blue	Minus Blue
Red	Minus Green	Minus Green
2. Blue	Essentially uncoloured	Minus Green
Red	Minus Blue	Minus Blue
Green	Minus Red	Minus Red
3. Blue	Essentially uncoloured	Minus Green
Green	Minus Blue	Minus Blue
Red	Minus Green Convertible to minus Red	Minus Red

In the above sensitive elements (materials) the blue sensitive layer is essentially uncoloured in the sense hereinbefore defined. It may, however, be coloured with a decolourable yellow colouring matter to protect the under-layers from blue light.

In the sensitive elements (materials) now to be described all the layers are, initially, essentially uncoloured although as in the above elements the blue sensitive layer may be coloured with a decolourable yellow colouring matter.

	Sensitivity order of the layers.	Colour to which the positive colour records are to be processed.
4.	Blue Green Red	Minus Red Minus Blue Minus Green
5.	Blue Red Green	Minus Green Minus Blue Minus Red
6.	Blue Green Red	Minus Green Minus Red Minus Blue
7.	Blue Red Green	Minus Red Minus Green Minus Blue
8.	Blue Green Red	Minus Green Minus Blue Minus Red
9.	Blue Green Red	Minus Red Minus Green Minus Blue
10.	Blue Red Green	Minus Red Minus Blue Minus Green
11.	Blue Red Green	Minus Green Minus Red Minus Blue
12.	Blue Green Red	Minus Blue Minus Red Minus Green
13.	Blue Red Green	Minus Blue Minus Green Minus Red

It will be seen that materials 4, 6, 8, 9 and 12 before colour processing are essentially the same, as are also materials 5, 7, 10, 11 and 13.

Subtractive three colour records when produced on the above materials from objects in colour, e.g. by camera exposure or printing, are false three colour records, although in the case of materials 3, 8, 9, 10, 11, 12 and 13 one colour record is a true colour record. Natural colour pictures can be obtained by suitable printing methods of which the following are examples:—

If an element composed of material 1 or 4 after positive colour processing is printed with white light upon the material 6, or if an element composed of material 6 after positive colour processing is printed with white light upon the material 1 or 4 then after positive colour processing of the printed material a natural colour picture results. Similarly, natural colour pictures can be obtained by printing an element composed of material 2 on material 7 or *vice versa* or by printing an element composed of material 6 on material 7 or *vice versa*.

A more specific example will now be given and in considering this it must be remembered that, in printing, each printed image will be found recorded in the print in that layer whose sensitivity corresponds to the component of the white printing light which is absorbed by the printing image. Thus, for example, a printing image coloured minus red absorbs red but is transparent to all colours except red; the corresponding printed image will therefore be found entirely in the red sensitive layer of the print. For convenience we have stated in the example the colour of the light component by which the respective images will be printed. If, for example, it is stated that an image prints with the red component of the printing light, the printed image must be sought in the red sensitive layer of the print; and similarly in the case of the blue and green components.

Material 1 or 4.		Material 2 or 5.	
Unexposed layers.	Exposed and colour processed layers. (False three colour record).	Unexposed layers.	Printed and colour processed layers. (True three colour record).
Blue sensitive. Essentially uncoloured.	Comprises record of blue original light component coloured minus red. (False colour record). (Image prints with red component of printing light).	Blue sensitive. Essentially uncoloured.	Comprises record of green original light component coloured minus green. (True colour record).
Green sensitive. Coloured yellow (minus blue) in material 1. Essentially uncoloured in material 4.	Comprises record of green original light component coloured minus blue. (False colour record). (Image prints with blue component of printing light).	Red sensitive. Coloured yellow (minus blue) in material 2. Essentially uncoloured in material 5.	Comprises record of blue original light component coloured minus blue. (True colour record).
Red sensitive. Coloured magenta (minus green) in material 1. Essentially uncoloured in material 4.	Comprises record of red original light component coloured minus green. (False colour record). (Image prints with green component of printing light).	Green sensitive. Coloured blue-green (minus red) in material 2. Essentially uncoloured in material 5.	Comprises record of red original light component coloured minus red. (True colour record).

In the operations outlined in the above brief description, positive processing is employed in all cases. It has already been pointed out that if in any of the sequences of exposure and printing negative processing is employed an odd number of times, a true three colour negative instead of a natural colour picture will result. Any such true three colour negative may be employed as a master negative for the production of natural colour pictures by known methods e.g. such as are described in Application No. 447,092.

