May 19, 1942. F. G. YANES 2,283,715

METHOD AND PRODUCT OF TONE-AND-COLOR SYNTHESIS IN COLOR REPRODUCTION

Filed Jan. 3, 1940

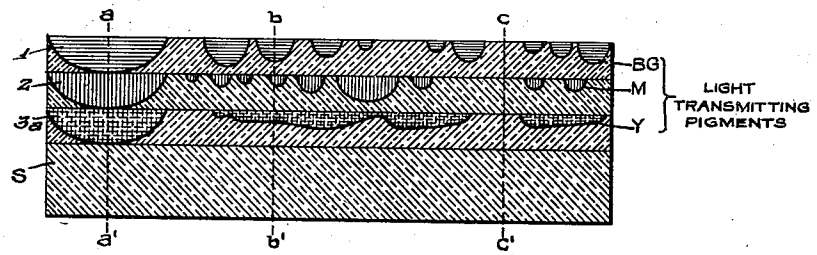


FIG. 1.

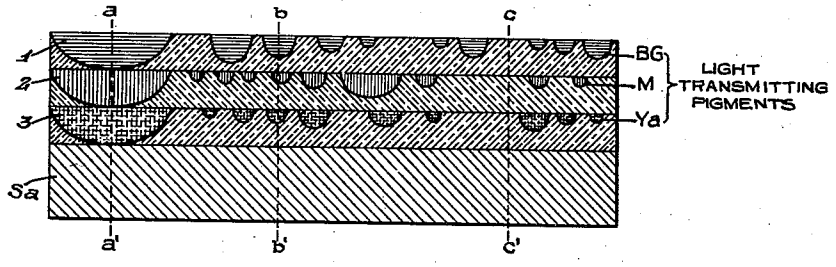


FIG. 2.

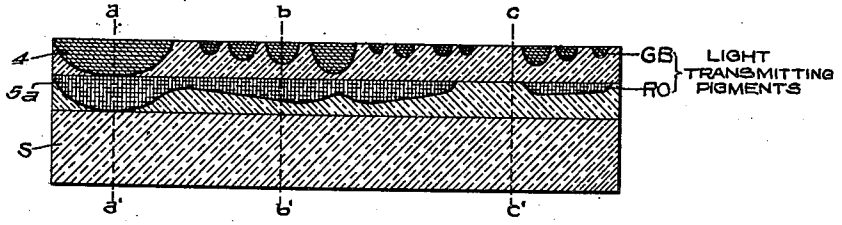


FIG. 3.

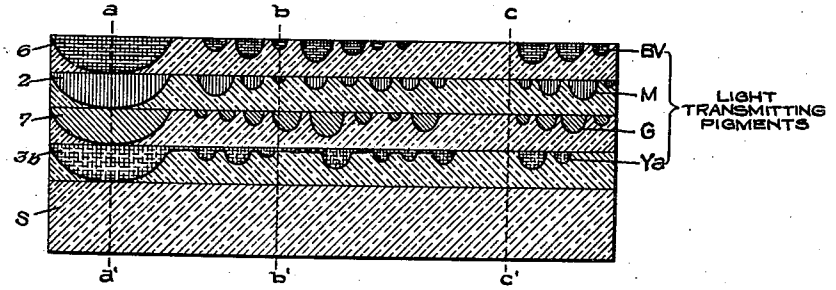


FIG. 4.

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Patented May 19, 1942

2,283,715

UNITED STATES PATENT OFFICE

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METHOD AND PRODUCT OF TONE-AND-COLOR SYNTHESIS IN COLOR REPRODUCTION

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Application January 3, 1940, Serial No. 312,307

6 Claims. (Cl. 95—2)

The present invention relates to a new method of color photography combining both the additive and subtractive synthesis for the reproduction of color and tone values, and also includes the new article of manufacture produced by said method.

The invention is based upon the same principle of the Method of tone-and-color synthesis described in my Patent No. 2,173,490, only that the elements for the dual synthesis are now arranged in a single picture space. In the first method two separate pictures of subtractive character are produced on two different areas and then additively combined by projection on the same space of a viewing screen. In the present invention the subtractive part of the synthesis is produced by superimposing or mixing in a picture area complementary pigments, while the additive effect is determined by extremely small elements distributed in juxta-position in corresponding sections of the same and single picture area.

