

[54] **PROCESS FOR REPRODUCING A FULL-COLOR PICTURE IN ONE IMPRESSION**

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Related U.S. Application Data

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[52] U.S. Cl. **101/211, 101/401.1, 101/450**

[51] Int. Cl. **B41m 1/20, B41m 3/00**

[58] Field of Search. **101/450-452, 211, 426, 175, 176, 395, 401.1; 96/30-32**

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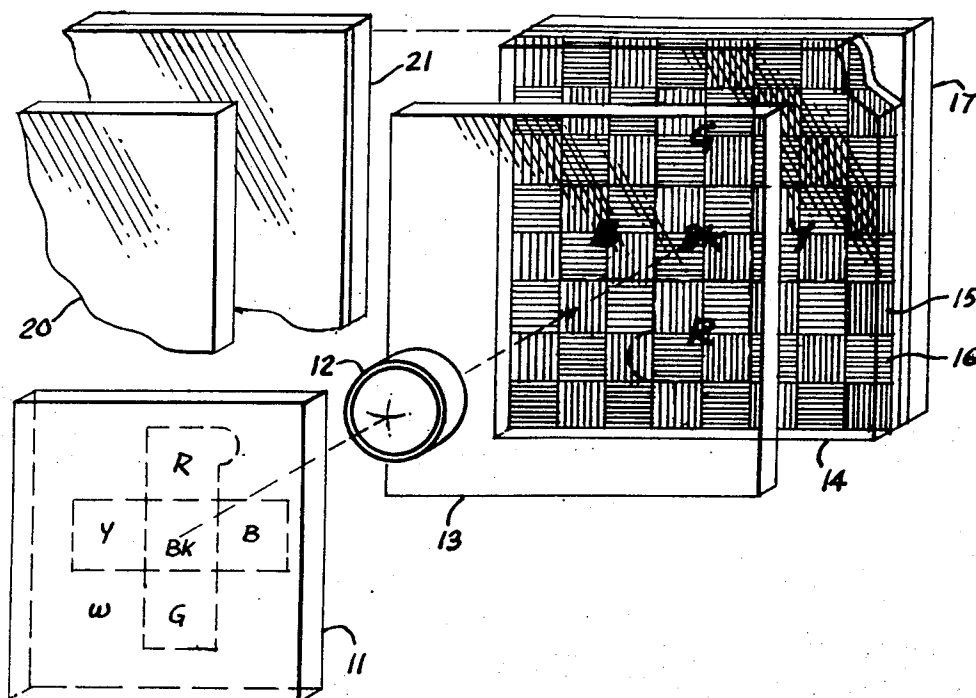
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[57] **ABSTRACT**

Process of producing an apparent full color print of a multicolored picture, comprising the steps of: (a) with a composite separation screen having interspersed first and second areas which transmit substantially red and substantially green information, respectively, of the multicolor picture, photomechanically forming upon a printing surface a corresponding composite plate image, the composite plate image being receptive to a substantially neutral tone dark ink; (b) photomechanically forming upon the printing plate, only in the plate portions corresponding to the first areas of the composite separation screen, a substantially cyan plate image of the multicolor picture, the cyan plate image being receptive to a substantially red ink; (c) inking the composite plate image with the dark ink and the cyan plate image with the red ink; and (d) making a single impression of the printing surface upon a receiving substrate having a selected pale color.

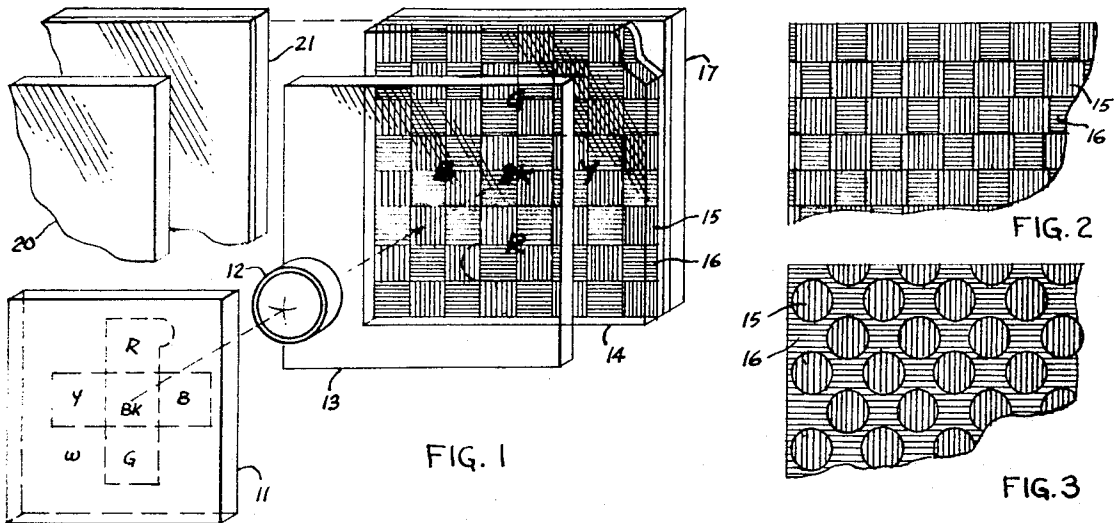
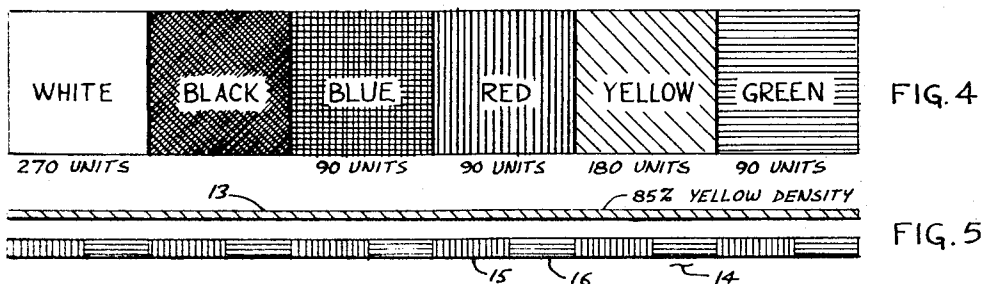
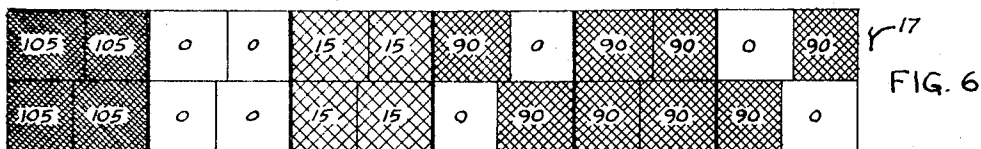
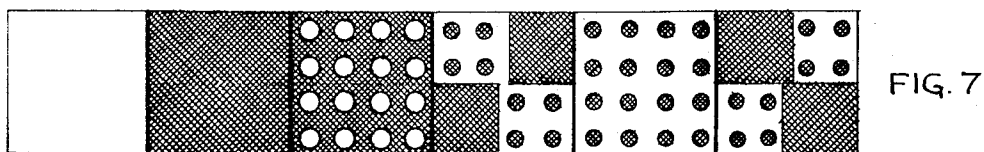
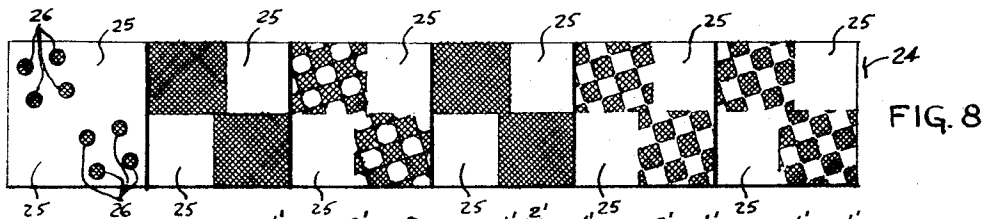
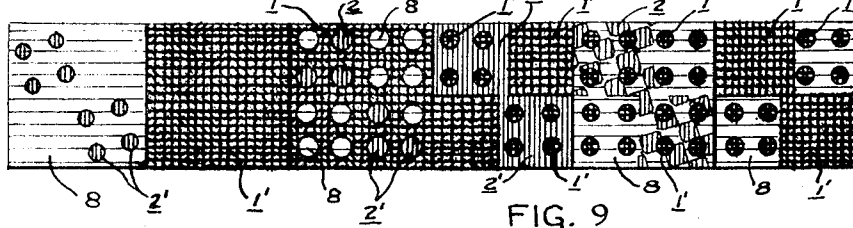
11 Claims, 23 Drawing Figures