In practice it is preferred to use positive processing employing material 1 for the camera exposure and material 2 for the printing.

The elements containing latent images may be processed to produce images in the required minus colours by any appropriate methods of which the following are examples:—

ELEMENTS ON MATERIALS 1 AND 2.
(POSITIVE PROCESSING.)

1. Develop the latent images to silver with an ordinary developer.
2. Fix.,
3. Treat with a solution which destroys the dye in the lower layers at the points where silver has been developed.
4. Treat with a solution which converts silver to a salt of silver soluble in a fixing bath.
5. Fix.

Washing steps are of course inserted between these various steps of chemical treatment, but the washing steps are omitted from the description for the sake of simplicity.

These operations produce reversed dye images in the lower layers but alone would leave the upper layer uncoloured.

A reversed dye image can be introduced into the upper layer by a number of possible methods of which the following two serve as examples.

(a) A dye which is capable of being decolourised in the presence of silver is introduced uniformly into the upper layer by diffusion, preferably between operations 2 and 3 so that a reversed dye image is formed in this upper layer in operation 3.

In place of introducing such dye directly, a leuco base or the components of a dye may be introduced into the upper layer so that the dye is formed *in situ*.

In the case of material 1, the dye introduced after exposure is blue-green (minus red), and in material 2, the dye introduced is magenta (minus green).

This step of introducing into one layer of a multi-layer differentially colour-sensitized photographic element, after the production of a latent image therein, a dye-stuff or colouring matter adapted to be decolourized (or alternatively fixed) in the presence of silver is believed to be novel, and enables initially an uncoloured layer to be processed by colour suppression.

(b) In operation 4, a bleaching agent is used which simultaneously tans the gelatine in the regions of the silver image, so that after the final washing and drying of the element, a reversed dye image can be produced by differential diffusion of a dye-stuff or colouring matter into the regions of the softer gelatine.

Material 3 is similar to material 1 except that the magenta dye present in the lowest layer is one which can be converted to blue-green in the course of the processing. Thus a magenta dye containing a free amino group may be used so that after the development and fixation of the element this dye can be diazotised and converted into a blue-green compound by reaction with a coupling component such as a phenolic substance. It is possible, however, to employ a simpler method by using Niagara Blue G. as the dye in the red sensitive layer. This dye, though more of a purple than a magenta in hue, is sufficiently transparent to red light to enable the layer in which it is incorporated to be exposed by red light. This dye is converted into a blue-green compound by reaction with pyridine in dilute solution. This conversion can therefore be effected by employing as the first fixing bath a solution of sodium thiosulphate containing pyridine.

As already indicated, those elements in which the layers are substantially uncoloured can be conveniently processed by methods of colour-development employing colour couplers in the developing solutions. The methods described in the Patent Specifications Nos. 447,092, 440,032 and 440,089 may be employed with appropriate alteration in the order in which the different colours are introduced. It is obviously immaterial in carrying out the present invention whether the layers are all on one side of the support or distributed as between the front and rear sides, but naturally regard must be had to this fact in deciding upon the appropriate colour-processing operations to employ.

Dated this 5th November, 1937.
W. P. THOMPSON & CO.,
12, Church Street, Liverpool, 1,
Chartered Patent Agents.

COMPLETE SPECIFICATION

Improvements in and relating to Colour Photography

We, KODAK LIMITED, a Company registered under the Laws of Great Britain, of Kodak House, Kingsway, London, W.C.2, and RAYMOND EDWIN CROWTHER, a British Subject, of 41, Belmont Road, Bushey, Hertfordshire, do hereby declare the nature of this invention which has been communicated to us by Eastman Kodak Company, a Company organised under the laws of the State of New Jersey, United States of America, of 343, State Street, Rochester, New York, United States of America, 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 improvements in colour photography. In particular it relates to subtractive colour photographs and to methods suitable for the production thereof.

The present invention employs photographic elements of the type having three gelatino-silver halide layers inseparably coated on a single support either containing superimposed image records of three colours covering substantially the whole of the visible spectrum or selectively sensitized to colours covering substantially the whole of the visible spectrum. In addition to such three gelatino-silver halide layers the photographic element may carry a lower layer of panchromatic emulsion dyed black and/or an anti-halation layer and/or layers of clear gelatine situated between any of the gelatino-silver halide

emulsion layers, which clear gelatine layers may contain decolourable colouring matter to serve as a screen for the under layer or layers. Such elements are referred to hereinafter as " of the type described."

