Aug. 14, 1945. J. A. C. YULE 2,382,690

COLOR REPRODUCTION

Filed April 1, 1942

FIG. 1A

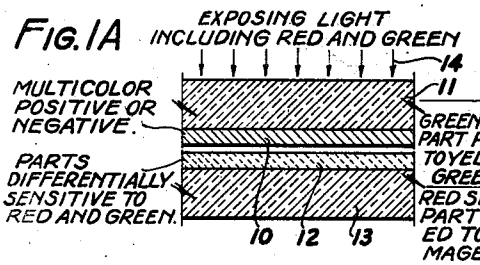


FIG. 1B

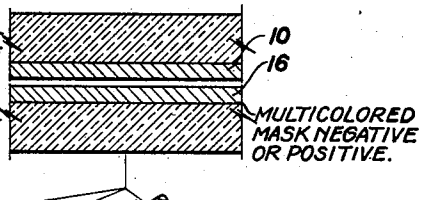


FIG. 1C

FIG. 1D

FIG. 1E

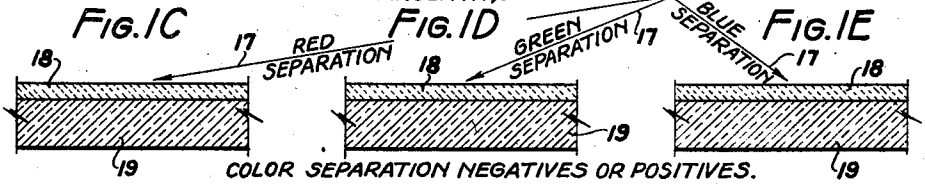


FIG. 2

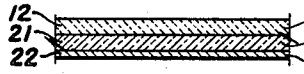


FIG. 3

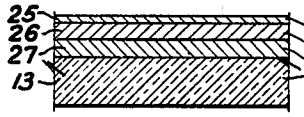


FIG. 4

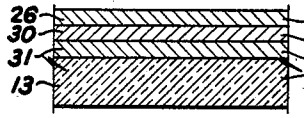


FIG. 5

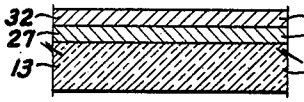


FIG. 6

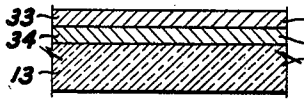


FIG. 7

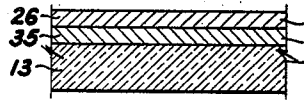
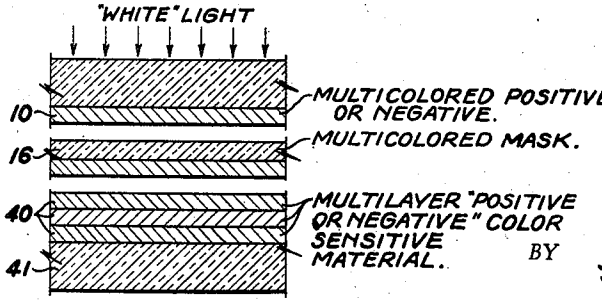


FIG. 8



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UNITED STATES PATENT OFFICE

2,382,690

COLOR REPRODUCTION

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Application April 1, 1942, Serial No. 437,156

29 Claims. (Cl. 95—2)

This invention relates to color reproduction and particularly to color correction of the masking type.

All color reproduction processes based on "three-color" theory involve the making of color separation records. In every case the red, green and blue components of a colored original are separated from one another and records (positive or negative, additive or subtractive) of these separations are made. In general, the term "separation" refers to that entity which is a component of the original and which is recorded in various ways at various stages of the process. Manners of recording, distinguishing, correcting and otherwise operating on the separations in the various known additive and subtractive color processes are well understood. The present invention is particularly applicable to processes in which at least two primary color separations must be modified each in accordance with at least one primary color separation. This is, of course, the phenomenon involved in the masking method of color correction. The commonest examples of such processes are those in which the final picture is made with subtractive coloring materials of which the magenta and cyan absorb some primary blue light and the cyan absorbs some primary green light.