Although the purpose of the invention may be achieved in different ways by combining known and more or less elaborate steps, we shall present as the simplest and preferred form a method which utilizes a fundamental subtractive synthesis, already furnishing solid heavy tones and clear uncolored whites, in combination with the improvement of adding a pointillist effect only in the middle-tones. Pictures of that quality are of unusual beauty and brightness.

It is well known that in subtractive pictures there is a loss of light resulting from the combined absorptions of pigments when color-part pictures are superposed or successively printed on a support. The result is dark and unpleasant unless the colors are too dilute, but then the general appearance of the picture is flat and degraded.

Additive pictures as mosaic plates show color particles in the whites, and no matter how slight the absorption of the colored elements might be, the mosaic-white is not comparable to a white area absorbing no light, especially in pictures to be examined by reflection. For that reason, and also because when enlarged the colored elements become too visible, the step has been adopted, when reproducing mosaic plates, of obliterating in different ways the mosaic effect in the whole picture and the result is a common subtractive one with all the drakness and unpleasantness already discussed.

According to a method proposed by us in application Serial No. 89,502, filed on July 8, 1936, for producing bright pictures on paper, the property of certain pigments was utilized which being opaque have the great reflecting power of color objects. Such pigments, though transmitting certain small amounts of light, would not easily combine their respective absorptions when superposed, and we suggested to produce the part-images for the synthesis by printing from ordinary color separation negatives while interposing a fine screen in the path of the printing light. In this manner the tones in the part-pictures were broken and permitted one image to show underneath another image thus producing a sort of pointillist effect additively complementing the synthesis.

In the application just referred to the possibility was contemplated of applying the same method to pictures to be examined by transmitted light or by projection on a screen if using, instead of nearly opaque, light transmitting pigments. In so doing, however, the results are not so pleasant as when the pigments are nearly opaque and the pictures to be examined by reflected light, because, when the pigments are transparent the slight additive effect in the heavy tones is more pronounced and produces certain degrading results in the shadows.

According to the present invention the additive effect is not produced in the heavy-tones, which remain substantially solid, nor in the whites which are clear, but only in the middle-tones which are the ones broken by the screening. Under such conditions the use of light transmitting pigments is completely satisfactory.

To practice the invention the scale of grays could be separately produced and the colors added afterwards. The part-pictures representing the colors would be broken in that case, and even could be broken by complemental screens known to the art in order that the color combinations in the middle-tones be purely additive. But such and similar operations, although practicable, cannot be compared with the simplicity of the preferred method of producing at once suitable part-pictures of broken middle-tones which when combined will subtractively produce solid shadows and colors brightened by an additive effect.

It has been proposed to combine in a color picture dotted part-images of the kind used in the half-tone process and having broken blacks and half-tones. Such type of images is unsuitable for the synthesis practiced in the present invention, first because the blacks are not solid, and second because the dots in the half-tone images have the same depth and different areas, thus

making the dotting and the values interdependent. In the example embodying the invention only photographic images are utilized, for in these images the values are produced in depth, independently of the tone-dividing and extremely fine screen. This can be adjusted to produce the desired effect of broken half-tones and solid blacks without substantially affecting the values of the picture, and without further resorting to retouching and additional operations.

In the example adopted to demonstrate the invention the part-pictures are contained in separate transparent layers assembled in register on a support, but obviously the same result may be obtained with dye-images printed on a single support and in many other known forms of the art in order to produce a picture having clear uncolored whites, solid heavy-tones and middle-tones showing, in juxta-position, an agglomeration of light transmitting particles of color matter. Such picture embodies the invention.

In the drawing:

Fig. 1 is a sectional view showing a tricolor form of the invention.

Fig. 2 is another tricolor form.

Fig. 3 is a bicolor form.

Fig. 4 is another form in four colors.

In all the figures of the drawing and for the purpose of demonstration the lines *a*—*a'*, *b*—*b'* and *c*—*c'* respectively indicate the heavy tones, the middle-tones and the uncolored whites of the different pictures. The letters BG, M, Y, etc., correspond to the different colors, all consisting of light transmitting pigments as specifically described in each figure. The letter S represents the support. And the numbers the differently colored layers. The character of the values in the combined part-images is shown in all of the figures by different thicknesses of light transmitting colored matter both in divided and undivided tones.

