AMENDED SPECIFICATION

Reprinted as amended in accordance with the Decision of the Superintending Examiner, acting for the Comptroller-General, dated the fourteenth day of October, 1940, under Section 11 of the Patents and Designs Acts, 1907 to 1939.

PATENT SPECIFICATION

Application Date: Feb. 21, 1936. No. 5227/36. **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, Belmond 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 improvements in photographic elements of the kind described in the specification of the aforesaid co-pending application, for another part, to methods of processing such elements, 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 visble 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

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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 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 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 the three primary colours. Although the image representing any one primary colour exists in only 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 conformity 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.

In that part of the invention which concerns subtractive colour photographic elements which are processed by colour suppression it is an object of the invention to provide a sensitive photographic element of the kind already indicated 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 a further 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 and believed to be novel 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 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. If the exposed element is processed to a subtractive three colour record without change of colour in either of the coloured layers, then printed upon the same material by the aid of white light and this print is processed to colour in the same way, another false three colour record in different colours is obtained and if this false three colour record is in turn printed on the same material and this print is processed to colour in the same way, a true three colour record is obtained.

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 true three colour record in one printing by employing as the camera exposure material and the printing material a sensitive element in which one of the coloured layers is coloured with a colour (such as one transmitting right to which the layer is sensitive) which can be changed, after production of the image by colour suppression, into the required minus colour, preferably the colour complementary to the primary colour to which the layer is sensitive.

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.

Another method of producing a true three colour record from a photographic sensitive material, having inseparably coated on a single transparent support three superimposed gelatino-silver halide emulsion layers respectively sensitized to red, green and blue of which the one hit first by incident light is sensitive to blue only, includes colour processing latent images produced by red, green and blue colour sensations in the respective layers to produce colour records in minus green, minus blue and minus red respectively, or in minus blue, minus red and minus green respectively, printing from such colour processed colour records with white light on substantially identical photographic sensitive material, colour processing the latent printed images to produce colour records in the same minus colours in layers having the same sensitivity and finally printing from such printed and processed colour records with white light on to substantially identical photographic sensitive material and again colour processing the latent images to produce colour records in the same minus colours in layers having the same sensitivity. 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 Green Red	Essentially uncoloured Minus Blue Minus Green	Minus Red Minus Blue Minus Green
2. Blue Red Green	Essentially uncoloured Minus Blue Minus Red	Minus Green Minus Blue Minus Red
3. Blue Green Red	Essentially uncoloured Minus Blue Minus Green Convertible to minus Red	Minus Green Minus Blue 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

Sensitivity order of the layers.	Colour to which the positive colour records are to be processed.
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 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:—

An element composed of material 1 after positive colour processing is printed with white light on the same material. The print after positive colour processing is a false three colour record different in appearance from the printing element. This print is then printed again on the same material with white light and after positive colour processing a natural colour picture results.

A natural colour picture can be likewise obtained by similar double printing with materials 2, 4, 5, 6 and 7.

In the case of materials 3, 8, 9, 10, 11, 12 and 13, the false three colour record obtained by the first positive colour processing can be printed with white light on the same material and after positive colour processing a natural colour picture results, i.e. with these materials a natural colour picture is obtained by a single printing. In material 3 the subtractive colour record constituted by the bottom (initially red sensitized layer) which is initially coloured minus green must be converted to minus red in the processing.

A number of examples will now be given and in considering these 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 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.

A. Two-step printing.

Material 1.

Unexposed Layers.	Exposed and colour processed layers. (False three colour record).	Printed and colour processed layers. First Printing. (False three colour record).	Printed and colour processed layers. Second Printing. (True three colour record).
Blue sensitive. Essentially uncoloured.	Comprises record of blue original light component coloured minus red. (False colour record).	Comprises record of green original light component coloured minus red. (False colour record).	Comprises record of red original light component coloured minus red. (True colour record).
	(Images print with red component of printing light).		
Green sensitive. Coloured yellow (minus blue).	Comprises record of green original light component coloured minus blue. (False colour record).	Comprises record of red original light component coloured minus blue. (False colour record).	Comprises record of blue original light component coloured minus blue. (True colour record).
	(Images print with blue component of printing light).		
Red sensitive. Coloured magenta (minus green).	Comprises record of red original light component coloured minus green. (False colour record).	Comprises record of blue original light component coloured minus green. (False colour record).	Comprises record of green original light component coloured minus green. (True colour record).
	(Images print with green component of printing light).		

Material 6.