It is an object of the invention to provide a color correction in those processes in which a multicolored picture is made from a multicolored record.

Specifically, it is an object of the invention to provide a mask, preferably a universal mask, to be held in optical register with the record while printing therefrom (e. g. while making color separation records or while printing onto a differentially sensitized multilayer material). The universal mask is one which remains in contact with the record while all three separations are being printed either simultaneously or successively. Such a mask is a decided advantage even when making distinct color separation records because of the difficulty of registering individual masks.

It is the primary object of the invention to provide a universal mask which gives better color correction than previous universal masks. A mask according to the present invention not only gives to an improved degree the type of color correction available with previous masks but also tends to correct for any hue errors in the final printing dyes or inks.

A short review of the more recent types of universal masks will aid in the understanding of the present invention. Copending application 337,300, Hanson, filed May 25, 1940, now U. S. Patent 2,294,981, describes the preferred method of making a neutral universal mask (that is, it is fundamentally neutral though it may be colored monochromously as described in application 413,442, Evans, filed October 3, 1941). Such a neutral mask corrects for the absorption of blue and red by the magenta used in the final print and for the absorption of blue and green by the cyan so used. If the hues of these final coloring materials are right (e. g. if the red and blue absorptions by magenta are exactly equal), such a neutral mask gives the maximum correction and even with shifted hues, Hanson's method gives the best possible neutral mask. The Evans monochromous mask just referred to, modifies the Hanson type of masking to correct for improper color gammas either in the original record or in the reproduction process, still apparently assuming proper hues.

One of the special advantages and objects of the present invention is that in addition to correction of this usual masking type, it also tends to correct for improper hues. Hence, it is especially useful in photo-mechanical processes wherein it is desirable, for the sake of improved brightnesses in the reds, to employ reddish magentas (so-called process red) and for the sake of improved purity in blues, violets and purples, to employ bluish rather than blue-green cyans (so-called process blue) even though their hues are definitely off. On the other hand, practically every process has some hue errors and, hence, the present invention finds general application.

The present invention is employed in a process for making multicolor pictures from a multicolor record. The process may be either photomechanical or photographic such as when using differentially sensitized multilayer materials. The multicolor record may be anything colored and if it is a photograph it may be a positive or a negative and may be produced subtractively or additively. Most commonly, it is a subtractive positive or negative transparency made on multilayer materials but it may be a real optical image projected from lenticular film through proper filters or it may be a screen record, in which case the mask should be made sufficiently diffused to obliterate the screen pattern, or a painting, or even a still-life subject. However, the invention will be described with reference to a transparency.

According to the invention the record is modi-

fied so that exposures therethrough will be color corrected, i. e. a universal mask is provided for the record. To do this, a sensitive material is placed in printing relation, preferably by contact but possibly by projection printing, to the record, which material is made up of separate parts which are sensitive to light of different primary colors and these parts are exposed through the record. The material may be either a multilayer or a mixed grain material and the sensitizing may be provided either by direct optical sensitization alone or by a combination of this with the proper color filters. The amount of exposure of each part is, of course, controlled by the color of the printing light.

After exposure, the material is processed to a multicolored mask for the record by processing the parts to differently colored images and in order to get color correction, the part whose exposure corresponds to the primary color separation which is to do the modifying, is processed to a color which absorbs the primary color corresponding to the separation which is to be modified. This mask is then held in optical register, preferably in contact with the multicolored record when printing separation negatives or another multilayer material therefrom. For example, when the blue and green separations must be modified respectively in accordance with the green and red separations, a sensitive material is used for the mask in which one part is sensitive to green light and another part is sensitive to red light and after exposure the green sensitive part is processed to a color which absorbs blue and the red sensitive part to color which absorbs green, in order to get the color correction required. Furthermore the red sensitive part is processed to a color which also absorbs red so as to reduce the red contrast to match the blue contrast. Therefore in the preferred form of the invention, the red sensitive part is processed to primary blue. In practice, when the red sensitive part is processed to blue either directly or in two portions, one to magenta and the other to cyan, the resulting blue absorbs some blue itself so that the blue separation is also modified to some extent by the red. The extent of this depends on the purity of the green and red absorbers.