The examples presented in Fig. 1, and Fig. 2, pertain to similar tricolor pictures. One is illustrated as having a transparent support S and the other a whitish reflecting support S*a*, showing that the invention is both suitable for pictures to be examined by transmitted or by reflected light. The layers 1, 2 and 3 are blue-green, magenta and yellow part-pictures in which the heavy-tones on the line *a*—*a'* are solid, the whites on the line *c*—*c'* are clear and uncolored and the middle-tones on the line *b*—*b'* are broken in extremely small sections, grossly exaggerated, which permit the showing of an image through another. In Fig. 1, the part-picture in layer 3*a*, is a continuous-tone image colored by a light transmitting clear yellow pigment Y, while the part-picture in Fig. 2, layer 3 has broken middle-tones and is colored by a darker yellow pigment Y*a*. Such difference is purported to show that a yellow part-image need not be broken unless a dark yellow is used, for the usual yellows, even when concentrated, show a low color saturation and if broken in the middle-tones would appear degraded. As yellow pigments produce an additive combination of red and green lights, a certain amount of white is also present which makes the breaking of the image unsuitable. As to the position of this yellow part-image in regard to other part-images, when held in different layers, it does not matter when the pigments as in the present invention are not opaque but transparent ones; however, in some cases, and for pictures to be examined by reflected light, it may be combined in a suitable order consistent with the best color effect.

In the example of Fig. 3, the colors chosen for the synthesis are greenish-blue and red-orange as more suitable for bicolor pictures. But obviously several pairs of colors respectively from opposite side-ends of the spectrum could be combined. Again in this example one of the part-pictures in the layer 5*a* appears unbroken. As in the case of the yellow part-image in layer 3*a*, Fig. 1, the grade of saturation of the red-orange pigment in regard to that of the bluish-green one may advise this arrangement.

In Fig. 4, a four color picture is illustrated in which three of the layers carry part-images with clearly broken middle-tones and the layer 3*b* a part-image having middle-tones broken only by weakened areas. Although illustrated as example for one of the layers, the weakened areas may substitute the clear areas in two or more of the middle-tone broken part-images of a picture. In the course of the present disclosure it will be understood by broken middle-tones both the ones in which the minute sections are separated by clear areas and those in which sufficiently weakened areas are separating the minute sections as to permit the showing of a part-picture behind. In regard to the colors in Fig. 4 they may of course vary according to the analysis.

Outside of the essential feature of broken middle-tones in the part-pictures the invention may present different variations in regard to the support which may be transparent, opaque or translucent; also on account of the position of the part-images which may be distributed on the same or opposite sides of a support or carried on separate supports of the same or different kind to be later assembled; the part-pictures may besides be contained on superimposed layers, or held in a single layer; one or the two part-pictures illustrated as monochromatic may also show a succession of colors belonging to one end-side of the spectrum. In fact, the invention is not concerned with the kind, form or chromatic composition of the picture, but with the fundamental conditions of the synthesis by utilizing the subtractive and additive effect, respectively, in the reproduction of tone and color values upon the same single picture space. The additive part of the synthesis permits to use any set of complementary colors for the analysis and any corresponding set of complementary pigments in the chromatic composition of the picture.

The other part of the invention relates to the method of producing pictures as the ones illustrated in the examples. Again in this case the invention is not concerned with how the photographic color values are converted into light transmitting pigments by any possible process, but,—after such values are pigments—in how these pigments are combined in order that the subtractive and additive effect should respectively contribute to the formation of tones and colors. As explained before the shadows are formed by mixing or superposing pigments so as to combine their absorptions, while in the formation of the colors extremely small light transmitting particles of color matter will appear arranged in juxta-position. As to the whites they are produced by uncolored sections furnishing the possible maximum of light.