The employment of elements in which the layers are inseparably coated on a single support secures substantial advantages in practice. The processing is accomplished without separating the layers from one another or from the support and consequently the respective colour images are always maintained in the same fixed relationship to one another. The possibility of inaccurate register is therefore substantially eliminated in both the processing and printing. During printing, any printing light must pass through all the layers and in consequence the same optical system is employed for directing the different colour images upon the material to be printed. The printing of the different colour images can be accomplished simultaneously since accuracy of register is automatically secured by the fixed relationship between the different colour records. In any event, however, the printing is all effected in one direction, i.e. the exposure of the sensitive element is wholly from one side.

Such elements may be of the kind described and claimed in Patent Specification No. 468,560 in which a single support carries a plurality of emulsion layers sensitized to different colours, of which layers one at least is uncoloured while one at least is coloured with a colouring matter adapted to be decolourised and/or removed selectively in either the exposed or unexposed areas. In colour processing such elements coloured images are produced in the uncoloured layer or layers by " colour production " and in the coloured layer or layers by " colour suppression " (in the sense in which these terms are defined in the Specification No. 5227/36).

Alternatively we may use the photographic elements hereinafter described in which one layer is uncoloured and adapted to be processed by " colour production " and two layers are coloured and adapted to be processed by " colour suppression." Such elements are claimed in our co-pending Application No. 5227/36.

Sensitive photographic elements of the kind above described can be exposed in the camera or printed upon from a subtractive three colour record by means of visible light and especially light of the primary colours. It has hitherto been a disadvantage of the colour suppression process that it has required for the exposure of one layer at least, the use of light outside the visible spectrum eg. infra-red light. This has rendered the use of coloured layers impracticable for the camera material and inconvenient for the printing material.

We may also, however, utilise photographic elements in which the colour processing of all the layers requires operations of " colour production " without " colour suppression." In the last case all of the differentially colour sensitized emulsion layers are essentially uncoloured; that is to say, they do not contain colour which appears as any part of the coloured image produced therein. In this aspect the present invention may be applied to the processing of the photographic elements having three differentially colour sensitized layers described in prior Specifications Nos. 440,032 and 440,089.

The gelatino-silver halide emulsion layers may be superimposed on the same side of the support or may be distributed between the front and rear sides of the support. The different layers may be successively coated by normal methods. In all cases in which the green and red sensitized emulsions have a relatively important sensitivity to blue light the layer first hit by incident light is sensitive to blue (i.e. insensitive to red or green) and it may contain decolourable yellow colouring matter to prevent access of blue light to the red sensitized and green sensitized layers therebeyond. Alternatively or in addition a decolourable yellow filter layer may be present between the layer sensitive to blue and the other layers as described and claimed in our Patent Specifications Nos. 444,198 and 441,325.

In greater particularity the present invention is concerned with subtractive colour photographic elements such as films and especially motion picture films in which a transparent carrier of material such as celluloid or cellulose acetate is used. The invention is, however, applicable to the production of still pictures and the final colour photograph produced may be on an opaque carrier of material such as paper. For the printing elements, however, and elements to be used for projection or to be viewed by transmitted light a transparent carrier is required.

The expressions " colour suppression," " colour production," " negative processing," " positive processing," " negative colour suppression," " positive colour suppression," " colour record," " three colour record," " processing to colour " or " colour processing," " subtractive colour record," " subtractive three colour record," " true colour record," " false colour record," " true three colour record," " false three colour record " and " essentially uncoloured " are employed

herein with the meanings defined in our co-pending Application No. 5227/36. We shall also, in this Specification employ the expression " coordinated colour " to signify that a record is in the colour complementary to the sensitivity of the layer in which it is present and " uncoordinated colour " to signify that a record is in the colour complementary to the sensitivity of one of the layers other than that in which it is present.

