[Third Edition.]

PATENT SPECIFICATION

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PROVISIONAL SPECIFICATION.

Improvements relating to Colour Photography and the like.

I, ARON HAMBURGER, of 51, Warwick Street, Regent Street, London, W. 1, a citizen of the United States of America, do hereby declare the nature of this invention to be as follows:—

This invention relates to the production by photographic methods of pictures in colour by dye toning, whether for direct observation or projection.

This invention consists broadly in fractionally and successively dyeing positives or negatives representing component colour values so as to produce colour pictures for direct observation or projection.

The invention in brief consists in applying to an emulsion containing a developer and fixed positive or negative image a combination of dyes of different colours, these dyes being so chosen that on subsequent treatment of the film by washing or treatment in a weak solution of a reducing agent, such as 1% potassium or sodium meta-bisulphite, they will be retained in the film in accordance with the gradations of light and shade and yield colours due to the dye components substantially individually and to a certain extent in addition due to the blending of the colours of the components.

In carrying this invention into effect as applied to the production of kinematograph film for projection in colours, I prepare negatives representing the component colour values so that these component colour values are represented in the image which is to be dyed by a density which will vary with the colour value of each component colour in the object photographed, either by the use of one or more panchromatic emulsions with the usual colour filters, or by employing a suitably sensitised emulsion for each colour group.

I then print from such negatives, positives either (*a*) on opposite sides of a film which is coated on both sides with light sensitive emulsion; or (*b*) on separate sensitised bases which may be superposed or transferred on each other, either before or after dyeing.

For instance, in dyeing positives printed on both sides of a double coated sensitive film, I commence by dyeing the side representing the yellow and red components of the picture. I do this by evenly coating the surface with yellow dye of a strength which will on subsequent bleaching represent approximately the amount of pure yellow required to represent the yellow value of the negative from which it was printed. This is only part of the yellow which the image as a whole could take up; hence, I call this fractional dyeing. I dye the other side which represents the green and blue components of the picture with a green dye similarly adjusted in strength to the green value of the negative from which it was printed. The double coated film is then re-dyed as to the side already yellow with a suitable red dye and as to the side already green with a suitable blue dye. After the whole of the dye has been applied the double coated and dyed film is immersed in a suitable bleaching liquor. The second dye coatings should be sufficiently concentrated to yield on subsequent bleaching fully dyed images.

The result of such treatment is as follows:—

On the red-yellow side are obtained all the gradations from pure yellow, through orange, to deep red, in relation to the varying density of the dyed silver image. On the green-blue side are likewise obtained all the gradations from pure green, through blue green, to deep blue.

When the bleached image is treated with a suitable yellow or light green dye

the parts corresponding to the lightest portion of the original silver image appear to become saturated with the dye. They therefore do not absorb further dye with the effect that applying the deeper colour dyes, namely, the red and blue or like dyes respectively, these are not absorbed in or held by the lighter portions but are readily removed by the subsequent treatment of the film in water or the like as indicated above. The result is that the lightest part of the silver image on either side which has been so made that it corresponds to the lightest shade is ultimately represented by one dye, the darkest portions corresponding to the deep colouration on either side substantially by one dye and intermediately the various gradations of colours and shades on each side by a combination of dyes. When two or more positives thus dyed are combined, each being dyed with two or more suitable dyes in appropriate proportions, substantially all the colour components of the object photographed may be secured.

The dyeing of the positive images as above described may be carried out after instead of before bleaching of the silver image by any suitable bleaching agent such as chromic acid, copper-ferricyanide, or a mixture of potassium ferricyanide, chromic acid and thio carbamide.

I prefer first to dye the positives with such dyes as for instance, acid yellow, followed by acid fuchsine as to one positive, and brilliant green and methylene blue as to the other side.

It is preferred to employ a bleaching solution in which the dyes are insoluble as I have found that with such dyes in the presence of a suitable bleaching agent stable dye salts appear to be formed with the silver images. All dye not so absorbed or fixed, that is, dye colouring the part of the film unacted on by light, becomes washed when soaked in water, thus leaving the "whites" clear.

Dated this 2nd day of July, 1923.

MARKS & CLERK.

COMPLETE SPECIFICATION.

Improvements relating to Colour Photography and the like.

I, ARON HAMBURGER, of 51, Warwick Street, Regent Street, London, W. 1, a citizen of the United States of America, do hereby declare the nature of this invention and in what manner the same is to be performed, to be particularly described and ascertained in and by the following statement:—

This invention relates to the production by photographic methods of pictures in colour by dye toning, whether for direct observation or projection.

The invention is applicable in connection with colour cinematography and for the production of colour transparencies, colour prints on a paper or other non-transparent base. It will herein be described mainly in connection with the production of colour cinematograph films for projection in the usual projector. At present the processes for producing cinematograph films in colours are very complex or the results are not entirely pleasing. As a means towards reducing the complexity of the problem two-colour processes of cinematography have been provided in recent years but in these the colour rendering is by no means akin to the colours of the originals from which the pictures have been made.