The breaking of the middle-tones in a part-image may be made in the color separation negatives, but such course is only suitable for contact work and would handicap the enlarging of the

picture. For that reason I prefer to produce first continuous-tone color separation negatives, and then I print from said negatives through screening means of suitable fineness in order to break the middle-tones in the positives. Such screening means may present different forms and can be separate or embodied with the sensitive material in which the picture is produced. A screen of fine texture and irregular pattern as those utilized in photogravure may be placed near or in contact with the printing plane of the emulsion, and, by regulating the exposure, the separation of the screen, the stop and distance of the printing light the screen effect may be made unnoticeable in the densest parts corresponding to the heavy-tones. A screen of this kind may be produced in a similar way as the dusting of copper plates for intaglio work. It is not necessary that such screen be of an opaque texture for translucent or semi-transparent particles will also facilitate the selective breaking of the middle-tones. For the purpose of the invention weakened areas attain the effect of the preferred clear areas separating the minute sections. The screen may also be produced on the printing side of the emulsion in the form of a very fine powder removable during or after the processing of the picture. The surface of the emulsion may also be printed or suitably embossed to determine different depths in the light effect. Even a translucent and finely divided light insensitive matter could be mixed with the emulsion or emulsions which would show a greater resistance to the light effect in the lighter tones. Whichever be the screening means the relative proportion between the silver grain of the emulsion and the fine grain of the pattern may be so chosen that by the mere effect of exposure the irradiation of the printing light will be sufficient to obliterate the screen effect in the shadows of the picture.

The fineness of the screening also contributes to make the small elements unnoticeable to the naked eye. For projection purposes the finest should be adopted. Otherwise and for the average sharpness of vision a screening corresponding to more than 250 lines to the inch is desirable. Coarser screening means should preferably be semi-transparent to dissimulate the separation of the small sections. Slight dye diffusion may equally contribute to that effect.

It is also necessary to have the screening means placed or distributed in such form for each part-picture that when combined the respective small sections will be out of register. The mere use of screening means of irregular distribution will be sufficient to produce that result, for the slightest displacement during the printing operations, will determine the lack of registration. In this manner while the combined part-pictures are in register the small sections of the respective broken middle-tones are not, for instead of that these will appear partly overlapping and partly in juxta-position.

In the form of the method presented as example, I first produce a set of continuous-tone color separation negatives; from these negatives I print the corresponding set of positives while interposing suitable screening means at or near the printing plane of the positive emulsion and, by adjusting the exposure, I produce the screening effect only in the middle-tones of the positives; at the same time I change for every print the position of the screening means so that the extremely small sections created in the middle-tones of one of the positives be out of register in regard to similar small sections in other broken positives. Then I color with light-transmitting pigments the part-pictures according to the subtractive method and combine in register the colored positives on a suitable support. The result is a picture having subtractive solid heavy-tones, additively combined bright colors, and pure uncolored whites. As to the middle and light-grays of the picture they are formed subtractively, for the minute sections partly overlap and partly are in juxta-position. Such grays also become brightened by the additive effect of the nonoverlapping areas and thus suitably match the brilliancy of the colors.

The improvement achieved by the invention is not a mere question of contrast for such expression would not correspond to a difference between color which is light and black which is no-light. It is rather a change of sign, if we may so express it, which causes values tending towards black to take an opposite direction in purity and brightness as a result of the additive part of the synthesis; an effect which cannot be obtained by photographic after-treatments. Part-images in which the middle-tones are merely reduced show a greater contrast than a combination of normal ones, but do not present the true chromatic brilliancy of the invention.

In pictures to be examined by reflection, in which the light passes the colored part-pictures twice, there is a loss of light which we suggested to avoid by using opaque or semi-opaque pigments suitably arranged to prevent two successive absorptions of the incident light, as explained in the above referred patent application No. 89,502 filed on July 8, 1936. Such double absorption does not concern the present invention which deals with quality and not quantity of light. Even under the handicap of that double absorption of the incident light in pictures to be examined by reflection, the new method brings an improvement in the chromatic values that cannot be found in ordinary subtractive pictures of the prior art.

In pictures to be examined by transmitted light or by projection on a screen, as the light passes only once through the colored part-images, the improvement of the invention may be fully developed without the double absorption just discussed. There is also the possibility of controlling the power of the illuminant, as practiced in moving picture propection. But it must be kept in mind that the adjustment of the illumination to counteract in general the absorption of pigments will not by itself produce the improved truthfulness and chromatic brilliancy obtained by the combined synthesis of the invention. If a picture showing a subtractive brownish orange or any other subtractive grayish mixture of pigments is projected on a screen, the colors will not give up their dingy stigma by only increasing the illumination. The black in the color shade will lose in saturation together with the color but it will always be present.

