[Second Edition.]

PATENT SPECIFICATION

Application Date: Feb. 8, 1926. No. 3525/26. 263,331

Complete Accepted: Dec. 30, 1926.

COMPLETE SPECIFICATION.

Improvements in or relating to Photography.

We, TECHNICOLOR MOTION PICTURE CORPORATION, a corporation organised under the laws of the State of Maine, United States of America, of 120, Brookline Avenue, Boston, Massachusetts, United States of America, and EASTMAN ATKINS WEAVER, a citizen of the United States of America, of 80, Federal Street, Boston, aforesaid, 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 dye absorbent photographic images which may be used in a projecting machine for displaying pictures on a screen or as printing matrices in reproduction by imbibition. The gelatine coating or other medium containing the images may be caused to absorb dye in accordance with the image distribution in any suitable way, as for example, by differentially hardening the gelatine so that either the image portions or the non-image portions are more absorptive, but preferably the non-image (or image) portions are etched off leaving a film of the well-known relief type. It has been developed for use in producing motion pictures in colors but it is also applicable in producing black-and-white motion pictures or in producing still pictures whether black-and-white or colored. In the production of color pictures the invention may be utilized either in an additive process, for example, in which the complemental images are separately projected along a branched path into registry on a screen, or in a subtractive process, for example, in which the complemental images are superposed in registry and projected along a single optical path.

In many branches of the art of photography difficulty has been experienced in securing the proper contrast throughout the high-light, half-tone and shadow regions respectively. In some cases the contrast is unsatisfactory only in the high-light regions or only in the shadow regions, but in few cases can satisfactory gradations (that is, variations in optical density relative to the variation of light intensity throughout corresponding portions of the object field) be secured throughout all three regions, especially in the various color processes employing stained reliefs.

This difficulty is particularly pronounced in dyed image and relief processes where the most striking defect in the appearance of the pictures is the excessive difference or contrast between light and intermediate values as compared with the difference between intermediate and dark values. This is accompanied by an excessive degree of "lost detail" (which in ordinary silver pictures is produced in mild degree by insufficient exposure); and ordinarily the lightest areas of the pictures have no detail whatsoever, merely consisting of clear celluloid. When producing positive reliefs by printing from negatives, for example, if the printing is increased to record this high-light detail, the intermediate values become still more excessively dark; and if in turn this is relieved by decreasing contrast, the deep shadows of the pictures become gray or brown. In other words, if the printing and contrast are such as to produce satisfactory detail in the high-lights and good black shadows, half-tones such as faces are too dark.

In imbibition processes for example, where stained relief matrices are employed to transfer images in colors upon a blank film or films, a fundamental defect is improper contrast gradations throughout the light, intermediate and dark values of the pictures. Causes contributing to this are the following:

First, practically all the dye from the thin portions of the relief migrates into the blank while increasing proportions of the dye are retained as the relief increases in thickness or depth. Secondly, the time required for migration of the dye from deep layers will be longer than that for thin layers, and as a commercial process requires the time of imbibition to be reduced to a minimum the deepest densities suffer somewhat from this cause. Thirdly, owing to the non-uniform spectral absorption of ordinary dyes successive additions of equal quantities of dye produce a continually decreasing series of effects on the color, since the portion of the spectrum most heavily absorbed by the dye will be largely filtered out by the earlier portions, so that the residual light is less subject to modification by the later strata. This corresponds to the well-known phenomenon experienced in using two identical color filters over a photographic lens, the second filter producing much less change in exposure than the first.

Another process in which certain of the aforesaid causes also operate against proper contrast gradations is that in which a plurality of stained complemental relief images are superposed and viewed with transmitted light.

A principal difficulty encountered in making photographic reproductions by means of gelatine reliefs is the tendency toward straightness of the characteristic curve, commonly called the H & D curve. In the typical curve for silver images the lower portion of the curve representing the under-exposure is concave upwardly, the intermediate position representing the average exposure is straight, and the upper portion representing the over-exposure is convex upwardly. In the relief curve the first and third portions tend to drop out, particularly when monochromatic light is employed in the exposure or in case the absorbing power of the emulsion is substantially uniform for all component colors of light employed in the exposure. The loss of the under exposure region in prior processes has rendered the use of relief images unsatisfactory.

Objects of the present invention are to correct defects in the contrast gradations of photographic images, particularly relief images for use in color photography, to control the contrast gradations at will to produce desired photographic and artistic effects, to increase the concavity of the characteristic curve in the lower portion ordinarily referred to as the under-exposure region, and to reduce the required image exposure in making relief pictures.