In one embodiment of the invention the green sensitive part is processed to yellow so that the green separation modifies only the blue separation, and in another embodiment it is processed to green so that the green separation modifies both the blue separation and the red separation. The relative advantages of these two types of color correction are well understood by those familiar with the various ramifications of the masking theories .

In these examples I have found that approximately the right degree of color correction is given when both parts are processed to effectively equal gammas. Furthermore, such an arrangement has an advantage when processing to yellow and blue respectively since if these complementary colors are processed to equal equivalent gammas, a gray scale such as is often incorporated into or mounted adjacent to the multicolor record being copied, reproduces as neutral gray and thus provides an accurate check on the processing of the mask. Any shift in color balance involving improper gammas of the records can be corrected in later stages of the process by reducing or increasing the gamma of one particular separation.

On the other hand, certain photo-mechanical processes usually require relatively reduced contrasts for the yellow (blue), and magenta (green) separations, which contrasts are normally controlled by varying the lens aperture or the distance of the halftone screen. To eliminate the need for this type of control, the yellow and magenta in the mask may be developed to a gamma higher than the cyan. This trick applies when the blue part of the mask is produced in two portions, one of which is cyan and the other magenta, but the same effect may be produced when a single blue dye is used by the use of a purplish blue. In fact, one of the most satisfactory methods of producing this mask is to use a multilayer material having three layers, one of which is sensitive to green and the other two of which are sensitive to red, and which layers contain couplers so that the green sensitive layer is developed to yellow or green, and the red sensitive layers are developed respectively to cyan and magenta having equal equivalent gammas or gammas which differ by the small amount referred to above. Also the present invention is not limited to the method in which the green sensitive part of the material is processed to a colored image. Since equal equivalent gammas of the three subtractive colors add to gray, the term "equivalent gamma" refers to the gamma of the gray scale equivalent to the color scale being measured. When a gray scale, exposed to neutral light and processed to a substantially neutral gray, has a gamma of one, the individual color components each have an equivalent gamma of one, although their absolute values are less than one as is well known. The conversion factor from absolute gamma to equivalent gamma is constant for each color. Equivalent gamma is a term pertinent only to 2 or 3 colors which are mutually complementary because summation to gray is obviously involved; it is, however, quite a useful property in such complementary systems.

The processing of the mask may be done separately and then the mask reregistered with the original or the mask may be processed in situ. In this latter case, the masking material may be provided with an adhesive and possibly also with a protective layer to protect the original record from the processing solutions. The material is placed in contact with the record, exposed through the record, processed, and while it is still in contact with the record, color separation negatives or a color print is made therefrom.

In the case where the green sensitive part is processed to green, I have found that it is desirable to use a light somewhat more deep orange than red when printing the red separation from the corrected record. Also in this case where the green sensitive part is processed to green, I have found that it is advantageous to process the red sensitive part to magenta or at least to a blue which transmits red light somewhat more than usual. In all cases, however, the green sensitive part is processed to a color which absorbs blue and transmits green and the red sensitive part is processed just oppositely to absorb green and transmit blue.

Whatever form of multicolored record is being printed, the mask always has a density negatively proportional to the density of the record, measured with respect to appropriate primary colors. Thus, if the multicolored record is a positive, the mask is a multicolored negative, and if the record is a negative, the mask is a positive.

As is common practice when discussing dyes, the terms "transmit" and "absorb" are used only

relatively meaning "transmit to a high degree" or "absorb to a high degree" since no dye absorbs or transmits any color completely.

The invention, its objects, advantages, and the principles involved, will be understood from the following description when read in connection with the accompanying drawing in which:

Figs. 1A to 1E illustrate the making of color separation records according to the invention.

