United States Patent [19]

Lorber

[11] **3,752,073**

[45] **Aug. 14, 1973**

[54] **PROCESS FOR SINGLE-IMPRESSION MULTICOLOR PRINTING**

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[73] Assignee: **Bernard Olcott,** Atlantic Highlands, N.J.

[22] Filed: **Apr. 26, 1971**

[21] Appl. No.: **137,688**

Related U.S. Application Data

[62] Division of Ser. No. 754,168, Aug. 20, 1968.

[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, 101/175, 176, 395–401.1; 96/30–32

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Primary Examiner—J. Reed Fisher
Attorney—Bernard Olcott

[57] **ABSTRACT**

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

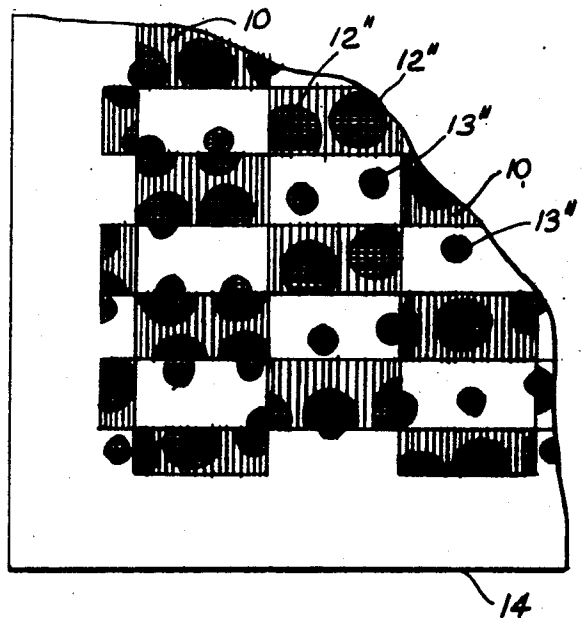
a. by use of a composite separation screen having interspersed 1st and 2nd filter areas which transmit substantially red and substantially green information, respectively, of the multicolored picture, photomechanically forming upon a printing surface halftone printing elements of a composite image having correspondingly interspersed 1st and 2nd information areas respectively for the red and the green information, all of the halftone printing elements being receptive to a dark ink of substantially neutral tone;

b. photomechanically forming field printing elements upon the printing surface only in portions of the surface corresponding to the 1st information areas, the field printing elements providing background to the halftone printing elements occurring within the 1st information areas, the field printing elements being receptive to a substantially red ink;

c. inking the halftone printing elements with the dark ink and the field printing elements with the red ink; and

d. simultaneously transferring the inks upon the printing elements to a receiving substrate of a selected pale color.