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SHEET 1 OF 3



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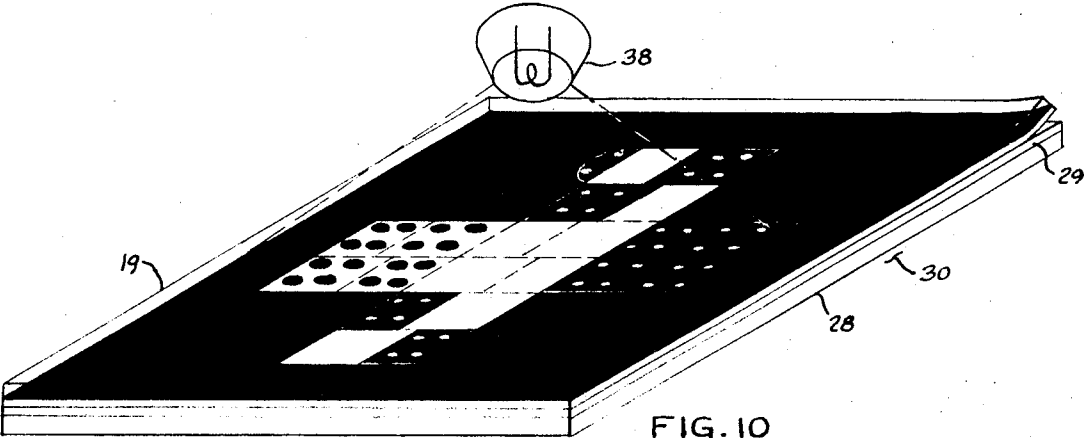


FIG. 10

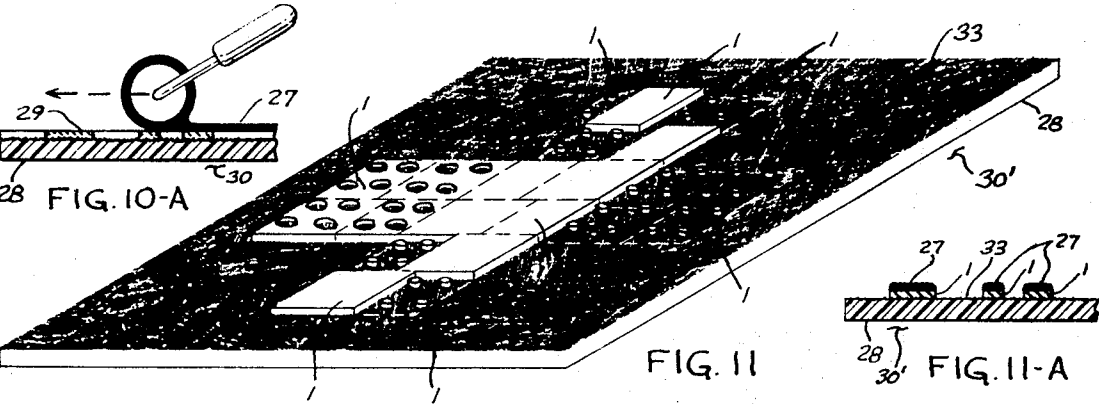


FIG. 11

FIG. 11-A

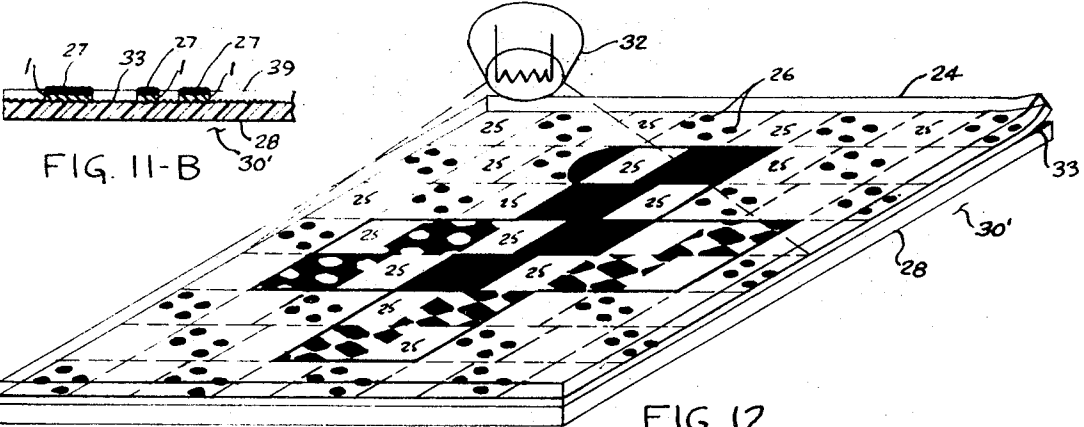


FIG. 12

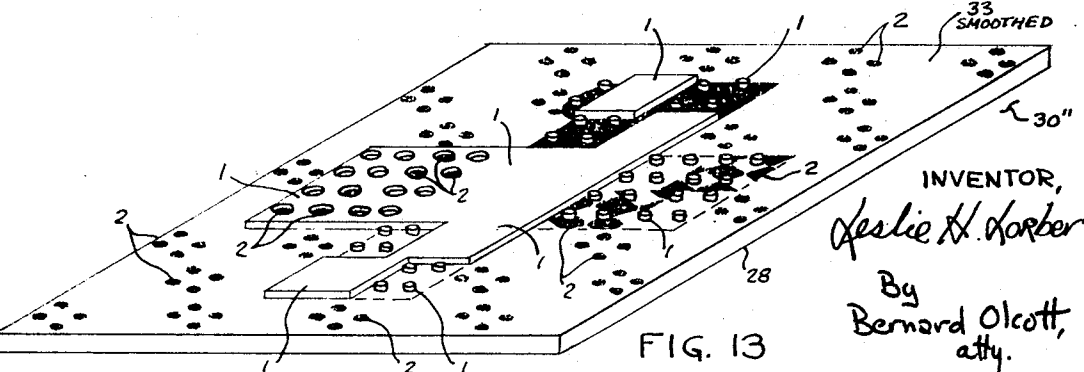


FIG. 13

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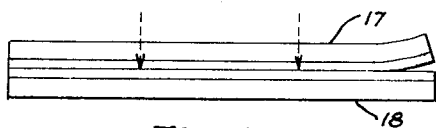