When pictures produced according to the invention and representing the same subject are projected in succession on a screen the brilliancy of the colors may be further enhanced by a second additive effect if desired, for the irregularly distributed colored minute sections if successively projected at a suitable speed would again blend their color sensations.

Although I have disclosed the present invention as an improvement of the subtractive syn-

thesis in order to simplify its practical demonstration, it may be convenient, for the sake of differentiation with the prior art, to observe that the invention is in fact a new method of synthesis which departs from the two classic ones. As described in the statement of the invention the new method combines both the additive and subtractive synthesis for the reproduction of color and tone values. The invention produces in the same picture space a combination of subtractive absorptions including blacks and heavy-tones, and additive mixtures of lights representing colored middle-tones. The photographic whites remain uncolored.

As to the fundamental idea of the invention it may be expressed by saying that it seems contradictory to reproduce combined colors by combined absorptions of pigments. In other words, that color combinations should not be subtractively obtained, because once the plural absorption of black is created in a pigmentary mixture it cannot be conveniently destroyed by the illuminant.

After having described to the best of my knowledge the new method and picture I wish to be understood that the present disclosure is for the purpose of illustration only and that my invention includes any equivalent or variations which fall within the scope of the appended claims.

I claim:

1. As a new article of manufacture, a supported color picture combining in register a plurality of subtractively complementary colored part-pictures of photographic character and consisting of different thicknesses of transparent color matter corresponding to their variation in density, each one of said part-pictures held in a different layer and having clear uncolored portions corresponding to the whites, continuous and solid portions corresponding to the heavy-tones, and broken portions corresponding to the middle-tones, these broken portions formed by slightly separated and extremely small light transmitting color sections, these small sections in each of the part-pictures arranged in different position as to those in other part-pictures, the small sections of each color part-picture partly overlapping and partly in juxta-position with the small sections of other colored part-pictures, the overlapping sections showing a subtractive chromatic effect and the ones in juxta-position a brightening additive effect.

2. As a new article of manufacture, a supported color picture combining in register a plurality of subtractively complementary colored part-pictures of photographic character showing values in depth, said part-pictures formed by different thicknesses of transparent color matter corresponding to their variation in density, one of the part-pictures being a continuous tone image, and at least another part-picture being an image having clear uncolored portions corresponding to the whites, continuous and substantially solid portions corresponding to the heavy-tones, and broken portions corresponding to the middle-tones, these broken portions consisting of slightly separated and extremely small sections suitably arranged to permit the showing of another part-picture behind, the relative position of said part-pictures when held in separate layers combined in an order consistent with the best color effect.

3. A supported color picture formed by subtractively complementary colored part-pictures combined in register, said part-pictures showing values in depth represented by different thicknesses of transparent color matter, said part-pictures having broken middle-tones divided into small sections slightly separated and in relative out of register arrangement permitting the showing of other part-pictures behind, and another part-picture of the same character in which the separating areas of said middle-tones are only weakened, all of the part-pictures showing clear whites and substantially solid heavy-tones.

4. As a new article of manufacture, a supported color picture combining in register complementary colored part-images in which the values are represented by different depths of transparent color matter, the part-images presenting clear uncolored sections corresponding to the whites, continuous and substantially solid sections corresponding to the heavy-tones, and sections corresponding to the middle-tones suitably broken into small colored areas appearing in the combined picture in out of register distribution showing different colors.

5. A method of producing a color photograph of an object comprising making a set of continuous tone color separation negatives from said object, producing from said negatives a set of photographic positives through screening means of suitable fineness, so as to divide the photographic values in depth into a plurality of very small sections also of varied depth, adjusting the conditions of the exposure to substantially limit the screen effect to the middle-tones, arranging the position of the screening means so that the small sections forming the broken middle-tones in one of the positives be out of register in regard to similar small sections in the middle-tones of the other positives; converting said positives into a corresponding set of part-pictures colored with complementary transparent pigments so that the different depth of the values be represented by different thicknesses of transparent color matter, and combining said color part-pictures on a support.

6. In a color picture combining in register a plurality of photographic color part-pictures, a part-picture consisting of different depths of transparent colored matter corresponding to its variation in density, said part-picture showing substantially solid blacks, pure whites, and middle-tones divided into a plurality of small sections of corresponding different densities separated by areas permitting to see through.

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