The present invention consists in exposing the film with light so distributed as to produce an image, as for example by contact printing, and also with uniformly distributed light having the effect of altering the contrast gradations of the picture or of reducing the required image exposure or both. For convenience we shall refer to the first as the image exposure and the second as the contrast exposure although the two exposures may be effected simultaneously as a single exposure and the contrast exposure may also be an image exposure as will hereinafter appear.

The contrast exposure may be made either before or after the image exposure as for example by running the film through a printer having a light of predetermined intensity and quality. When exposed to the contrast light (or otherwise treated to afford an equivalent effect) before being exposed to the image light, the film may be said to be a pre-exposed film. Instead of making the contrast exposure before or after the image exposure it may be made simultaneously with the image exposure, as for example in projection printing by simultaneously projecting the image light and the contrast light to the film along separate optical paths. Indeed, in printing, either by projection or by contact, both lights may pass through the printing image if the contrast light is absorbed less than the other light as would be the case, for example, if the printing image is a relief dyed with different dyes so as to absorb differently colored lights and if such differently colored lights are employed for the image and contrast exposures respectively. In this case the printing image may be impressed more or less upon the contrast light as well as upon the image light.

If the effect of the contrast exposure according to the present invention is impressed upon the photographic film during the process of manufacture, the film may be exposed to produce an image in the same way as ordinary film, except that the exposure may be reduced as hereinafter described. The contrast exposure or pre-exposure herein referred to may be effected in ways other than by exposure to light as for example by exposure to the fumes of a chemical which produces a similar effect upon photographic emulsions as is well-known, or by heat, pressure, electricity, etc.

The intensity of the contrast light depends upon the effect to be produced

but ordinarily it should be an amount approximately, but preferably somewhat under, the threshold exposure, the threshold exposure for the production of relief images being the exposure which results in an infinitesimally thin film of gelatine after development, hardening and etching. The image exposure should be somewhat less than ordinarily employed, for example that amount which alone records substantially no detail in the high-lights but which, in conjunction with the contrast exposure, records detail in the extreme high-lights.

The invention further consists in using a film which is light absorptive and making the contrast exposure with light which is absorbed by the film, thereby to cause the contrast light to affect the film most on the entrant side (that is, the side through which the image light enters) where the high-light portions of the resulting relief are formed. In this connection it is to be noted that the two exposures should be made from the same side of the film, that is, either both from the emulsion side or both from the celluloid side of the film. This can best be done by employing monochromatic light of which the film is absorptive, that is light having only one color or dominant hue to which the film is sensitive. An effect similar to that produced by monochromatic light can be obtained with polychromatic light if the film has approximately uniform absorptivity for all the colors employed. If white light is used in the contrast exposure the film should absorb substantially all the spectral range to which it is sensitive.

The invention further consists in proportioning the image light and the contrast light to produce the predetermined contrast gradations desired; and, when using colored light of which the film is absorptive, of correlating the color of the light and the absorptivity of the film to control the contrast gradations.

The invention further consists in a relief image having more gradual thickness gradations (i.e. variations in relief thickness relative to variation in light intensity throughout corresponding portions of the object field) in the thinner portions than in the intermediate portions, and in a color relief image having more gradual optical-density gradations in the high-light portions than in the half-tone portions (relative to variations in light intensity throughout the corresponding portions of the object field). The effect of the invention is represented by a characteristic curve asymptotically approaching either the horizontal line of zero density, known as the exposure axis, or a line parallel thereto.

Referring to the accompanying drawing RT is a characteristic curve showing the thickness gradations of an ordinary relief image, OD is a characteristic curve showing the optical-density gradations of the same image when stained and RT^1 and OD^1 are similar curves illustrating the effect of the present invention, it being understood that the curves of each pair of relief-thickness and optical density curves are coincident throughout their intermediate and lower portions.

The lower portion of curve OD^1 which is upwardly concave and which approaches the line of zero density asymptotically, is known as the "under-exposure region", and it is the absence of this region in ordinary reliefs, as illustrated by the straight lower portion of curve OD, which characterizes the difficulties against which this invention is directed.

It should be here noted that notwithstanding that the straight-line curve OD may correspond to accurate physical reproduction of the object field (that is, it makes screen brightness proportional, neglecting color differences, to brightness in the object field) it is inferior for many purposes to the concave curve OD^1. For example, in producing motion pictures, the negative almost never receives adequate exposure to make use of only the straight-line portion of the curve, and the contrast sensibility of the dark-adapted eye in a motion picture theatre is such a rapidly varying function of the brightness that for accurate ocular or subjective reproduction of the original scene the straight-line curve is inadequate.