The present invention is concerned with processes in which the printing materials and printed materials are of different character by which is meant that not more than one of the records in each element is processed to the same subtractive colour as that in the layer which was correspondingly sensitized in another element. In these circumstances it has been found that if an element contains three false colour records a true colour record is obtained by a single printing upon a material of different character in which the record in each of the layers is processed to a different subtractive colour from that in the layer which was correspondingly sensitized in the other element and other than that complementary to the sensitivity of the layer. It has further been found that if an element contains two or three false colour records, it is possible to obtain, by a single printing upon different material a further false colour record which when printed upon a suitable third material of different character from either of the others will give a true colour record. A rule by which the appropriate materials for this double printing can be selected is given hereinafter. A characteristic feature of the invention, however, is that in at least one of the elements at least two of the records are processed by colour production.

One form of the single printing method, according to the present invention, for obtaining a subtractive true three-colour record of a coloured object from a photographic element of the type described containing the three colour records of the object consists in processing the blue colour record to minus red, the green colour record to minus blue and the red colour record to minus green and then printing the resulting false three colour record on to another photographic element having inseparably coated on a single support three layers sensitized respectively to the primary colours and processing the record in the blue sensitive layer to minus green, that in the green sensitive layer to minus red and that in the red sensitive layer to minus blue, and is further characterised in that in at least one of the photographic elements at least two of the records are processed by colour production.

The other form of the single printing according to the present invention consists in processing the blue colour record to minus green, the green colour record to minus red and the red colour record to minus blue, and then printing the resulting false three colour record on to another photographic element having inseparably coated on a single support three layers sensitized respectively to the primary colours and processing the record in the blue sensitive layer to minus red, that in the green sensitive layer to minus blue and that in the red sensitive layer to minus green, and is further characterised in that in at least one of the photographic elements at least two of the records are processed by colour production.

The double printing method, according to the present invention, for obtaining a subtractive true three colour record of a coloured object from a photographic element of the type described consists in processing the element to a false three colour record, printing this false three colour record onto a different element of the type described and processing this to a different false three colour record and printing this false three colour record on to a third different element of the type described and processing this to a true three colour record, the method being carried out by processing all of the layers in one of the elements and two of the layers in the remaining elements to uncoordinated colours according to the rule hereinafter given and being further characterised by the fact that in at least one of the photographic elements at least two of the records are processed by colour production. In the double printing method the records in all of the layers in the first element may be processed to uncoordinated colours, e.g. the blue colour record to minus red, the green colour record to minus blue and the red colour record to minus green. In the second element the record in the blue sensitive layer may then be processed to minus red, that in the green sensitive layer to minus green and that in the red sensitive layer to minus blue. In the third element the record in the blue sensitive layer may then be processed to minus blue, that in the green sensitive layer to minus red and that in the red sensitive layer to minus green.

In either form of the invention it is possible to start from a photographic element in which the records have already been processed to the subtractive colours appropriate to the invention. The operations then consist in printing and colour processing the printed element or

elements.

For any of the stages there may be employed an element in which the layers are essentially uncoloured and adapted to be processed by colour production or an element in which one or two layers are adapted to be processed by colour suppression. Generally speaking elements with essentially uncoloured layers will be most desirable as camera exposure materials whereas elements with one or two coloured layers may be most convenient as printing materials.

In the case of elements containing a coloured layer or layers such colour must be capable of transmitting the light to which the layer or layers is or are sensitive as well as the light to which the under layer, if any, is sensitive. Since the uppermost layer, with respect to incident light, must be sensitive to blue this means that this layer must be essentially uncoloured and that the middle layer can only be coloured minus blue.

Since the elements dealt with in the present invention contain the colour records in superimposed layers, it is not necessary to employ separate optical projection means for the different colour records to be printed and accurate registry in the prints is therefore ensured. Moreover since all the colour records are in the minus colours of the three different primary colours, white light may be employed for printing. However, the different colour records may, if desired, be printed either simultaneously or successively by differently coloured visible exposure lights obtained with the aid of sharp cutting filters or by prismatic dispersion in order to obtain a better resolution of the colour records. Even in this case, however, it will be appreciated that the colour records are superimposed while being printed. The employment of light of the primary colours, separately or in admixture, for printing, makes it possible to employ the same colour sensitizers in elements employed for camera exposure and printing.

If the first false three colour record has been obtained by positive processing, then positive processing of the printed record to appropriate minus colours will yield a natural colour picture. If, on the other hand the first false three colour record has been obtained by negative processing, then negative processing of the printed record to appropriate minus colours will give a natural colour picture. Indeed, it may be generally stated that the true three colour record will be a natural colour picture whenever the number of negative processing steps, if any, involved in its production is even; if the number is odd, a true three colour negative will result.