Fig. 2 shows one form of material for making a multicolor mask according to the invention.

Figs. 3 to 7 illustrate various forms of multilayer material useful for making masks according to the invention.

Fig. 8 illustrates printing onto a multilayer material according to the invention.

In Fig. 1A a multicolored record 10 which may be either positive or negative and is provided with a support 11 is to be used for making color separation negatives or positives. For this purpose a sensitive material 12 carried on a support 13 is placed in printing relation to the record 10 specifically in contact therewith. The material 12 is made up of parts differentially sensitive to red and green and is exposed as indicated by arrows 14 through the record 10 by light including red and green. Then as indicated by the arrow 15 the green sensitive part is processed to yellow or green and the red sensitive part is processed to blue. As shown in Fig. 1B the multicolor record 10 is now masked by a multicolor mask 16 which is negative with respect to the record, i. e. is negative if the record is positive, and is positive if the record is negative. This universal mask 16 is held in contact with the record 10 while the red, green, and blue separations are made therethrough as indicated by arrows 17 onto sensitive materials 18 of appropriate sensitivity and carried on supports 19. As is well known, the separations may be exposed by monochromatic red, green, and blue light. In the embodiment wherein the green sensitive part of the material 12 is processed to green, I prefer to use a somewhat orange light for the printing of the red separation, but this is not critical to the present invention.

In Fig. 2 the sensitive material 12 is provided with a thin support 21 and on the rear surface of the support with an adhesive 22 so that it may be fastened permanently to the record 10 and remain in contact therewith during processing and subsequent printing. The support 21 may alternatively be thick if a diffuse mask is desired as described in my copending application filed.

The differentially sensitive parts of the material 12 may be incorporated therein in any known manner, but I prefer to use a multilayer material as illustrated in Figs. 3 to 7. In Fig. 3 the support 13 carries three layers, the top one of which is a yellow filter 25 to cut off blue light and the second and third layers are respectively a green sensitive one 26, and a red sensitive one 27. Since these layers are to be processed directly to negatives with respect to the exposing light, I prefer to provide the color development by means of couplers in the layers. As is known, couplers are usually those compounds having a reactive methylene group or phenolic hydroxyl group and which couple with the development product of a primary aromatic amino developing agent. Of course, the present invention is not limited to this detail. Examles of such couplers are given in copending application 371,612, Jelley and Vittum, now U. S. Patent 2,322,027, and in Serial No. 314,689, Mannes and Godowsky, now U. S. Patent 2,304,940. Useful couplers, specifically a green coupler, are also described in U. S. 2,126,337, Mannes and Godowsky. A copending application filed concurrently herewith relates to the materials I prefer to use for making the masks.

In Fig. 4 the red sensitive part is made of two layers 30 and 31, one of which contains the magneta coupler and the other of which contains the cyan coupler. In Fig. 5 the red sensitive part is all in one layer 27 which contains a blue coupler or which contains both magneta and cyan couplers and the green sensitive part 32 contains a green coupler. In Fig. 6 the green sensitive part 33 is provided with a yellow coupler and the red sensitive part is provided with a magneta coupler in layer 34 and the mask then does not balance the red contrast which therefore is corrected separately in later steps of the process. In Fig. 7 the green sensitive part 26 is provided with a yellow coupler as before and the red sensitive part 35 is provided only with a cyan coupler so that the blue and green separations are modified by the red separation only to the extent in which the cyan unavoidably absorbs the blue and green. In general, this latter embodiment provides correction of blue by green and the correction of red by red to control contrast only and is not preferable since it provides no correction of green by red which is important in present day processes.

In Fig. 8 the multicolor record 10 is provided with a multicolor mask 16 while printing onto a multilayer material 40 carried on a support 41. If the multicolor record 10 is a positive, the mask 16 should be a negative and the multilayer material 40 may be processed by reversal to a positive. On the other hand, if the record 10 is a negative and the mask 16 is a positive, the layer 40 should be processed directly so as to give a positive. The color correction is, of course, for errors in the spectral distribution of absorption by the dyes used in the layer 40 in this case.