FIG. 14

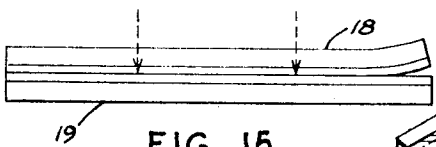


FIG. 15

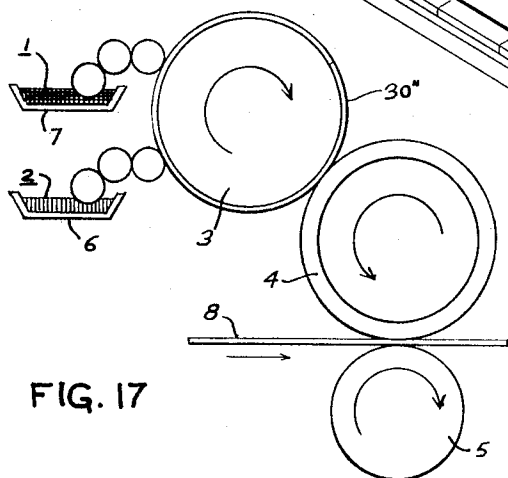


FIG. 17

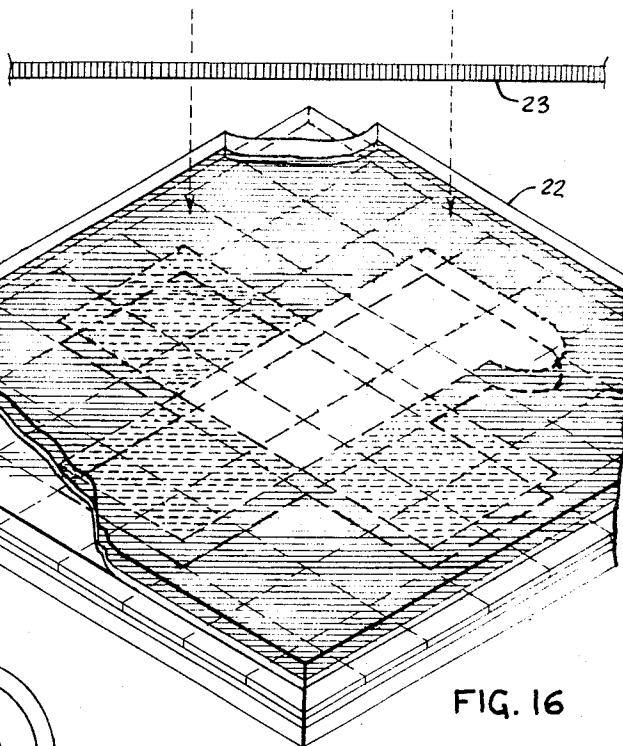


FIG. 16

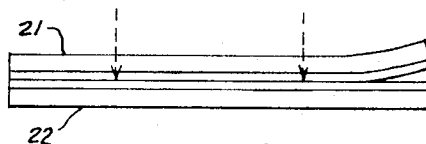


FIG. 18

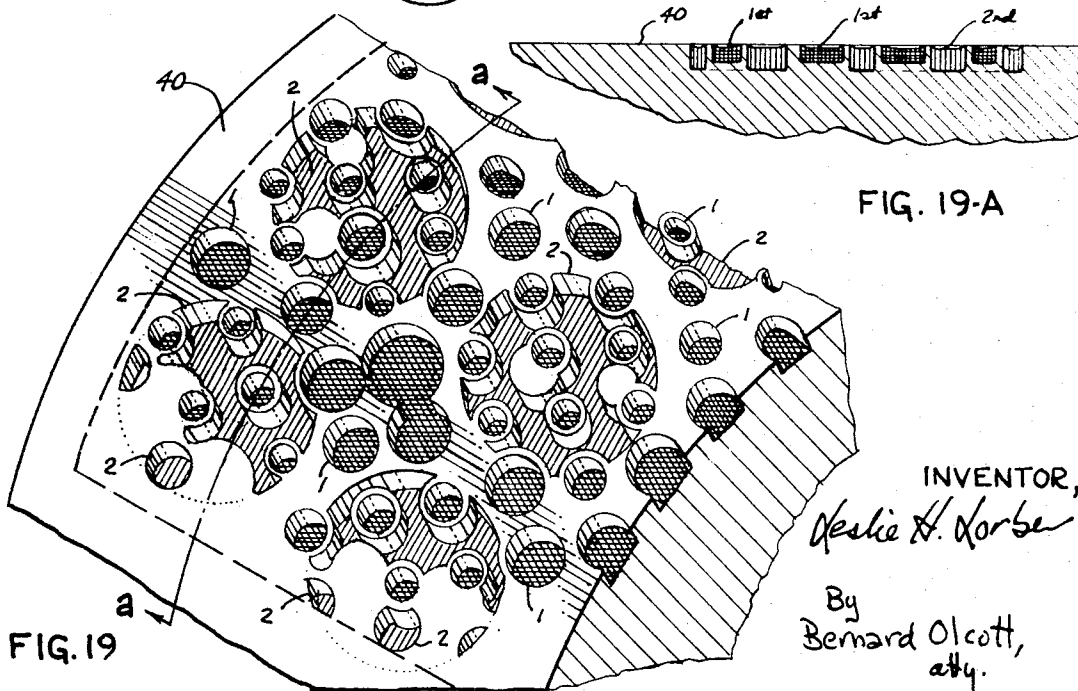


FIG. 19-A

FIG. 19

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PROCESS FOR REPRODUCING A FULL-COLOR PICTURE IN ONE IMPRESSION

This application is a continuation-in-part of my co-pending application Ser. No. 754,168, now abandoned, filed Aug. 20, 1968 and titled PLATES FOR SINGLE-IMPRESSSION MULTICOLOR PICTURE AND TWO-COLOR PRINTING

This invention concerns a process of double-imaging latent 2-color printing surfaces, and also concerns a method of using any printing surface imaged as herein-after described. Considered together, the two aspects of this invention will advance the art of reproducing a full-color picture from a single printing surface.

The following definitions will assist understanding:

"Printing Surface" refers generally to an imaged printing plate or printing cylinder, and particularly to the face thereof;

A "2-Color Printing Surface" or "2-Color Surface" refers to a printing surface having a 1st image intended to receive ink of a 1st color and a 2nd image intended to receive ink of a 2nd color;

The term "1st-Image Elements" refers to all elements or portions of a printing surface associated with a 1st image thereon, and the term "2nd-Image Elements" refers to all elements or portions of a printing surface associated with a 2nd image thereon;

A "latent" 2-color printing surface refers to a plate or cylinder, considered as a whole, which plate or cylinder is structurally suited to have 1st-image elements and 2nd-image elements formed on its face;

"Full-Color Picture" refers to subject matter to be graphically reproduced, normally having pictorial content in flat and/or gradient tones which may be of any colors;

"Color" refers to a visual sensation commonly ascribed to surface, e.g., red, green, blue, yellow, cyan, magenta, orange and brown, also including the "achromatics" white, black and gray, and which sensations may have any tint or shade or chromatic leaning;

An "effective" reproduction of a full-color picture is here considered one which appears to contain all colors in the picture even though the apparent colors are not precisely identical, and which exhibits good general brightness, deep blacks and sharpness of detail presuming such qualities were present in the said picture.