Another important disadvantage of the lack of the under-exposure region is the difficulty of printing correctly inasmuch as increase or decrease in printing exposure corresponds to translation to right or left respectively in the figure. With a straight-line curve such as OD, too much printing will carry the whites up to a considerable density whereas too little printing will carry the whites and possibly the light colors down to clear celluloid. With an asymptotic curve such as OD^1, on the other hand, variation in printing exposure is much less significant.

The concrete mode of procedure which we recommend in practising the present invention is as follows:

First dye the positive film with a pigment more or less strongly absorptive of the contrast light. Inasmuch as the present invention is preferably employed

in conjunction with that described and claimed in our copending Application (No. 3526/26, (263,650) filed on even date herewith), we preferably employ a dye which will serve both purposes. Examples of such dyes are naphthol-yellow and quinoline-yellow, or a mixture of these dyes, for example in equal amounts, as described in said application. The dye may be incorporated by bathing the film but is preferably incorporated in the emulsion before being coated on the celluloid. While the amount of dye may be much less than described in said application, the maximum amount which the emulsion will retain in non-crystalline form when employing said mixture, as described in said application, is satisfactory for most purposes. Film thus dyed is then exposed both with image light and also with contrast light.

In making color positives separate films may be printed respectively with complemental negatives representing different color aspects of the object field, one or both films also being exposed with contrast light of which the emulsion is absorptive, preferably to approximately the threshold exposure. When using yellow dyes such as above mentioned the contrast light is preferably violet, for example such as obtained with a Wratten D filter. The exposures are preferably effected by first running the positive film through a printer adapted to expose approximately to the threshold point with the contrast light, and then running both the positive and the negative films through the printer to print, with any suitable printing light, the images on the spaces previously exposed to the contrast light. When employing the invention disclosed in our aforesaid application the printing light employed in making the second exposure is polychromatic, as described in said application. If, for example, the finished product is to consist of a reddish-record direct-relief positive and a greenish-record direct-relief positive secured together back-to-back in registry, the two positives are exposed through the back (that is through the celluloid) both to the contrast light and to the image light, the films thus exposed being developed, hardened, etched and stained in any suitable way to produce colored reliefs. The positives may be secured together after completion but when securing them together back-to-back they are preferably joined together immediately after printing and before wetting in order to secure more accurate register of the complemental images.

If, for example, it is desired to give the finished picture a warm tint the contrast exposure of the reddish-colored positive may be carried somewhat beyond the threshold exposure.

The effect of the contrast exposure may be controlled by regulating the degree of the exposure, that represented by the lower concave portion of curve OD^1 being the effect produced by approximately a threshold exposure. If the contrast exposure is decreased the upper end of the concave portion joins the straight portion at a lower point and intersects the base line at an angle instead of being accurately asymptotic to it. If the contrast exposure is increased the concave portion asymptotically approaches a horizontal line located above the base line a distance depending upon the amount of exposure in excess of the threshold exposure.

The effect on the contrast gradations may be further controlled by regulating the absorptivity of the emulsion, either in degree or with respect to the color of the contrast light, by regulating the sensitivity of the emulsion to various colors, and by regulating the color of the contrast light.

The image light should be reduced as the contrast light is increased, the total light preferably producing approximately the same tone in the extreme high lights as is ordinarily produced in printing without any contrast light, thereby to obtain greatest clearness in the extreme high lights.

The increase in speed produced by the contrast exposure is represented in the figure by the space between curves OD and OD^1.

In the production of relief pictures the additional exposure herein described does not produce a veil over the picture unless employed in excess; indeed it has the opposite effect as if the negative had a fog or veil which is eliminated in reproducing according to the present invention.

An alternative method of making a relief image whose characteristic curve is upwardly concave at its lower end consists in exposing the emulsion with image light, to such extent that detail in the high lights is recorded in the resulting relief, staining the relief with a suitable dye, preferably substantially to saturation throughout, and subsequently washing the relief, for example, with an aqueous solution. We have found that the dye washes out in different proportions in the thick, intermediate and thin portions of the relief and that a greater proportion washes out of the portions of intermediate thick-

ness, that is a greater amount of dye washes out of the intermediate portions in proportion to the total amount contained in such portions than washes out of the thinner and thicker portions in proportion to the amounts contained therein respectively. The emulsion should be absorptive as above described but need not be so strongly absorptive. The dye washes out more or less rapidly depending upon the alkalinity or acidity of the wash solution, the rate being increased by increased alkalinity and decreased by increased acidity in case of acid dyes. The effect of the wash may therefore be controlled by varying the acidity or alkalinity of the solution; also by regulating the time of washing and the degree of agitation of the solution. This alternative method is more difficult to practice than the method involving a contrast exposure and does not give such good results, particularly as regards uniformity of color balance between the complemental images. However, for certain purposes a slight wash may be employed to advantage to supplement the contrast exposure method.