Having thus described the preferred embodiments of my invention, I wish to point out that it is not limited to these arrangements but is of the scope of the appended claims.

What I claim and desire to secure by Letters Patent of the United States is:

1. In a process for making a subtractive multicolored picture from a multicolored record in which process at least two primary color separations must be modified each in accordance with at least one different primary color separation by factors equivalent to the unwanted absorptions of the primary color in each case by the coloring material complementary to said different primary color used in making said muticolored picture, the method of modifying the record while printing therefrom so that exposures made therethrough will be color corrected which method includes the steps of placing in printing relation to the record a material, separate parts at each point of which are sensitive to light of the different primary colors, exposing said parts through the record to light including said different primary colors, processing the material to a multicolored mask for the record by processing said parts to differently colored images negative to the record, the parts whose exposures correspond to said different primary color separations being processed to colors which absorb the primary color to be correspondingly corrected and to gammas approximately equal to

the corresponding unwanted absorption factors and printing from the multicolored record a color separation of each primary color while holding said mask in optical register to the record.

2. In a process for making a subtractive multicolored picture from a multicolored record in which process the blue and green separations must be modified in accordance with the green and red separations respectively by factors proportional to the blue and green absorption by the magneta and cyan materials used in making the multicolored picture, the method of modifying the record while printing therefrom so that exposures made therethrough will be color corrected which method includes the steps of placing in printing relation to the record a material having at each point one part which is sensitive to green light and another part which is sensitive to red light, exposing said parts through the record to light including red and green, processing the material to a multicolored mask for the record by processing said parts to differently colored images negative to the record, the green sensitive part being processed to a color which absorbs blue and to a gamma approximately equivalent to the blue absorption factor of the magneta material to be used in making the multicolored picture and the red sensitive part being processed to a color which absorbs green and to a gamma approximately equivalent to the green absorption factor of the cyan material used in making said multicolored record, and printing from the multicolored record a color separation of each primary color while holding said mask in optical register with the record.

3. The method according to claim 2 in which the red sensitive part is processed to blue whereby it also absorbs red.

4. A method according to claim 2 in which the green sensitive part is processed to yellow and the red sensitive part is processed to blue.

5. A method according to claim 2 in which the green sensitive part is processed to green and the red sensitive part is processed to magenta.

6. A method according to claim 2 in which the green sensitive part is one layer of the material and is processed to yellow and the red sensitive part is two other layers of the material, one of which is processed to cyan and the other of which is processed to magenta.

7. A method according to claim 1 in which said parts are processed to equivalent gammas which are effectively equal to each other and the colors of the differently colored images are complementary whereby a gray area in the record gives a gray area in the mask.

8. A method according to claim 2 in which said parts are processed to equivalent gammas which are effectively equal to each other and the colors of the differently colored images are complementary whereby a gray area in the record gives a gray area in the mask.

9. The method according to claim 1 in which said printing of the color separations is successive.

10. The method according to claim 1 in which said printing of the color separations is simultaneous and onto a multilayer differentially color sensitized material.

11. The method according to claim 1 in which the material is placed substantially in contact with the record and remains in contact during said exposing, processing, holding, and printing.

12. The method according to claim 2 in which said printing of the color separations is successive.

13. The method according to claim 2 in which said printing of the color separations is simultaneous and onto a multilayer differentially color sensitized material.

14. The method according to claim 2 in which the material is placed substantially in contact with the record and remains in contact during said exposing, processing, holding, and printing.

15. The method of making color corrected color separation negatives from a multicolored positive which comprises placing in printing relation to the positive a material having at each point part which is sensitive to green light and part which is sensitive to red light, exposing the material through the positive to light including red and green, processing the material to a subtractively multicolored negative mask for the positive by processing said parts to differently colored negative images, the green sensitive part being processed to a color which absorbs blue and to a gamma approximately equivalent to the blue absorption factor of magenta materials used in a subtractive color reproduction process and the red sensitive part being processed to a color which absorbs green and transmits blue and to a gamma which is approximately equivalent to the green absorption factor of cyan materials used in the reproduction process, printing red and blue separation negatives from the positive while holding said mask in register with the positive.