In conventional "Process" printed reproduction of a full-color picture, at least three inks are required by theory, of the colors yellow, magenta and cyan, though practice usually demands use of a fourth ink of black color. Component images in respective ink colors are successively transferred into coincident register upon a white substrate, from separate printing surfaces. Mostly by subtractive interaction, the yellow, magenta and cyan inks, variously distributed, optically produce close equivalents of all the colors present in the original picture. The black ink improves contrast and sharpness of detail, and can also print any accompanying typographic matter. Process reproductions, particularly those using black ink, can be very effective.

Various means have been proposed to as effectively reproduce a full-color picture from a single printing surface.

To such end, dependence has of late been upon a printing surface which can distinctly receive at least three inks, usually of the colors yellow, magenta and cyan. The three inks may be generally applied, as in C.S. Miller, U.S. Pat. No. 3,213,787, and separately re-

ceived by respective surface elements. A 3-color printing surface can receive inks only in juxtaposed relation, and therefore properly relies upon equal intermixing (on the substrate) of all three inks to produce a black, upon equal mixing of a selected two inks to produce primary red, green and blue, and upon proportionate intermixing of all three inks to produce intermediate or tertiary colors. The black so-produced is typically of poor depth and tone, and cannot be produced in fine picture detail. For the latter reason these surfaces are unable to print accompanying typographic matter of small size (about 12-point or less), except in a particular one of the three ink colors. Moreover, the colors reproduced tend to appear paled, because of light reflected from small unprinted, or weakly covered, portions of substrate between adjacent deposits of ink. In many such processes, including that of Miller, the chemical immiscibility of the inks interferes with their admixture on the substrate, and makes the selection of substrate a critical concern.

Miller's surface is believed outstanding of its kind, but nevertheless cannot produce what is herein considered to be an effective reproduction. Although the use of a fourth ink of black color would sufficiently enhance such a reproduction, and is proposed by Miller, he is unable to give any specific mechanism, i.e., chemical treatment and ink formulation, which would allow it to be distinctly received, nor is any apparent. Even with a fourth ink of black color, his surface, and other surfaces having a fixed array for ink-receiving elements, would still be unable to reproduce fine black picture detail, because only every fourth surface element would receive black ink. To compensate for the aforementioned limitations, Miller's and other 3-color surfaces are, in practice, best used as the first in series with a conventional black-printing surface. The latter can overprint amounts of black and also print any accompanying black typographic matter. Accordingly, only by two impressions is an "effective" reproduction produced.

Considering now 2-color printing surfaces, such as are known, none are able to effectively reproduce a full-color picture in a single impression. They have found use only (to knowledge) in reproducing "duotone" pictures and other copy having just two color components disposed either separately or in interspersion for limited additive secondary color effects, and which components can be exactly matched by the two ink colors, and also in reducing the number of separate plates needed for "Process" and other reproductions by three or more inks. The limitations experienced are to be expected from classical color theory, which postulates the need for at least three inks, usually of the colors yellow, magenta and cyan.

It has nevertheless been found that all colors, in certain instances, and most colors, in most instances, can in fact be perceived in a picture reproduced by only two colors or "stimuli". This was strikingly demonstrated by Edwin H. Land with the aid of paired photographic transparencies having the character of "red" and "green" separation images, conjunctive with pairs of colored illuminants (including white light as a "color"), as described in *Scientific American*, May 1959, "Experiments in Color Vision", and elsewhere. But attempts by Land, as in U.S. Pat. No. 3,034,890, and by Lorber, of instance, in U.S. Pat. No. 3,429,702, to produce an equivalently full range of colors on the

printed page, by use of only two inks, e.g., with red and black inks, have at best produced only "multicolor" effects. These have been characteristically deficient of blue, among particular shortcomings (poor contrast and weak reddish blacks in the first instance, yellows poorly distinguishable from white in the latter instance, to specify some). For a variety of technical and practical reasons the use of red and black inks is preferred to other combinations upon a white or pale paper. But the deficiencies of known red-black reproductions will persist if they are, by any apparent means, produced from a 2-color printing surface instead of from separate plates as was described in the art. Presumably, this accounts for the before-mentioned commercial limitations of known 2-color printing surfaces.

A variety of other means have been proposed to reproduce a full-color picture from a single printing surface. None of these, including "collecting" processes and surfaces, has been found sufficiently effective and/or practical to complete commercially with conventional "Process" reproductions. As the art now stands, an "effective" reproduction of a full-color picture can neither be accomplished in a single impression nor from a single printing surface. In remedy of this situation, the principal objects of this invention are:

To enable a 2-color printing surface to effectively reproduce a full-color picture, conjunctive with appropriate inking;

To permit effective reproduction of a full-color picture by use of only two inks not of complementary colors, thus avoiding deficiencies typical of complementary-color prints;

To permit effective reproduction of a full-color picture by use of only two inks, respectively of a black tone and a red color, yet by means avoiding deficiencies heretofore experienced in the use of red and black inks for such purpose;

To permit full-color pictorial reproduction of good quality from a single printing surface doubly imaged and inked with two inks, one of the inks having a black tone providing detail and contrast and also being suited to reproduce any accompanying black typographic matter or B&W pictures; and

To extend the commercial utility of 2-color printing surfaces.

Means to accomplish the above and other objects of this invention will be understood from the following description, and by reference to the accompanying Drawing, which is schematic and not to scale, in which:

FIG. 1 shows a camera set-up for obtaining precursors to 1st and 2nd platemaking images;

FIG. 2 and FIG. 3 show different suggested patterns for a 2-color screen used in direct composite color separation;

FIG. 4 represents selected colors of a full-color picture;

FIG. 5 represents a section through a 2-color screen and general filter combination;

FIG. 6 shows the encodement of selected picture colors in a continuous-tone composite color separation;

FIG. 7 shows a positive halftone equivalent of the composite color separation of FIG. 6;

FIG. 8 represents minus- "cyan" picture content as encoded in the form of halftone densities in a 2nd platemaking image;

FIG. 9 depicts the printed representation of selected picture colors (no color being observable here);

FIG. 10 shows photomechanical formation of 1st-image elements on an exemplary latent 2-color printing surface; and FIG. 10-A shows the suggested application of ultraviolet-opaque developing ink to said surface subsequent to exposure and prior to development;

FIG. 11 and FIG. 11-A respectively depicts results of the procedure of FIG. 10 and FIG. 10-A; FIG. 11-B show the optional application of gum to hydrophilic portions of a singly imaged latent 2-color surface obtained by above operations;

FIG. 12 shows photomechanical formation of 2nd-image elements on the latent 2-color printing surface of FIG. 10, using the film image shown in FIG. 8;

FIG. 13 shows an exemplary 2-color printing surface, absent of ink, having special 1st and 2nd images as herein described;

FIG. 14 and FIG. 15 show procedures to convert the continuous-tone composite color separation obtained in FIG. 1 into an equivalent halftone negative of appropriate lateral sense for use in FIG. 10;

FIG. 16 and FIG. 18, in reverse order, show steps in converting the "cyan" separation obtained in FIG. 1 into a laterally correct intermittent halftone image of positive sense, having minus-"cyan" information, such as shown in FIG. 8 and FIG. 10;

FIG. 17 shows means of using the 2-color surface doubly imaged as described; and

FIG. 19 and FIG. 19-A depict a 2-color gravure surface which has been double-imaged as herein described.