5 Claims, 27 Drawing Figures



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SHEET 1 OF 4

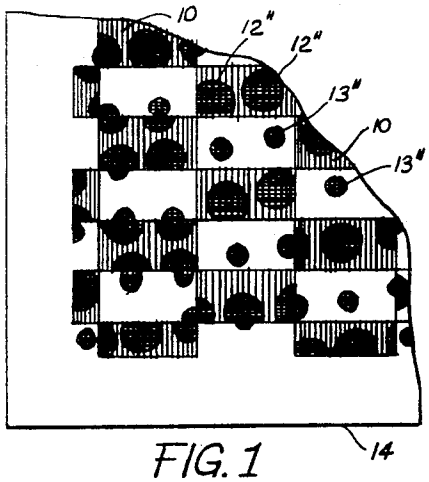


FIG. 1

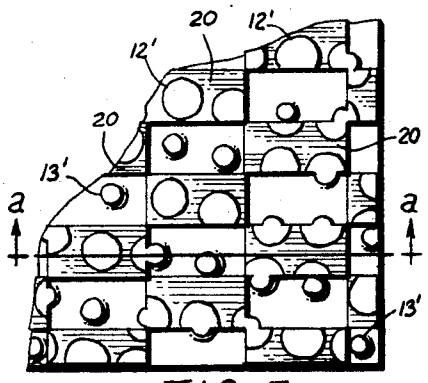


FIG. 5

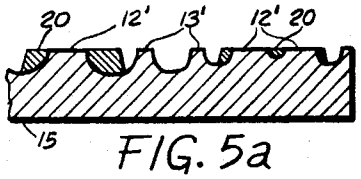


FIG. 5a

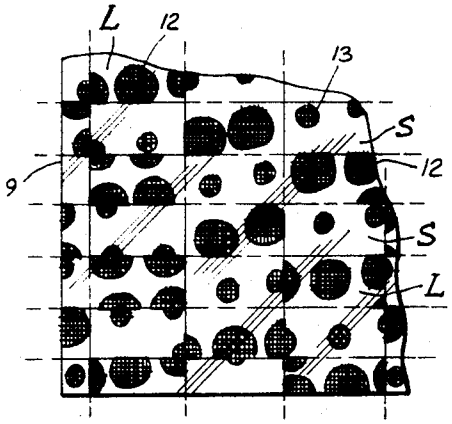


FIG. 2

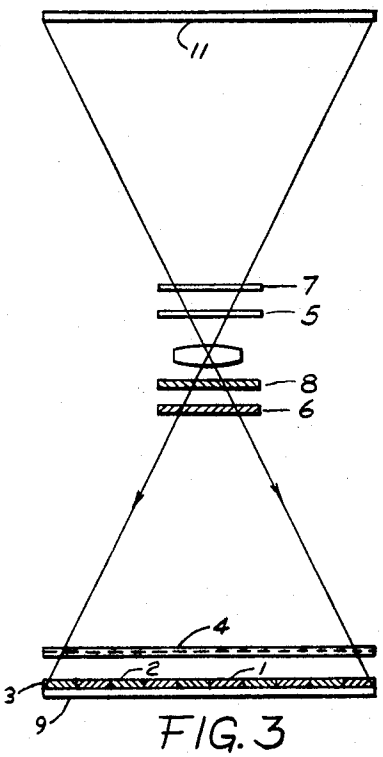


FIG. 3

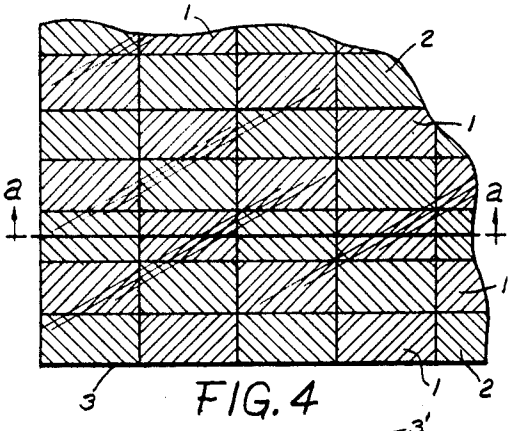


FIG. 4

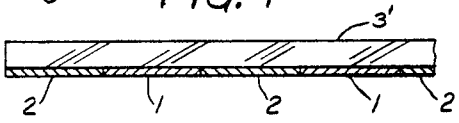


FIG. 4a

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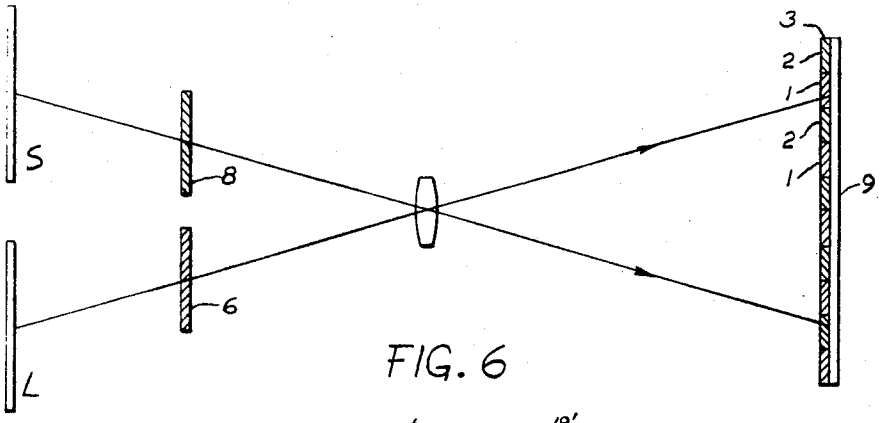