Unexposed Layers.	Exposed and colour processed layers. (False three colour record).	Printed and colour processed layers. First Printing. (False three colour record).	Printed and colour processed layers. Second Printing. (True three colour record).
Blue sensitive. Essentially uncoloured.	Comprises record of blue original light component coloured minus green. (False colour record).	Comprises record of red original light component coloured minus green. (False colour record).	Comprises record of green original light component coloured minus green. (True colour record).
	(Images print with green component of printing light).		
Green sensitive. Essentially uncoloured.	Comprises record of green original light component minus red. (False colour record).	Comprises record of blue original light component coloured minus red. (False colour record).	Comprises record of red original light component coloured minus red. (True colour record).
	(Images print with red component of printing light).		

A. Two Step Printing.

Material 6.—continued.

Red sensitive. Essentially uncoloured.	Comprises record of red original light component coloured minus blue. (False colour record).	Comprises record of green original light component coloured minus blue. (False colour record).	Comprises record of blue original light component coloured minus blue. (True colour record).
	(Images print with blue component of printing light).		

B. One Step Printing.

Material 3.		Material 3.	
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 green. (Image prints with green component of printing light). (False colour record).	As before.	Comprises record of green original light component coloured minus green. (True colour record).
Green sensitive. Coloured yellow (minus blue).	Comprises record of green original light component coloured minus blue. (Image prints with blue component of printing light). (False colour record).	As before.	Comprises record of blue original light component coloured minus blue. (True colour record).
Red sensitive. Coloured magenta. (minus green).	Comprises record of red original light component coloured minus red by colour change. (Image prints with red component of printing light). (True colour record).	As before.	Comprises record of red original light component coloured minus red by colour change. (True colour record).

Material 9.		Material 9.	
Unexposed layers.	Exposed and colour processed layers. (False three colour record).	Unexposed layers.	Printed and colour processed layers. (True three colour record).

B. One Step Printing.

Material 9.—continued.

Blue sensitive. Essentially uncoloured.	Comprises record of blue original light component coloured minus red. (Image prints with red component of printing light). (False colour record).	As before.	Comprises record of red original light component coloured minus red. (True colour record).
Green sensitive. Essentially uncoloured.	Comprises record of green original light component coloured minus green. (Image prints with green component of printing light). (True colour record).	As before.	Comprises record of green original light component coloured minus green. (True colour record).
Red sensitive. Essentially uncoloured.	Comprises record of red original light component coloured minus blue. (Image prints with blue component of printing light). (False colour record).	As before.	Comprises record of blue original light component coloured minus blue. (True colour record).

In those cases in which the same material is employed for exposure and printing and 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.

In practice it is preferred to use positive processing.

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 or 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 20th day of February, 1936.
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 and sensitive elements 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 antihalation 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 or successively 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 hereinafter).

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." 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 e.g. 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. 441,198 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 opaque 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.

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

COLOUR SUPPRESSION.

A process for producing coloured images in which a photographic emulsion layer is uniformly coloured by a colouring matter which is adapted to be de-colourised and/or removed selectively in either the exposed or unexposed portions, e.g. by bleaching out the colour in the exposed area with the catalytic aid of the silver produced by development of an image in silver salt.

COLOUR PRODUCTION.

A process for producing coloured images in which a photographic emulsion layer initially essentially uncoloured (i.e. either colourless or containing only colour which is substantially wholly removed in the processing operations) has a coloured image produced therein during subsequent processing e.g. by colour development, mordanting or imbibition. Such coloured

image may be produced by dyeing the layer uniformly after exposure and then subjecting it to colour suppression.

NEGATIVE PROCESSING.

Operations performed upon photographic emulsion layers containing light images whereby greatest opacity is produced in the areas most affected by the light.

POSITIVE PROCESSING.

Operations performed upon photographic 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 photographic 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 and 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 record of any one primary colour exists in only one layer, 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 layers.

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 conformity 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.

The present invention is concerned with processes in which the printing materials and printed materials are of the same character by which is meant that the records in the layers of each element are processed to the same subtractive colours as those in the layers which were correspondingly sensitized in the other elements; that is to say the correspondence between the sensitization of each layer and the colour to which it is processed is the same in the printed and the printing materials. In these circumstances it has been found that if an element contains only two false colour records a true colour record is obtained by a single printing on material of the same character whereas if an element contains three false colour records, another false three colour record results from such single printing but a true three colour record can be obtained by a second printing, i.e. by printing the first print on to another element of the same character.