The instant process of double-imaging is applicable to more than one species of latent 2-color surface, but is explained as it may be practiced upon a latent 2-color surface described by R.S. Storms in U.S. Pat. No. 3,368,483, intended for use in offset lithography.

Referring to FIG. 1, a full-color picture 11 to be reproduced is, for simplicity, assumed to only have the colors red (R), green (G), blue (B), yellow (Y) and black (Bk) arranged as a cross upon a white (W) background. The half-round protrusion in the red is provided as a indication of lateral sense, for reference. The selected colors shown, also assumed to be fully saturated and of a uniform flat tone, are "key" colors, in that an understanding of how they are reproduced on the printed page will assist in understanding the reproduction of other colors. However, the visual phenomena involved is not certainly understood even by the inventor.

Through an optical system 12, preferably through a general color filter 13, and through a 2-color screen 14, the picture 11 is imaged upon the face of panchromatic film 17. The 2-color screen is of a contact type, and has on its face an interspersed 2-part pattern of transparent "red" elements 15 and "green" elements 16 which act as limited-area color filters. Acceptable results will obtain if the "red" and "green" elements are substantially pure red and green, or if only the "red" elements are substantially of pure color. Preferably, and as a convenience in practice here assumed, the "red" elements are a full magenta (transmitting equal red and blue) and the "green" elements are a full cyan (transmitting equal green and blue), while a general filter 13 is yellow of about 85 percent purity. Such combination of general filter and 2-color screen effectively allows the "red" screen elements to transmit full red plus about 15 percent blue, and the "green" screen elements to transmit full green plus about 15 percent blue. Herein-

after, references to "red" and "green" screen elements (or components transmitted therethrough) will not imply that such element (or components) need specifically be of the colors red and green. If desired, the screen elements could be formulated so that each transmits a minor amount of blue in addition to its primary color, thus avoiding need for a separate yellow filter.

For a single and correct exposure to be made upon the film 17, without need of balancing filters, a selected one set of screen elements may have neutral density or a complementary color component added, as required, to equalize the "filter factor" of all screen elements. The single exposure may then be such as will produce a substantially normal range of image densities.

Though, for simplicity, a checkerboard pattern is shown, the 2-color screen may have any other interspersed 2-part pattern. In practice the pattern of FIG. 2 is generally preferred, wherein the "green" elements have about 5 percent smaller area than "red" elements, as is also the case for the pattern of FIG. 3 (particularly recommended for use in preparing a 2-color gravure surface). Diminished final results will be had if "red" and "green" elements are of equal size or if "red" elements have smaller area than "green" elements.

The screen elements must be very small relative to the size of the reproduced picture, as they determine color resolution in the print. A group of four coadjacent screen elements may be considered the "normal" unit of color resolution, as shown for each "key" color, except white, in FIG. 1. The white color images through many "normal" units of color resolution, each comprising two "red" screen elements and two "green" elements. In practice it will be found that there is an "effective" unit of color resolution, of indeterminate size, which is substantially smaller than the "normal" unit, and which permits very small color detail to be seen. This is in part due to a random factor, and in part due to the synthesizing ability of the eye in reading pictures. Generally, most colors will have a size enabling them to image through tens, hundreds or thousands of coadjacent screen elements.

As with a halftone screen, the 2-color screen elements may be much coarser for poster and like work than for a magazine, book or newspaper picture. But in prints of the latter types it is neither necessary nor desirable that the color screen pattern be so fine as not to be resolvable when (the screen itself) viewed from a comparable distance. For in the printed reproduction the screen pattern will be effectively obscured by the co-presence of halftone structure, and by the eye's concern for reading the subject content of the reproduction, analogously to the non-perception of highlight dots in a conventional halftone print.

Use of a (relatively) coarse 2-color screen is a practical and not seriously compromising means to avoid resort to halftone screens of excessive fineness. For example, "red" and "green" screen elements could be nominally about one-sixtieth inch along a side (or across, where round), when a halftone screen of 100, 133 or 150 lines is subsequently to be employed. For news pictures, color screen elements as coarse as about one-fortieth inch may be used, yet the color screen pattern will be indistinct in the print. As a matter of interest, color screen elements of about one-sixtieth inch will prove more than sufficient to reproduce the color of such small details as the iris of an eye in any common

size picture wherein a person is the principal subject.

The b 2-color screen 14 may be prepared by a variety of apparent means, including the use of subtractive color film. So that the very same screen may also be used in later procedures, it preferably has a thin, e.g., 0.004 inch, base of dimensionally stable material, e.g., "Estar", brand of polyethylene terephthalate.

The developed image on film 17 is a continuous-tone composite color separation, in effect, an interspersed 2-part encodement of "red" and "green" picture content. This image is represented in FIG. 6. To facilitate understanding, the colors represented by film density are shown in FIG. 4, in positions above the corresponding film densities. FIG. 5 depicts the 2-color screen 14 and yellow filter 13 combination through which the densities of FIG. 6 were obtained, and the screen is shown to have "red" elements larger than "green" elements, as recommended. The numbers shown below each "key" color in FIG. 4 are in arbitrary units, merely intended to show an assumed actinic potential of each color, and are not values which might actually exist. Neither are the density values shown in FIG. 6 those which might actually result in practice. These values here assume that about 15 percent blue was transmitted through both "red" and "green" screen elements, but in practice a lesser amount of blue can still produce effective final results.

Referring specifically to FIG. 6, it will be seen that blue is differently represented than black, that black has the least value and white the most, and that yellow has a density slightly less than white. In each case the two pairs of densities that represent each color are equal, but in practice some difference can exist in the densities of conjunctive pairs. In the case of red and green, one pair of densities is seen to have negligible value while the conjunctive pair has a high, but not maximum, value. White is here presumed to have been slightly overexposed. This is desired. The correct exposure is best determined, in practice, if a yellow sample photographed through the screen and filter combination produces an average density of about 90 percent or slightly more, when the resulting negative is routinely developed. This yellow density is preferably higher, e.g., about 95 percent, if the yellow filter 13 has a purity of 90-95 percent.

With reference now to FIG. 14, the developed image on film 17 is printed onto the face of autoscreen film 18, or is otherwise halftoned. The screen angle is best determined empirically, but may be about 30° different from the effective angle of the 2-color screen. The halftoned (and positive) form of the composite color separation is shown in FIG. 7. Its correspondence to the continuous-tone (negative) form may be seen by referring to FIG. 6, above. Next, as shown in FIG. 16, the halftone image on film 18 is printed onto copy film 19. The resulting halftone negative on film 19 has a desired lateral sense, and is the first platemaking image.