The object of the present invention is to provide an improved process which may be carried into effect in a very simple manner and give pictures pleasing in character with a wide range of colours and readily producible on an industrial basis.

To that end I have made a large number of experiments and have found that by the selection of suitable dyestuffs I can produce pictures in colour having the advantages referred to above.

Mixtures of dyes have heretofore been proposed for the colouring of photographic silver positives, the silver being suitably removed, but as far as I am aware no process has been disclosed wherein separation of simultaneously or successively applied dye mixtures by subsequent treatment is obtained, that is to say, wherein the result is a gradation substantially from one colour of the dyes employed to the other. Indeed in some prior proposals mixtures of reacting dyes or successively applied dyes such as acid and alkaline or basic colours have been suggested which could not possibly be separated.

The invention in brief consists in applying to an emulsion containing a developed and fixed positive or negative image and either containing silver or having been freed from silver, a combination of dyes of different colours simul-

taneously or successively, these dyes being so chosen that on subsequent treatment of the film by washing or treatment in a weak solution of a reducing agent, such as 1% potassium or sodium meta-bisulphite, they will be retained in the film in accordance with the gradations of light and shade and yield colours due to the dye components substantially individually and to a certain extent in addition due to the blending of the colours of the components.

In carrying this invention into effect in one form by way of example applied as an illustration to the production of cinematograph film for projection in colours, I prepare two negatives approximately representing the component complementary colour values so that these component colour values are represented in the image which is to be dyed by a density, which will vary with the colour value of each component colour in the object photographed.

According to one method I employ two silver emulsion films (*a*) and (*b*), one, the (*a*) film, sensitised principally to green and blue-violet colours by erythrosine, and the other or (*b*) film sensitised principally to red, orange and yellow by bathing in a solution of pinacyanol. The (*a*) film may be exposed without a light filter and the (*b*) film exposed through a tricolour red or red-orange filter. The negatives after developing, fixing, washing and drying in the usual manner are printed on to films to form positives. I prefer to print them on to opposite sides of a film coated on both sides with light sensitive emulsion.

The completed positive is then dye coated by applying a mixture of two or more dyes to each of the emulsions forming the two images one on each side of the film.—

To the side of the film corresponding to the (*a*) negative I apply, for example, a mixture of rhodamine B and auramine in equal parts of 3% solutions, such solutions having been well mixed together. To the other side of the film, namely, that corresponding to the (*b*) negative I apply, for example, a mixture of malachite green (containing a small amount say 5%, of xylene red) and brilliant green in equal parts of 3% solutions. These mixtures are conveniently applied in any suitable coating machine and the film is then allowed to stand for a few moments so that they set to a certain extent. It is then immersed in a bleaching liquor formed for example of a mixture of equal parts of 1% solutions of pure chromic acid and pure potassium ferricyanide to which $^1/_{10}$th part of a 2% solution of thiocarbamide may be added. It remains in this bath for a few minutes until the silver has been thoroughly bleached. The subsequent treatment comprises washing or treatment in a weak solution of a reducing agent, such as 1% potassium or sodium meta-bisulphite and on removal therefrom is washed until the high lights or parts not substantially acted on by light are sufficiently clear. Bleaching may precede dye coating.

It will then be found that in the case of the series of pictures which have received the mixture of red and yellow dyes the result in colour is a pleasing gradation from red to yellow in the colour of the dyed image in the part corresponding to the bleached silver image corresponding with the density of the original silver image so that the darker portions of the picture approach a dark red, while the lighter portions are approximately yellow, the dyes being discharged from the portion of each image corresponding to the high lights or parts not substantially acted on by light leaving clear unstained whites. A similar action occurs on the other side of the film, the process resulting in emphasis of blue in the darker parts and a greenish colouration in the lighter parts.

As a whole therefore the double-coated film gives approximately the effect of a four-colour process, or more accurately, a five-colour process when proceeding on the lines given above because the bleached silver image of itself acts to give a ground work or greyish key varying in intensity according to the lights and shades of the object photographed.

The above dyes work well but other suitable dyes may be employed and it is a simple matter to test any particular dye mixtures because when applied to a film and treated as described above if on washing the lighter portions are coloured substantially to the colour of one dye and the shadows substantially to the colour of the other with gradations between they are suitable but it does not necessarily follow that the result will be so pleasing as with the dyes I have mentioned.

This gives a convenient method therefore of ascertaining whether any other dyes that it is desired to use are suitable for the process or not.

As regards the amount of dye applied to coat the surface the quantity of say the yellow dye should be such that it will on subsequent bleaching of the silver represent approximately the amount of pure yellow required to represent the yellow value of the negative from which it was printed.