The colour processing in the above methods may be accomplished by colour suppression or colour production, the latter method being employed in all cases for the images in an uncoloured sensitive layer. If positive colour suppression is employed to process the coloured layer or layers in an element, positive colour formation must be employed for the essentially uncoloured layer or layers in that element. Thus in proceeding with the aid of colour forming developers, the images may first be reversed and the reversed images processed to colour by the methods adopted in Specifications Nos. 447,092, 440,032, or 440,089 with appropriate modification of the colour forming developers employed.

The invention will be understood more clearly by the following brief description of some suitable photographic elements (materials) and their manner of use. For the colouring of the colour records positive processing is, for convenience, assumed.

Sensitivity order of the layers.	Colours of the layers. (Decolourable where the silver image develops).	Colour of the positive colour records.
1. Blue	Essentially uncoloured	Minus Red
Green	Minus Blue	Minus Blue
Red	Minus Green	Minus Green
2. Blue	Essentially uncoloured	Minus Green
Red	Minus Blue	Minus Blue
Green	Minus Red	Minus Red
3. Blue	Essentially uncoloured	Minus Green
Green	Minus Blue	Minus Blue
Red	Minus Green Convertible to minus Red.	Minus Red

In the above sensitive elements (materials), which are claimed in our co-pending Application No. 5227/36, the blue sensitive layer is essentially uncoloured in the sense defined in Application No. 5227/36. It may, however, be coloured with a decolourable yellow colouring matter to protect the under-layers from blue light.

In the sensitive elements (materials) now to be described all the layers are, initially, essentially uncoloured although as in the above elements the blue sensitive layer may be coloured with a decolourable yellow colouring matter.

	Sensitivity order of the layers.	Colour to which the positive colour records are to be processed.
4.	Blue	Minus Red
	Green	Minus Blue
	Red	Minus Green
5.	Blue	Minus Green
	Red	Minus Blue
	Green	Minus Red
6.	Blue	Minus Green
	Green	Minus Red
	Red	Minus Blue
7.	Blue	Minus Red
	Red	Minus Green
	Green	Minus Blue
8.	Blue	Minus Green
	Green	Minus Blue
	Red	Minus Red
9.	Blue	Minus Red
	Green	Minus Green
	Red	Minus Blue
10.	Blue	Minus Red
	Red	Minus Blue
	Green	Minus Green
11.	Blue	Minus Green
	Red	Minus Red
	Green	Minus Blue
12.	Blue	Minus Blue
	Green	Minus Red
	Red	Minus Green
13.	Blue	Minus Blue
	Red	Minus Green
	Green	Minus Red

It will be seen that the materials 4, 6, 8, 9 and 12 before colour processing are essentially the same, as are also materials 5, 7, 10, 11 and 13.

It will be apparent also that elements may be employed which correspond to elements Nos. 4, 5, 6, 7, 9, 11, 12 and 13, as regards sensitivity of the layers and the colours to which they are to be processed but differ from them in that the layer last hit by incident light is coloured with a colouring matter adapted for the production of coloured images by colour suppression. In this event two layers will be processed by colour formation and one layer by colour suppression.

It will be seen, moreover, that there are five different characters of material in the sense hereinbefore indicated. These may be designated by the letters A, B, C, D and E. Materials of the character A comprise Nos. 1, 4 and 7 which are of the same character because the blue sensitive layer is processed minus red, the green sensitive layer minus blue and the red sensitive layer minus green. Materials of the character B comprise Nos. 2, 5 and 6. Materials of the character C comprise Nos. 3, 8 and 11. Materials of the character D comprise Nos. 9 and 10. Materials of the character E comprise Nos. 12 and 13.

Subtractive three colour records when produced on the above materials from objects in colour, e.g. by camera exposure or printing, are false three colour records although in the case of materials 3, 8, 9, 10, 11, 12 and 13 one colour record is a true colour record. Natural colour pictures can be obtained by suitable printing methods of which the following are examples:—

If an element composed of material 1 or 4 or 7 (Character A) after positive colour processing is printed with white light or the primary components thereof upon the material 2 or 5 or 6 (Character B) or if an element composed of material 2 or 5 or 6 (Character B) after positive colour processing is similarly printed upon the material 1 or 4 or 7 (Character A), then after positive colour processing of the printed material a natural colour picture results.