Referring back to FIG. 1, the picture 11 is also imaged through the optical system 12 onto the face of ortho film 21. The film 21 is here assumed to also have an autoscreen feature and an effective screen angle about 30° different than that of film 18, but in practice other halftoning means can be used. What is essentially desired by this exposure is a "cyan" color separation, it merely being a convenience to use ortho film and to directly halftone. (The 2-color screen 14 is not employed). The exposure is preferably just sufficient to

leave about 8–10 percent “highlight windows” in density representing picture white. Though the exact balance of blue and green light recorded is not critical, superior final results will obtain if one component is only about 85 percent the strength of the other component. To this end a pale yellow filter 20 is inserted into the optical path, and will attenuate the blue component. Instead, a pale magenta filter can be used to attenuate the green component. Hereinafter, reference to a “cyan” separation (or component) is not to imply that blue and green are equally recorded (or present).

It is important to appreciate that densities in a “cyan” separation are not reciprocal to densities in a (minus-red) print made from a conventional red separation. In a “cyan” separation full green and blue are each represented by densities of middle value, while in a minus-red image green and blue are each represented by maximum density. Similarly, the term “minus-cyan” does not mean “red”, but refers to densities which are reciprocal to those obtained in a “cyan” separation, and to the complex component (including red) of a picture directly represented by said reciprocal densities.

Next, as shown in FIG. 18, the developed halftone “cyan” separation image on film 21 is printed onto the face of autopositive film 22. This provides lateral reversal without change of negative-positive sense. Subsequently, as shown in FIG. 16, the image on film 22 is printed by red light, e.g., as passes through a red filter 23, onto the face of panchromatic film 24 through the same 2-color screen 14 which was used in FIG. 1. As shown, the film 22 is face-down upon the body of screen 14. By using the same 2-color screen, rather than an identical twin, the possibility of misregister is greatly minimized, as even symmetrical and regular patterns may have slight irregularity. The screen 14 is suitably “keyed” to assure that the same corner which was in the upper left part of the image in FIG. 1, is now in the corresponding corner of the image here passed through it. By the procedure of FIG. 16 “green” screen elements will block the passage of red light, so that the resulting minus-“cyan” halftone image on film 24 is regularly interrupted or blanked.

The developed minus-“cyan” image is represented in FIG. 8, and would appear “positive” by visual examination. It will be noted that, except where interruptions or blanks 25 occur, yellow and green will be represented by about 41 percent halftone density, and blue will be represented by about 48 percent halftone density (assuming, for these values, that in the original “cyan” separation the blue component had about 85 percent the strength of the green component). Also to be noted are the small halftone dots 26, in practice about 10 percent size or less, which are a desired consequence of the highlight windows formed in the original “cyan” separation. This image is the second platemaking image, on film 24.

The first and second platemaking images obtained by the aforementioned procedures may be used as follows:

Referring to FIG. 10, the 1st platemaking image on film 19 is placed upon the sensitized coating 29 of Storms’ latent 2-color surface 30, having a Teflon body 28. (The coating sensitivity is best largely or wholly in the visible range). Then an exposure is made to light from a source 38, preferably having little or no ultraviolet component. The exposure should be adequate to render insoluble all portions of the coating 29 which were not shielded by halftone density in the film image.

(This operation corresponds to that shown in FIG. 3 of Storms’ patent.)

In departure from Storms’ procedure, and with reference to FIG. 10-A, an ultraviolet-opaque developing ink 27 preferably is applied to the exposed but undeveloped coating 29. Carbon-black inks are suitably absorbent and may be used; flake aluminum ink can also be used, among others which will be apparent. The ink-base is suitably one which will quickly become surface-dry and which will be water repellant.

FIG. 11 (corresponding to Storms’ FIG. 4) shows the latent 2-color surface 30’ after development of the first image. The constituent first-image elements 1 are, for schematic clarity, shown absent of residual developing ink 27, but the presence of such ink, as shown in FIG. 11-A, will be understood. The amount of relief of first-image element is negligible, and is shown greatly exaggerated. The first-image elements are oleophilic-hydrophobic, whereas the plate surface 33 is hydrophilic (having been finely etched in manufacture). It is important to understand that the first image is an inverse representation of the composite color separation on film 17 (also being halftoned), and therefore the first-image elements represent “minus” amounts of “red” and “green” in the picture 11. (The image on film 17 is properly a “positive” record of “red” and “green”, although appearing as a negative by visual inspection.)

FIG. 11-B shows an ultraviolet-transparent gum coating 39 upon the hydrophilic surface 33. This may be done as in conventional litho platemaking, e.g., using gum arabic. This coating is optional, and merely has as its function to level up the single-imaged surface 30’ so that a second platemaking image can lay in flatter contact on it.

With reference to FIG. 12 (corresponding to Storms’ FIG. 5, with minor difference), the second platemaking image on film 24 is optically printed onto the plate surface 33 by the action of ultraviolet light from a source 32. Sufficiently intense U.V. light has ability to smooth the etched surface 33, in which state it will be repellant to both greasy ink and aqueous ink. In minor departure from Storms’ practice, it will be noted that the film 24 does not have co-imaged thereon a “positive” equivalent of the first platemaking image. The optical shielding which such a co-image would provide above formed first-image elements 1 (FIG. 11) is instead equivalently provided by a residual layer of developing ink 27 (FIG. 11-A).

FIG. 13 (corresponding to Storms’ FIG. 6) shows the double-imaged 2-color printing surface 30’’ (absent of any ink), which is obtained by the preceding operations. Instead of having had two arbitrary images formed thereon, first-image elements 1 and second-image elements 2 have particular dispositions and information content which will cooperatively allow the surface 30’’, when appropriately inked, to effectively reproduce a full-color picture. It is important to note that only certain of the halftone densities on film 24 have formed as corresponding hydrophilic second-image elements 2. The prior presence of first-image elements 1 has effectively limited the extent to which the second image formed. To be especially noted, are the very few second-image elements within the plate portion representing blue. This limited presence is deliberate, instead of total absence. Also to be noted is the complete absence of second-image elements in plate

portions representing green and black, and the interrupted distribution of second-image elements 26 of about 10 percent halftone value in the plate portion representing white. Except as noted, the interference of first-image elements with the formation of second-image elements, will allow the latter to form generally proportionate to the degree in which a red-light component is present in a picture color, though not to an extent greater than corresponding density on film 24. By such mechanism (and with the understanding that red ink will be received by second-image elements) the red quantity in such colors as red, orange, yellow, yellow-green and purple is provided. The intermediate halftone density for yellow, relative to the full halftone density for red, in the image on film 24 (FIG. 12 and FIG. 8), acts to limit the maximum formation of second-image elements in the yellow-representing plate portion. Similar biasing occurs in systematic manner for other colors containing red, as a consequence of the "cyan" separation, and is deliberate and desired. The exact parts of any given halftone densities on film 24, which are able to form as second-image elements, will depend on the random "lay" of halftone structure in the first and second platemaking images as results from the prescribed differential angling. For example, the few second-image elements in the blue-representing plate portion may not have the particular positions shown, or even be completely circular, though they will form generally in the same quarters of said portion. It should be appreciated that second-image elements actually represent amounts of minus-"cyan", although they will receive red ink.