While the present invention is particularly applicable to relief processes it is obviously applicable wherever it is desirable to alter the characteristic curve, particularly by bending the lower portion of the curve.

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

1. A dye absorbent photographic image of the type formed photographically in sensitized emulsion to absorb dye in varying degree throughout its area depending upon the scene depicted, characterized in that the image has more gradual optical-density gradations in the high-light portions than in the half-tone portions, for the same range of light intensities in the scene, so that the detail of the scene may be accurately reproduced in the more highly reflecting and/or illuminated portions of the scene.

2. A dye absorbent photographic image according to Claim 1 further characterized by selective dye absorptive characteristics represented by a characteristic curve in which the lower portion is concave.

3. A dye absorbent photographic image according to Claim 1 further characterized in that the image is in the form of a relief having a stratum of uniform thickness in addition to the image strata.

4. A dye absorbent photographic image according to Claim 3 further characterized in that the image has more gradual thickness gradations in the thinner portion than in the thicker portions.

5. The method of forming a dye absorbent photographic image such as set forth in Claim 1 characterized by exposing the sensitized emulsion to uniformly distributed light, as well as to the image printing light, the uniform exposure having an intensity predetermined to produce an image whose optical-density gradations are represented by a characteristic curve in which the lower portion is located above a tangent to the central portion of the curve.

6. The method set forth in the preceding claim further characterized by underprinting the film with the image light.

7. The method set forth in either of the preceding claims further characterized in that the uniform exposure is made with light of a color which is rapidly absorbed by the emulsion.

8. The method set forth in any of the preceding method claims further characterized in that the uniform exposure is effected through the back of the film.

9. The method set forth in any of the preceding method claims further characterized in that the uniform exposure does not substantially exceed the threshold exposure for forming relief images.

Dated the 8th day of February, 1926.

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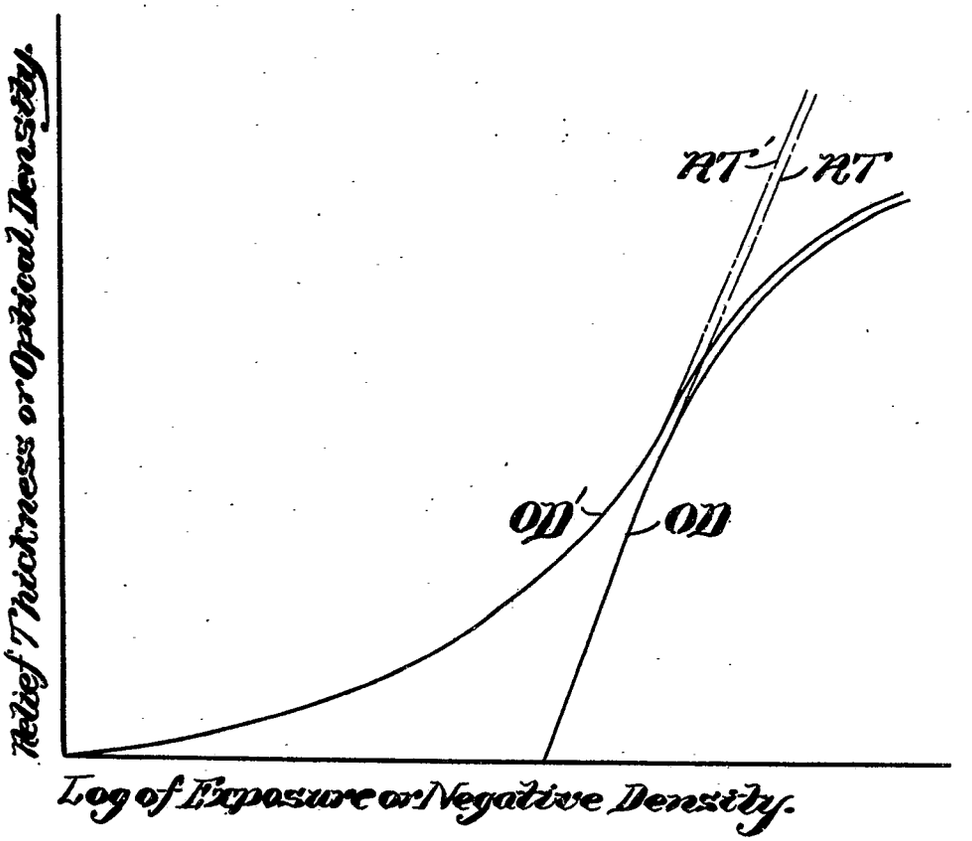
Chartered Patent Agents.

Abingdon: Printed for His Majesty's Stationery Office by Burgess & Son.
[Wt. 123A.—50/7/1931.

2nd Edition



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

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