Other variations are possible. For example, the false three colour record constituted by an element of material 1 (Character A) exposed to a coloured object and processed to colour may be printed on an element of material 9 (Character D). The three colour record obtained by colour processing the element of material 9 is a false colour record and when this is printed on an element of material 12 (Character E), colour processing results in a true three colour record.

The rule for obtaining a true three colour record by such double printing may be expressed as follows. Place the letters A, B, C, D and E representing the five characters of material at the apices of a solid double triangular pyramid in the manner shown in Fig. 1 of the accompanying drawing. In this figure E is the point farthest removed from the observer. If any triangular face is now viewed from an external point the three materials represented by the apices taken in a clockwise direction represent three materials and the order in which they are taken in the double printing method. This figure may be drawn in one plane, for convenience of viewing entirely from in front of the paper, by repeating one of the letters C, D or E as shown, for example, in Fig. 2 where the letter E is repeated. Here, by directly viewing any small triangle, the apices taken in a clockwise direction again represent three materials and the order in which they are taken in the double printing method.

In the remaining figures of the drawing, Fig. 3 represents a natural colour object to be photographed, placed in association with a three-layer exposure element represented by Fig. 4. A three-layer printing element represented by Fig. 5 is placed in association with the three-layer exposure element.

The natural colour object is for convenience divided up into portions each representing a different primary colour or combination of primary colours. The primary colours are designated by the letters R (for Red), G, (for Green), B for Blue); and the compound colours formed by two primaries are also designated by the letters $-R$ (minus Red), $-G$ (minus Green) and $-B$ (minus Blue). Similarly each of the three layers in the exposure and printing elements is divided up into corresponding portions on which are indicated the areas in which colours are produced by exposure or printing and colour processing and the nature of the colours so produced.

At the left hand side of the elements are indicated the primary colours to which the layers are respectively sensitive; at the right hand side are indicated the minus colours to which the images in the layers are processed. For convenience, in the layers themselves are indicated the colours of the light actually transmitted by images so coloured.

When considering the drawings, it must be remembered that, in printing, each printed image will be found recorded in the print in that layer whose sensitivity corresponds to the primary colour component of the printing light which is absorbed by the printing image. Thus, for example, a printing image coloured minus red absorbs red but is transparent to all colours except red; the corresponding printed image will therefore be found entirely in the red sensitive layer of the print. For convenience we have stated in the examples the colour of the light component by which the respective images will be printed. If, for example, it is stated that an image prints with the red component of the printing light, the printed image must be sought in the red sensitive layer of the print; and similarly in the case of the blue and green components.

Figure 4 shows the colours produced in an element of material 1 or 4 after exposure to the coloured object represented by Fig. 3. Figure 11 shows the colours produced in an element of material 2 or 5 after being printed from the coloured element of Fig. 4. Figure 4 is a false three-colour record and Fig. 5 is a true three-colour record of the original object.

In those cases in which the first print is still a false three-colour record such first print may conveniently constitute a master print from which a large number of natural colour pictures can be obtained by printing. This is particularly valuable in the motion picture field where it is desirable to avoid wear and tear of the original picture and where it is desired to make a large number of prints for projection simultaneously in different places.

In the operations outlined in the above brief description, positive processing is employed in all cases. It has already been pointed out that if in any of the sequences of exposure and printing negative processing is employed an odd number of times, a true three-colour negative instead of a natural colour picture will result. Any such true three-colour negative may be employed as a master negative for the production of natural colour pictures by known methods e.g. such as are described in Application No. 447,092. It is to be observed, however, that the drawings are equally illustrative of operations involving negative processing since they are concerned entirely with the colours of the images and not with the character of the images.

The elements containing latent images may be processed to produce images in the required minus colours by any appropriate methods of which examples are given in our co-pending application No. 5227/36, and the elements may be made as therein indicated.

Having now particularly described and ascertained the nature of the said invention and in what manner the same is to be

performed, as communicated to us by our foreign correspondents, we declare that what we claim is:—

1. The method of obtaining a subtractive true three colour record of a coloured object from a photographic element of the type described containing the red, green and blue component records of the object consists in processing the blue colour record to minus red, the green colour record to minus blue and the red colour record to minus green and then printing the resulting false three colour record on to another photographic element having inseparably coated on a single support three layers sensitized respectively to the primary colours and processing the record in the blue sensitive layer to minus green, that in the green sensitive layer to minus red and that in the red sensitive layer to minus blue, and further characterised in that in at least one of the photographic elements at least two of the records are processed by colour production.