Referring to FIG. 17, the 2-color printing surface 30'', double-imaged as described, may be used on substantially conventional offset lithographic equipment, e.g., including a plate cylinder 3, an offset cylinder 4, and impression cylinder 5 and two fountains 6 and 7 having distribution and form rollers. Normally the fountain first in line according to the direction of cylinder rotation, e.g., fountain 6, would be used to apply a colorless, aqueous, wetting solution to hydrophilic plate areas, while the fountain next in line, fountain 7, would apply greasy lithographic ink of any desired color. As here adapted, the greasy lithographic ink 1 is specifically of a black tone and the aqueous solution 2 is of red color, and may include binder and other components of an ink. The 2-color printing surface 30'' is mounted to cylinder 3, and will be given successive general applications of the inks 1 and 2 (in reverse order) as the cylinder rotates. But ink 1, of black tone, being greasy will be received only by first-image elements of the surface 30'', and ink 2, of red color, being aqueous will be received by 2nd-image elements of the surface 30''. If desired, the two inks could be components of an emulsion applied from a single fountain, the component inks being selectively received by first-image elements and second-image elements. Such emulsion systems are known for lithography, though usually the aqueous component is colorless. Hereinafter, reference to "1st" and "2nd" inks will not imply sequence or even separate application, nor (as will be understood from further example), necessary difference in composition or base.

Regarding ink colors, the black tone is preferably blue-black (such as will also be suited to reproduce typographic matter), and the red color is preferably a bright red. Departure from these recommended colors,

e.g., a neutral black or green-black, or a very deep or medium red, is permissible but will be less effective.

Conjunctive with the recommended use of blue-black ink and bright red ink, most effective results will be obtained when the printed substrate 8, e.g., paper, is of a selected pale color other than neutral white. The preferred substrate color is a pale green, e.g., about a 5-8 percent green tint. Such a substrate color would be analogous to the color of "Eye-Ease" writing paper, but lacking a bluish quality. The use of such off-white paper will negligibly affect the subjective general brightness or "crispness" of the reproduction, because of the excellent contrast and detail provided by the black-tone ink and because of other factors, e.g., a large proportion of substrate show-through for green and colors having a green-light component. A substrate of exceptionally high reflectance is not essential for effectiveness.

The printed representation of selected "key" colors is shown in FIG. 9, relative to FIG. 4, above. A substrate 8 of pale green tint has had simultaneously printed upon it, e.g., by the 2-color surface 30'', deposits 1' of a "first" ink having blue-black tone and deposits 2' of a "second" ink having bright red color. The ink deposits are in the form of halftone densities, and areas uniformly shaded in the drawing represent full halftone density. By reference to FIG. 4 it will be self-evident how the red and blue-black ink deposits "represent" respective "key" colors, but it will not be evident how such representation gives rise to the perception of correct color in each instance. The following paragraphs will attempt to clarify this.

Assuming a whole reproduction and not just selected individual colors thereof, all picture detail and tonal values would be represented by the halftone deposits of the blue-black ink. In the absence of red ink the reproduction would seem to be an ordinary "black-and-white" halftone print. But the particular distribution and amounts of red ink cause the observer to perceive a full-color reproduction. This phenomena (not observable from the Drawing) is related to the previously cited discoveries of Edwin H. Land, but as here applied to the printed page incorporates certain refinements. In common with Land's projected images and illuminated transparencies, the perceived colors here elicited are indistinguishable from "real" colors and have excellent constancy. Their physical absence would not be suspected, neither does knowledge of their physical absence diminish their apparent reality.

By physical measure (if possible) or by direct comparison, colors perceived in this reproduction will not be as bright as those in a conventional "Process" print. (The relative lack of brightness should not be confused for paleness.) Subjectively, however, the reproduction will appear more natural and correct than does a "Process" print. This is because a reduction of a life scene to page size normally has the psychological effect of making the reader unnaturally aware of the colors, per se. Reproductions of the instant type, in distinction, may be generally described as having a character akin to that of a skillfully hand-dyed photo print having both tints and tones of color, with comparable sharpness of detail and contrast (allowing for normal losses due to halftoning). The color quality of hand-dyed photo-prints is unique and pleasing, although such prints are largely obscure because of more rapid means of reproducing color.

White is perceived even though there is a presence of about 10 percent red dots, whether on a pale green substrate or a white substrate, presumably by reference to the reproduction as a whole. The red dots provide density to give other apparent colors correct value relative to perceived white. (By a variety of mechanical means the red dots can be prevented from forming in accent areas of a picture.) The absence of highlight black dots in areas representing white is instrumental in permitting the perception of yellow distinctly from white.

The sensation of yellow is experienced presumably because, in the immediate presence of red ink, exposed portions of substrate assume the additive role of a bright green, and also because the presence of slight black density provide a correct relative value compared with areas representing white. A full amount of red ink in yellow areas would render the yellow as orange, and such full presence of red has therefore been prevented.

Luminosity (by reflectance) from exposed portions of the substrate in areas representing green, gives rise to a strong sensation of green although there may be no red deposits immediate thereto to account for such effect by simultaneous contrast. A red referent elsewhere in the reproduction is presumably responsible. This effect is not dependent upon the use of a green-tinted paper.

The sensation of full red is seen in areas representing red, presumably by the substantial absence of any other luminosity from such area. Slight desaturation is caused by the minor blue component in blue-black ink, and this is largely compensated by the larger relative size of red deposits than blue-black ink deposits in the red-representing areas. The apparent brightness of reds is increased by the phenomena of simultaneous contrast, when, as recommended, the 2-color screen pattern is slightly coarser than could not be resolved by the eye. Accordingly, a physical measure of red intensity would be misleading. (Similar reinforcement of apparent intensity is present in areas representing green.)

The apparent presence of blue is believed to result from the fact that areas representing blue have slightly less halftone density than areas representing black, together with the small, permissibly almost insignificant, amounts of red therein. The red component is believed to additively combine with the minor blue component of the blue-black ink to form a dark purple, either confused with blue or which gives rise to a sensation of blue. (It is known that strong blue light will cause a sensation of weak purple.) By another explanation, the small amount of luminance from portions of substrate in such area tends to accentuate the blue component of the blue-black ink.

In any area representing black the blue quality of the blue-black ink is unnoticed, presumably because these areas are the darkest in a picture and automatically are considered black in the picture context. The absence of small "shadow dots" is deliberate, and intended to prevent accentuation of the blue quality of the blue-black ink, such as occurs (presumably) for blue.

The production of other apparent colors results from minor differences in amounts of red and black such as occur for the "key" colors, flesh tones, metallic tones, oranges, browns and purples being among those perceivable.

The recommended inclusion of a blue quantity in the black ink is in recognition of the fact that the first-

image elements do not merely represent amounts of minus-"red" and minus-"green", but also represent positive (indeterminate) amounts of blue, at least for all colors not purely red and/or green, or the color black. By some visual mechanism not well-understood, the bluish quality of the blue-black ink becomes pronounced generally to a degree which is locally appropriate. Because the substrate acts largely as if it were green (while at the same time its paleness enhances the picture brightness), the "green" together with the red ink and the blue of the blue-black ink, may in part operate in accordance with classical 3-color additive theory to produce an effective color reproduction.