FIG. 6

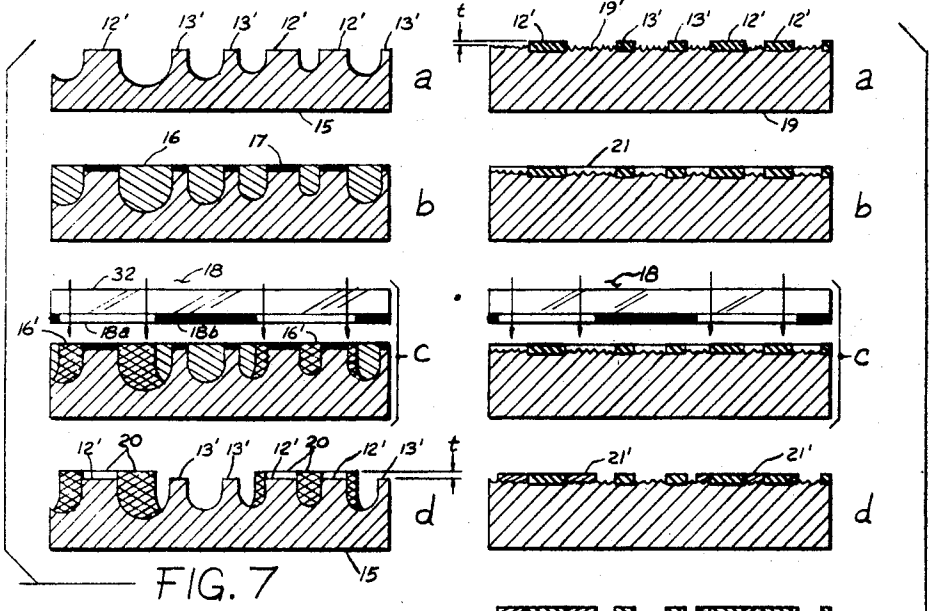


FIG. 7

FIG. 8

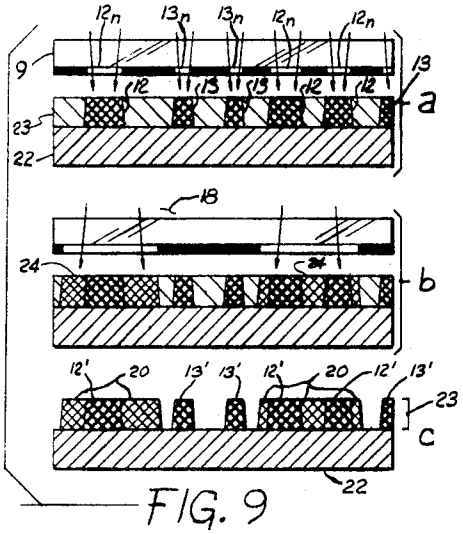


FIG. 9

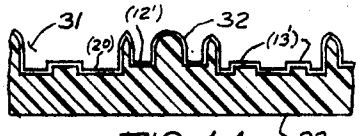


FIG. 11

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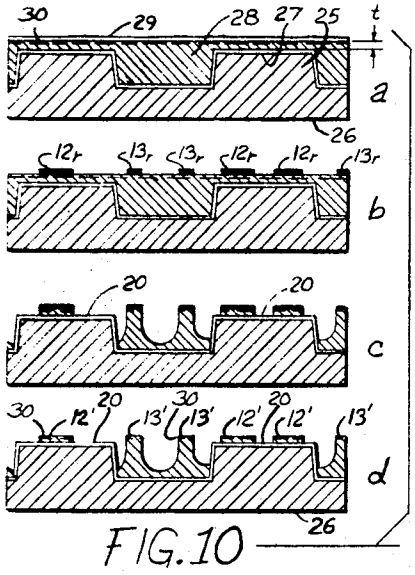