16. The method according to claim 15 in which the material is placed substantially in contact with the record and remains in contact during said exposing, processing, holding, and printing.

17. The method of making color corrected color separation negatives from a multicolored positive which comprises placing in printing relation to the positive a material having at each point part which is sensitive to green light and part which is sensitive to red light, exposing the material through the positive to light including red and green, processing the material to a subtractively multicolored negative mask for the positive by processing said parts to differently colored negative images, the green sensitive part being processed to a color which absorbs blue and transmits green and to a gamma approximately equivalent to the blue absorption factor of magenta materials used in a subtractive color reproduction process and the red sensitive part being processed to a color which absorbs green and transmits blue and to a gamma approximately equivalent to the green absorption factor of cyan materials used in the reproduction process and printing each of the three primary color separations from the positive while holding the mask in optical register therewith.

18. The method according to claim 17 in which the green sensitive part is processed to yellow.

19. The method according to claim 17 in which the green sensitive part is processed to green and of the three primary color separation negatives the red one is printed with deep orange light.

20. The method according to claim 17 in which the green sensitive part is processed to yellow and the red sensitive part to blue and both parts are processed to equivalent gammas which are effectively equal to each other whereby a gray area in the positive gives a gray area in the mask.

21. The method according to claim 17 in which the red sensitive part is made of two portions one

of which is processed to cyan and the other to magenta and in which the green sensitive part is processed to yellow, the processing to yellow and magenta being to an equivalent gamma slightly and appreciably higher than that to which the cyan is processed.

22. The method according to claim 17 in which the material is placed substantially in contact with the record and remains in contact during said exposing, processing, holding, and printing.

23. For use in a color reproduction process in which at least two primary color separations must be modified each in accordance with at least one other primary color separation by a factor equivalent to the unwanted absorption of each primary color respectively by the coloring materials complementary to the respective other primary colors used in the reproduction, the combination of a color record and a universal mask in register with the record, said universal mask being subtractively multicolored and having at each point densities to said two primary colors negatively proportional respectively to the densities of the record respectively to the other primary colors, the proportionality factor being approximately equivalent to said unwanted absorption factor in each case.

24. The combination of a multicolored positive transparency and a universal negative subtractively multicolored mask in register therewith said mask having at each point yellow and blue parts, the density of the yellow part to blue light being negatively proportional to the green density of the transparency and the density of the blue part to green light being negatively proportional to the red density of the transparency, the proportionality factors being respectively those required for color correction in a subtractive color reproduction process.

25. The combination of a multicolored positive transparency and a universal negative subtractively multicolored mask having at each point green transmitting and green absorbing parts, the density of the green transmitting part to blue light being negatively proportional to the green density of the transparency and the density of the green absorbing part to green light being negatively proportional to the red density of the transparency, the proportionality factors being respectively those required for color correction in a subtractive color reproduction process.

26. In a process for making a subtractively multicolored picture from a multicolored record in which process at least two primary color records must be modified each in accordance with at least one different primary color separation by factors equivalent to the unwanted absorption of the primary color in each case by the coloring material complementary to said different primary color used in making said multicolored picture, the method of modifying the record which comprises placing in printing relation to the record a material having at each point separate parts which are sensitive to light of said different primary colors, exposing said parts through the record to light including said different primary colors, processing the parts to differently colored images negative to the record and to gammas approximately equalivent to the corresponding unwanted absorption factors, to form a subtractively multicolored mask for the record and printing three primary color separation records from the record and mask held in optical register.

27. The method according to claim 26 in which the material is placed substantially in contact with the record and remains in contact during said exposing, processing, and printing.

28. The method according to claim 26 in which said printing of the color separations is successive.

29. The method according to claim 26 in which said printing of the color separations is simultaneous and onto a multilayer differentially color sensitized material.

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