Although a picture is the only matter which has been shown double-imaged upon the 2-color surface 30'', it will be understood that the "first" image on the surface 30'' could include incidental matter which is to reproduce in black (or blue-black) ink, while incidental matter which is to reproduce in red ink could comprise part of the "second" image on the surface 30''. It will therefore be appreciated that this invention is concerned only with forming a quantity (all or less than all) of first-image elements and second-image elements which cooperate to reproduce a full-color picture, when suitably inked.

The aforementioned procedures may be modified to form such cooperating first-image elements and second-image elements upon other latent 2-color printing surfaces. The necessary modifications will be dictated by the structure of the particular other latent 2-color surface.

For example, FIG. 19 shows a gravure equivalent of the 2-color printing surface 30'. In the gravure surface 40, first-image elements 1 and second-image elements 2 are recessed. The first-image elements (shown with cross-shading) and the second-image elements (shown with linear shading) may be assumed to have relative dispositions and information content equivalent to their counterparts on the 2-color surface 30'', except that a 2-color screen as in FIG. 3 was used for compositing the "red" and "green" separations. The portion of gravure surface represented is schematic, and of an arbitrary section of a whole reproduction, and elements therein are not intended to be a representation of any particular color. Use of the 2-color screen of FIG. 3 has given second-image elements of relatively full halftone density, a generally circular, rather than rectangular, shape, the circular shape being believed more suited for smooth traverse of a doctor blade.

Subsequent to their formation, first-image elements have been chemically treated to be exclusively receptive to a first ink, of black tone, and subsequent to their formation second-image elements have been given a chemical treatment so they will be exclusively receptive to a second ink, of a red color. The first and second inks may, aside from color, be of respective greasy and aqueous composition, or of any other compositions which are mutually immiscible, and they should have a consistency suited for gravure as well as different physical density. Such differential treatment of gravure cavities, together with suitably different ink compositions and means of generally applying such inks, is known in the art, e.g., as described by C.S. Miller in U.S. Pat. No. 3,213,787, previously cited. FIG. 19-A shows 1st and second inks as selectively received.

It is essential that the first-image elements and second-image elements be of a halftone structure such as

will result from a so-called "halftone gravure" process employing a halftone screen, and providing variable dot sizes (and optionally, variable depths). As in the preparation of Storms' surface, the first-image elements must be formed first, so their presence can govern the extent to which second-image elements will form. It will also be apparent that both platemaking images must normally be "positive", as etching of the surface 40 will be through a photo-resist. As a peculiar requirement of a 2-color gravure surface is that individual pockets be formed for respective inks, precautions must be taken to form a thin wall 41 around all first-image elements wherever they may be intimately juxtaposed to subsequently formed second-image elements. Optical formation of a thin ring of resist around all first-image elements will assure that a wall 41 will remain thereunder. Various particulars of these procedures will be apparent to those familiar with the preparation of gravure surfaces.

It must be understood that film intermediates of any kind, including first and second platemaking images, will not always be essential to actually forming the prescribed two images upon a latent 2-color printing surface, neither need there be material difference between first-image elements and second-image elements for them to be selectively receptive of generally applied inks. The following paragraphs will illustrate both these points by a single example.

Any photoconductive (PC) surface, e.g., a xerographic surface, is latently a 2-color printing surface, because techniques are known to form two (or more) images in common register thereon, and to give each image a distinctive color of ink. But it has been unobvious to form two images having disposition and information as hereinbefore described. Provided only that the PC surface is of a kind having sensitivity also to red light, the novel images may be formed as follows:

- a. The PC surface is electrostatically charged.
- b. A full-color picture to be reproduced is projected onto the PC surface, through a 2-color screen and separate yellow filter combination substantially as hereinbefore described.

By choice of illuminant, or by balancing filters or adjustment of screen colors, the PC surface is given an effective panchromatic sensitivity, if it was but poorly sensitive to red. The 2-color screen is preferably micro-fine and in the form of a reticle in the optical system, and has a pattern suited to allow "stepping" of the screen by an increment which will transpose spatial positions of red (sic) and "green" screen elements. If the PC surface does not have sufficient resolution to reproduce continuous-tones, a shiftable-angle halftone screen, e.g., of cross-line type, micro-ruled, may be placed just in front of the 2-color screen, or an equivalent halftone screen, macro-ruled, may be positioned close above the PC surface. (Red screen elements should here not transmit blue.)

- c. Toner of blue-black color is conventionally applied, and is received by the first-image elements optically formed in (b).
- d. The PC surface is recharged. Properly done, e.g., as with a charge of slightly lesser intensity, this need not cause separation of blue-black toner from the singly imaged PC surface.
- e. The yellow filter is removed from the optical path and a "cyan" filter is substituted; also, the 2-color screen is "stepped", and the halftone screen (if one

is used) is suitably reangled from the angle previously employed.

- f. A second exposure is made, the remaining charge areas being the second-image elements.

When no halftoning was used, the charges forming second-image elements will vary in strength, and may be co-incident with toner deposits on 1st-image elements. When halftoning was employed, these charges will be of uniform strength and in discrete areas co-disposed among the inked first-image elements. The presence of inked first-image elements will in either case limit the extent of formation of the charges constituting second-image elements.

- g. Toner of bright red color is conventionally applied, and is received substantially only by second-image elements optically formed as in (f).

- h. The two applied and received toners are conventionally transferred to a substrate of pale color, e.g., white or pale green, and conventionally fixed upon the substrate.

The above procedures, which are subject to refinement and modification as may be obvious, will produce a good representation of the original full-color picture, though involving slight compromise in general quality.

Any quantitative values which were hereinbefore given were solely to assist in understanding, and are not to be considered as limiting.

What I claim is:

1. Process of producing an apparent full color print of a multicolored picture, comprising the steps of:

- a. with a composite separation screen having interspersed 1st and 2nd areas which transmit substantially red and substantially green information, respectively, of said multicolor picture, photomechanically forming upon a printing surface a corresponding composite plate image, said composite plate image being receptive to a substantially neutral tone dark ink;

- b. photomechanically forming upon said printing plate, only in the plate portions corresponding to said first areas of said composite separation screen, a substantially cyan plate image of said multicolor picture, said cyan plate image being receptive to a substantially red ink;

- c. inking said composite plate image with said dark ink and said cyan plate image with said red ink; and
- d. making a single impression of said printing surface upon a receiving substrate having a selected pale color.

2. Process according to claim 1 wherein said composite plate image and said cyan plate image are halftone images.

3. Process according to claim 1 wherein said dark and red inks are mutually immiscible.

4. Process according to claim 1 wherein said tone of said substantially neutral tone dark ink is bluish black.

5. Process according to claim 1 wherein said substantially red ink is bright red.

6. Process according to claim 1 wherein said receiving substrate is white.

7. Process according to claim 1 wherein said receiving substrate is greenish white.

8. Process according to claim 1 wherein said substantially red separation also records a minor amount of blues.

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9. Process according to claim 1 wherein said substantially green separation also records a minor amount of blues.

10. Process according to claim 1 wherein said substantially cyan separation records blues more strongly than greens.

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11. Process according to claim 1 wherein said printing surface has text printing areas, and said text printing areas are inked with said dark ink together with said composite plate image.

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