2. The method of obtaining a subtractive true three colour record of a coloured object from a photographic element of the type described containing the red, green and blue component records of the object which consists in processing the blue colour record to minus green, the green colour record to minus red and the red colour record to minus blue, and then printing the resulting false three colour record on to another photographic element having inseparably coated on a single support three layers sensitized respectively to the primary colours and processing the record in the blue sensitive layer to minus red, that in the green sensitive layer to minus blue and that in the red sensitive layer to minus green, and further characterised in that in at least one of the photographic elements at least two of the records are processed by colour production.

3. The method of obtaining a subtractive true three colour record of a coloured object from a photographic element of the type described containing the red, green and blue component records of the object which consists in processing the element to a false three colour record, printing this false three colour record on to a different element of the type described and processing this to a different false three colour record and printing this false three-colour record on to a third different element of the type described and processing this to a true three colour record, the method being carried out by processing all of the layers in one of the elements and two of the layers in the remaining elements to uncoordinated colours according to the rule hereinbefore given and being further characterised by the fact that in at least one of the photographic elements at least two of the records are processed by colour production.

4. The method as claimed in Claim 3 in which the records in all of the layers in the first element are processed to uncoordinated colours.

5. The method as claimed in Claim 4 in which in the first element the blue colour record is processed to minus red, the green colour record to minus blue and the red colour record to minus green.

6. The method as claimed in Claim 4 or 5 in which in the second element the record in the blue sensitive layer is processed to minus red, the record in the green sensitive layer is processed to minus green and the record in the red sensitive layer is processed to minus blue.

7. The method as claimed in Claim 4, 5, or 6 in which in the third element the record in the blue sensitive layer is processed to minus blue, the record in the green sensitive layer is processed to minus red and the record in the red sensitive layer is processed to minus green.

8. The method as claimed in any of the preceding Claims in which at least one of the colour records in at least one of the elements is produced by colour suppression.

9. The method as claimed in any of Claims 1 to 7 in which two of the colour records in at least one of the elements are produced by colour suppression.

10. The method as claimed in any of Claims 1 to 7 in which at least one of the colour records in each element is produced by colour suppression.

11. The method of obtaining true three-colour records with the aid of intermediate false three colour records, employing materials of different character, substantially as herein described.

12. True three colour photographic records, whenever obtained by the methods described and claimed.

Dated this 5th day of November, 1937.

W. P. THOMPSON & CO.,
12, Church Street, Liverpool, 1,
Chartered Patent Agents.

Leamington Spa: Printed for His Majesty's Stationery Office, by the Courier Press.—1937.

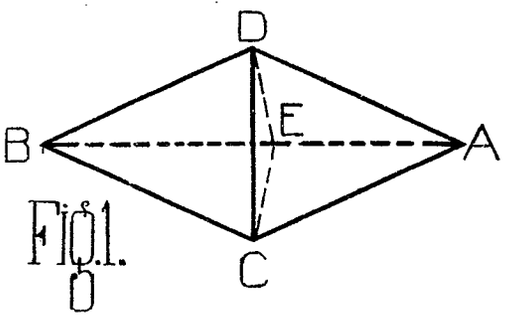

FIG. 1.

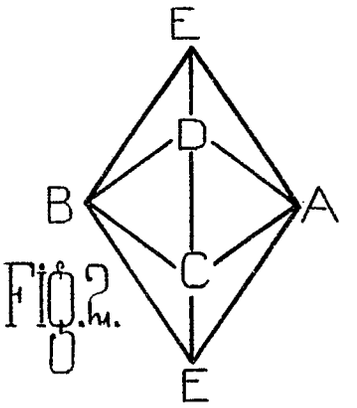

FIG. 2.

FIG. 3.

SENSITIVITY		R	G	B	G+B (−R)	R+B (−G)	R+G (−B)	R+G+B W

COLOUR →

FIG. 4.

V									
B	G+B	G+B	G+B				G+B		−R
G	R+G	R+G		R+G		R+G			−B
R	R+B		R+B	R+B	R+B				−G

FIG. 5.

B	R+B	R+B		R+B		R+B			−G
R	R+G	R+G	R+G				R+G		−B
G	G+B		G+B	G+B	G+B				−R

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