Similarly the dye on the other side

which represents the green and blue components of the picture is adjusted in strength to the green and blue values of the negative from which it was printed.

According to a modified process instead of applying mixtures of the dyes to each side I first apply one dye, say, of each pair of dyes, and then apply the remaining dyes. Thus, the double coated film may be dyed as to the appropriate side first yellow and then re-dyed with a suitable red dye, the other side of the film first being dyed say green and then re-dyed with a suitable blue dye.

The second dye coatings should be sufficiently concentrated to yield on subsequent bleaching fully dyed images, bleaching not being effected until all dyeing has been completed; the strength of both dye solutions and the strength of the bleach should be adjusted so that the bleaching and dyeing of the image take place practically simultaneously.

When the bleached image is treated with a suitable yellow or light green dye the parts corresponding to the lightest portion of the original silver image appear to become saturated with the dye, They therefore do not absorb further dye with the effect that applying the deeper colour dyes, namely, the red and blue or like dyes respectively, these are not absorbed in or held by the lighter portions but are readily removed by the subsequent treatment of the film in water or the like as indicated above. The result is that the lightest part of the silver image on either side which has been so made that it corresponds to the lightest shade is ultimately represented by one dye, the darkest portions corresponding to the deep colouration on either side substantially by one dye and intermediately the various gradations of colours and shades on each side by a combination of dyes. When two or more positives thus dyed are combined each being dyed with two or more suitable dyes in appropriate proportions substantially all the colour components of the object photographed may be secured.

The dyeing of the positive images as above described may be carried out after instead of during bleaching by the use of suitable dye mixtures, for example, auramine and basic magenta for the (*a*) film and brilliant green and methylene blue for the (*b*) film.

The whole of the silver may be removed from the image before dye coating leaving only gelatine in various degrees of hardness as is well known. As an example of suitable dyes for use in such cases where the silver has been completely removed I find the following mixtures to work well, namely, a mixture composed of acid yellow and acid magenta mixed in equal parts of about 2% strength solutions and a mixture formed from acid violet and azo blue of a strength similar to the former.

If it is desired to use only two colours instead of four for the purpose of obtaining in an easier cheap manner colour representations of limited range or for use, for example, in connection with the title parts of a cinematograph film this may be effected by employing a positive film coated on one side only and applying the two suitable colours thereto.

In place of employing a film coated on both sides separate sensitised bases may be used which are superposed or transferred on to the same support or otherwise sufficiently accurately registered either before or after dyeing. Instead of using special colour sensitised films for the preparation of the negatives commercial panchromatic emulsions may be employed with the appropriate colour filter. Also any other suitable colour sensitisers than those mentioned above may be used.

In place of the bleaching bath described any other suitable bleaching solution may be used.

It is preferred to employ a bleaching solution in which the dyes are insoluble as I have found that with such dyes in the presence of a suitable bleaching agent stable dye salts appear to be formed with the silver images. All dye not so absorbed or fixed, that is, dye colouring the part of the film unacted on by light, becomes washed when soaked in water, thus leaving the " whites " clear.

In place of positives, negatives prepared by removing the silver from a negative image will give a substantially similar effect by the use of appropriate dyes, for example, those of the pinatype series.

Having now particularly described and ascertained the nature of my said invention and in what manner the same is to be performed, I declare that what I claim is:—

1. A method of producing photographs in colour which consists in applying to an emulsion containing a developed and fixed positive or negative image and either containing silver or having been freed from silver, a combination of dyes of different colours simultaneously or successively, these dyes being so chosen that on subsequent treatment of the films by washing or treatment in a weak solution of a reducing agent, such as 1% potassium or sodium meta-bisulphite, they will be retained in the film in

accordance with the gradations of light and shade and yield colours due to the dye components substantially individually and to a certain extent in addition due to the blending of the colours of the components.

2. A process as claimed in Claim 1 in which two emulsions, each containing a developed and fixed positive or negative silver image, and four or more dyes are employed, for example, a mixture of red and yellow dyes for treating one emulsion and a mixture of green and blue dyes for treating the second emulsion.

3. A process as claimed in Claim 2 in which the yellow and red dyes are formed from auramine and rhodamine B respectively and the green and blue dyes from brilliant green and malachite green containing a small proportion of xylene red.

4. A process as claimed in Claim 1, in which two emulsions, each containing a developed and fixed positive or negative image which has been freed from silver and four or more dyes are employed in which for one emulsion the dyes comprise acid yellow and acid magenta and for the other a mixture of crystal violet and azo blue.

5. Processes for the production of photographs in colours substantially as herein described.

6. Colour photographs when prepared by the processes described and claimed herein or by their obvious chemical equivalents.

Dated this 6th day of December, 1922.

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