The single printing method, according to the present invention, of 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, therefore consists in processing the three colour records to three different subtractive colours, two only of them being processed

to false colour records, then printing the resulting false colour record on to a sensitive photographic printing element of the type described and processing the three printed records to three different subtractive colours, the two printed from the false colour records being each processed to the colour complementary to the sensitivity of the layer containing the other. In the first element the blue colour record may be processed to minus green, the green colour record to minus blue and the red colour record to minus red or the blue colour record may be processed to minus red, the green colour record to minus green and the red colour to minus blue.

The double printing method according to the invention, of 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 record to minus red, the green colour record to minus blue and the red colour record to minus green, then printing the resulting false three colour record on to a sensitive photographic printing element of the type described, 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 finally printing the resulting false three colour record on to another sensitive photographic printing element of the type described and colour processing it in the same manner. In this form of the invention in which double printing is employed, in all three elements minus red may be replaced by minus green, minus blue by minus red and minus green by minus blue.

According to a further feature of the present invention there is provided a photographic element for use in the carrying out the method of the invention or of that of Application No. 475,784, which is of the type described and in which the layer first hit by incident light is sensitive 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, which is characterized is that the colour to be suppressed in the layer next beyond the blue sensitive one is yellow (minus blue) and in that there is an additional 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. The selectively colour sensitized layers may all be coated on one side of the support or one may be on one side and two on the other. 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.

We are aware that in Specification No. 483,463 there is described and claimed (1) a light sensitive multi-layer material, more particularly a recording material for taking multi-colour pictures, comprising a front layer which is colourless and blue sensitive, a second layer which is dyed yellow and sensitized either to green or to red and a third layer coloured with a colour which absorbs those light rays for which the second layer is sensitized, the third layer being sensitized to red or to green respectively and all the layers being carried on one or both sides of a single support, (2) a process of producing a multi-colour image which consists in effecting exposure on a multi-layer light-sensitive material comprising a front layer which is colourless and blue sensitive, a second layer which is dyed yellow and sensitized either to green or to red, and a third layer coloured with a colour which absorbs those light rays for which the second layer is sensitized, the third layer being sensitized to red or to green respectively, all the layers being carried on one or both sides of a single support, and transforming the material after exposure into a three-colour image by local destruction of the dyestuff in the pre-dyed layers and by the formation of a dyestuff image in the uncoloured front layer.

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, the 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	Minus Red
	Convertible to 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	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 charcater 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 pic-

tures can be obtained by suitable printing methods of which the following are examples:—

An element composed of material 1 (character A) after exposure to a natural colour object and positive colour processing is a false three colour record. When this false three colour record is printed with white light (or the primary components thereof) on the same material, the print after positive colour processing is a false three colour record different in appearance from the printing element. This print is then printed again on the same material with white light or the primary components thereof and after positive colour processing a natural colour picture results.

A natural colour picture can be likewise obtained by similar double printing with materials 4 and 7 (character A) or 2, 5 and 6 (character B).

In the case of materials 3, 8 and 11 (character C), 9 and 10 (character D) and 12 and 13 (character E), the false three colour record obtained by the first positive colour processing can be printed with white light or the primary components thereof on the same material and after positive colour processing a natural colour picture results, i.e. with these materials a natural colour picture is obtained by a single printing. In material 3 the subtractive colour record constituted by the bottom (initially red sensitized layer) which is initially coloured minus green must be converted to minus red in the processing.

A number of examples will now be described with reference to the accompanying diagrammatic drawings in which Figures 1, 5, 9 and 12 represent a natural colour object to be photographed, placed in association with three-layer exposure elements represented by Figures 2, 6, 10 and 13 respectively. Three-layer first printing elements represented by Figures 3, 7, 11 and 14 are shown placed in association with the respective exposure elements and three-layer second printing elements represented by Figures 4 and 8 are shown placed in association respectively with the three-layer first printing elements represented by Figures 3 and 7.

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, before operation 3 but preferably after operation 2, so that a reversed dye image is formed in this upper layer in operation 3 simultaneously with the formation of the reversed dye image in the lower layers.

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).

A suitable blue green dye is Diphenyl Fast Blue-Green B L (Geigy Co. United States Patent No. 1,829,673) which can be introduced into the layer by bathing it in a solution of the dye slightly acidified with acetic acid. Another dye which may be employed is Niagara Blue G (Schultz Farbstofftabellen No. 497) if the bathing is followed by treatment with a dilute solution of pyridine which improves the colour. Another suitable dye is Niagara Sky Blue (Schultz Farbstofftabellen No. 513).

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 in either the areas where the silver is present or where the silver is absent, is believed to be novel, and enables an initially uncoloured layer to be processed by colour suppression.

(b) In operation 4, a bleaching agent is used which simultaneously bleaches the silver to a soluble silver salt and 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.

A bleach of this type may have the following composition:—

Potassium bichromate	3.25	grams.
Acetic acid (glacial)	20.	cc.
Potassium alum - -	10	grams.
Potassium ferricyanide	9.5	grams.
Potassium bromide -	6.9	grams.
Water to - - -	1	litre.

However, after Step 5 when this method is used there will be dye images in the two layers only. The washed and preferably well-dried material is then treated with a dye having the property of dyeing the unhardened gelatine more rapidly than the hardened gelatine. By this means a reversed dye image is introduced into the top layer also. The depth of this final dyeing may be governed visually in order that the density of the third dye image may balance that of the first two. This may be done by controlling the length of time for which the film is submitted to the dye solution. A dye image of this type for use in material 1 is produced with Alizarine Uranol BB (Schultz Farbstofftabellen, No. 1209) used in a 2% solution at 110° F. or Alizarine Celestol B (Colour Index No. 1075) used in a 2% solution at 110° F.

Anothed method is to introduce a leuco base, or dye components, into the top layer, from which the dye may be formed. For example the leuco compound formed by the reduction of Indanthrene Blue SG may be introduced into material 1 after developing and fixing by bathing the film in a solution of the leuco compound. This may be oxidized to the dye with a solution of sodium perborate and a bleached dye image subsequently formed by bleaching in the regions of the silver with alkaline stannous chloride. No claim is made herein to such bleaching of a vat dye with alkaline stannous chloride.

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. Such a dye may be made by diazotizing and coupling 2:4-dinitroaniline or 2-bromo-4-nitroaniline with metaphenylene diamine, meta-cresidine or meta-anisidine in acid solution. The dye, which is insoluble in neutral or dilute acid solution, can be prepared in a colloidal dispersed form in the gelatine. To change its colour from magenta to blue green, it can be diazotized in the gelatine by a cold hydrochloric acid solution containing nitrous acid and coupled with 1-amino-8-naphthol to give a blue-green dye. It is possible however, to employ a simpler method by using Niagara Blue G (Schultz Farbstofftabellen No. 497) 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. The conversion can therefore be effected by employing as the first fixing bath a solution of sodium thiosulphate containing pyridine. The composition of the fixing bath containing pyridine may be as follows:—

Sodium thiosulphate -	150	grams.
Pyridine - - -	5	cc.
Water to - - -	1	litre.

As already indicated, those elements in which the layers are substantially uncoloured can be conveniently processed by method 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.

In making the sensitive elements for use in the present invention, known sensitizers for the red and green sensitive layers may be employed. As a red sensitizer 8-methyl - 2:2^1 - diethyl-3:4:3^1:4^1-dibenzthio-carbocyanine bromide (see Specification No. 378,885) may be used. As a green sensitizer 1:2^1-diethyl-5:6-benzthio-pseudocyanide iodide (see Specification No. 385,267) may be used.

In those materials in which the middle layer is sensitive to red, for example material 2, there may be some difficulty in selecting a suitable sensitizer since most red sensitizers confer also a slight sensitivity in the green region. The difficulty may be overcome, however, by the use of one of those known infra-red sensitizers which sensitize also for the visual red without sensitizing for the green, such as 2:2^1 - diethyl - 5:6:5^1:6^1 - dibenzthiadicarbocyanine iodide. When using this this method for sensitizing the middle layer of a sensitive printing material, it is necessary either that the blue-green dye of the element to be printed does not transmit infra-red light or that if such blue-green dye does transmit infra-red, the

infra-red component of the printing light must be removed. This can be done with a filter, but since it is difficult to make a stable filter that will absorb infra-red without absorbing visual red it is considered better to bring about spectral dispersion of the printing light, then to block off the infra-red component of the beam and finally to recombine the visual components for the actual printing.

Another method for sensitizing the middle layer effectively for red light only, is to sensitize the emulsion for red in the ordinary way but to use for the green sensitive layer an emulsion which is much faster (for example, about 16 times) to green light than the emulsion which is sensitized to red. A sufficiently dense minus green filter may be then used in the printing or exposing beam to enable the green sensitive layer to be exposed or printed by green light without affecting the red-sensitive layer apreciably.

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), and 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.

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

Figs. 5, 6, 7, and 8 represent similar operations with elements of material 6. As before, Figs. 6 and 7 are false three-colour records of the object represented by Fig. 5 and Fig. 8 is a true three-colour record.

The foregoing represent two examples of producing a true-three-colour record by double printing on the same material.

Fig. 10 shows the colours produced in an element of material 3 or 8 after exposure to a coloured object represented by Fig. 9, Fig. 11 shows the colours produced in another element of material 3 or 8 after being printed from the coloured element of Fig. 10. Fig. 10 is a false three-colour record and Fig. 11 is a true three-colour record.

Figs. 12, 13 and 14 represent similar operations with elements of material 9.

These are examples of producing a true three-colour record by single printing on the same material.

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.

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 three colour records of the object, which consists in processing the three colour records to three different subtractive colours, two only of them being processed to false colour records, then printing the resulting false colour record on to a sensitive photographic printing element of the type described and processing the three printed records to three different subtractive colours, the two printed from the false colour records, being each processed to the colour complementary to the sensitivity of the layer containing the other.

2. The method of obtaining a subtractive true three colour record from a false three colour record in which two only of the records are false colour records which consists in printing the false three colour record on to a sensitive photographic element of the type described and processing the three printed records to three different subtractive colours, those printed from the false colour records being each processed to the colour complementary to the sensitivity of the layer containing the other.

3. The method as claimed in claim 1 or 2, in which in the first element the blue colour record is processed to minus green, the green colour record to minus blue and the red colour record to minus red.

4. The method as claimed in claim 1 or 2, in which in the first element the blue colour record is processed to minus red, the green colour record to minus green and the red colour record to minus blue.

5. The method of 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, which 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, then printing the resulting false three-colour record on to a sensitive photographic printing element of the type described 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 finally printing the resulting false three colour record on to another sensitive photographic printing element of the type described and colour processing it in the same manner.

6. The method of obtaining a subtractive true three colour record from a false three colour record in which the blue colour record has been processed minus red, the green colour record has been processed minus blue and the red colour record has been processed minus green which consists in printing the false three colour record on to a sensitive photographic printing element of the type described, processing the printed element to another false three colour record printing this false three colour record on to another sensitive photographic printing element of the type described and processing this to a true three colour record by processing the record in the blue sensitive layer of each of the printing elements to minus red, the record in the green sensitive layer of each of the elements to minus blue and the record in the red sensitive layer of each of the elements to minus green.

7. A modification of the method as claimed in claim 5 or 6 according to which in all three elements, minus red is replaced by minus green, minus blue is replaced by minus red and minus green is replaced by minus blue.

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 as claimed in any of claims 1 to 7 in which two of the colour records in each element are produced by colour suppression.

12. A sensitive photographic element, especially a film, of the type described for use in carrying out the method claimed in any of the preceding claims or in any of claims 1 to 11 of Application No. 475,784 and in which the layer first hit by incident light is sensitive 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, characterised in that the colour to be suppressed in the layer next beyond the blue is yellow (minus blue) and in that there is an additional layer of pan-

chromatic emulsion dyed black situated furthest from the blue sensitive layer.

13. A sensitive photographic element as claimed in claim 12, in which all the layers are on the same side of the support.

14. A sensitive photographic element as claimed in Claim 12 or 13, in which the colour sensitized layer beneath the yellow layer is sensitized to green and coloured minus red.

15. A sensitive photographic element as claimed in Claim 12 or 13, in which the colour sensitized layer beneath the yellow layer is sensitized to red and coloured minus green.

16. A sensitive photographic element especially a film, of the type described and for use in carrying out the method claimed in any of claims 1 to 11 or in any of claims 1 to 11 of application No. 475,784 and in which the layer first hit by incident light is sensitive 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, characterized in that the colour to be suppressed in the layer next beyond the blue is yellow (minus blue), and that the colour sensitized layer beneath the yellow layer is sensiized to red and coloured minus green with a colour which is adapted to be changed to minus red during the colour processing.

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

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

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SENSITIVITY ↓ COLOUR →

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

Fig. 1.

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. 2.

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. 3.

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. 4.

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

Fig. 5.

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

Fig. 6.

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

Fig. 7.

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

Fig. 8.

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

Fig. 9.

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

Fig. 10.

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

Fig. 11.

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

Fig. 12.

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

Fig. 13.

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

Fig. 14.

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