FIG. 10

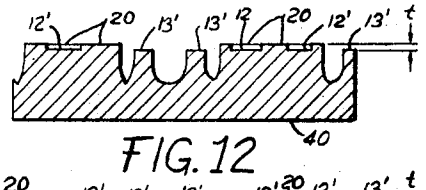


FIG. 12

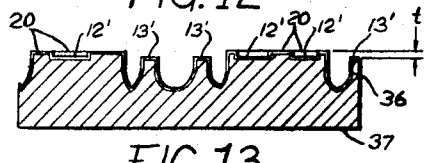


FIG. 13

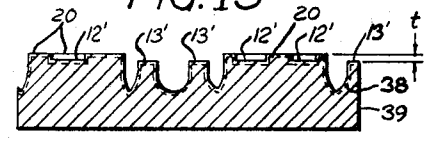


FIG. 14

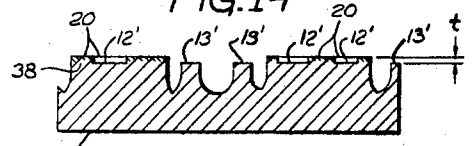


FIG. 15

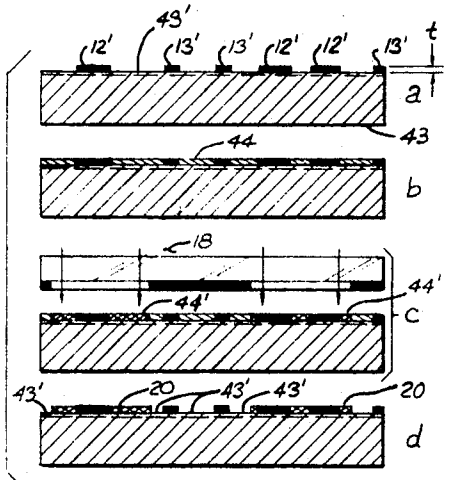


FIG. 17

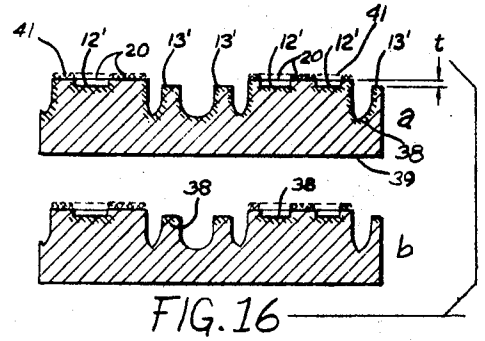


FIG. 16

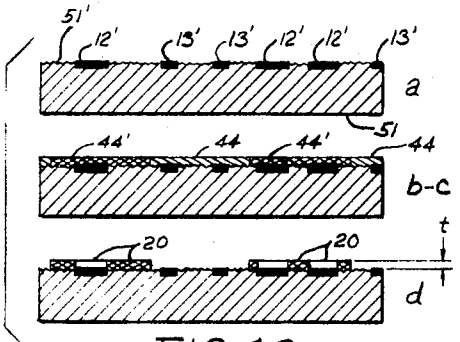


FIG. 18

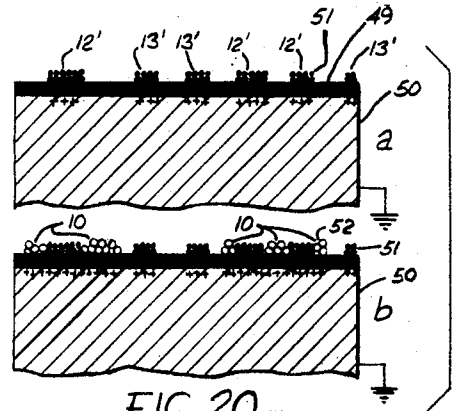


FIG. 20

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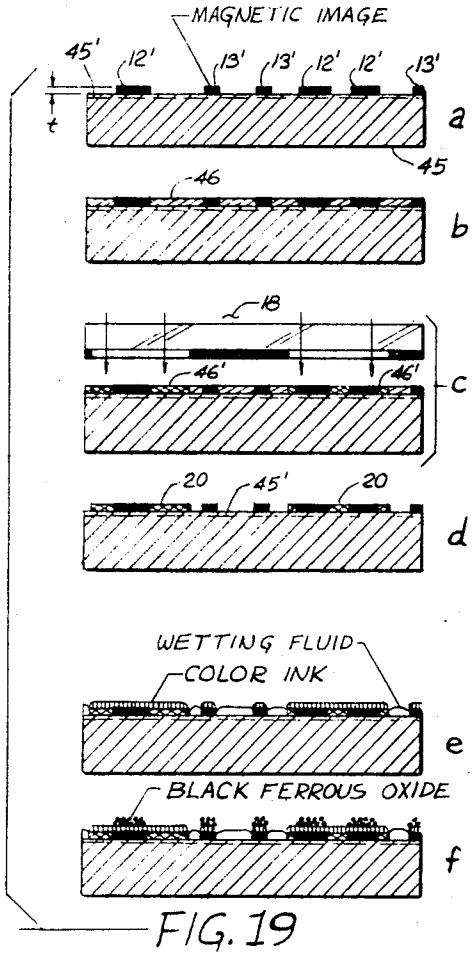


FIG. 19

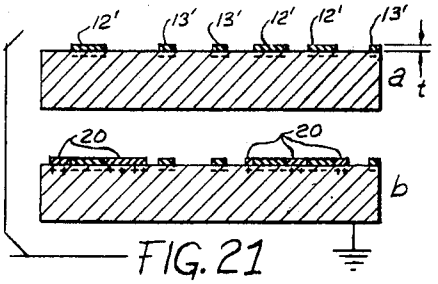


FIG. 21

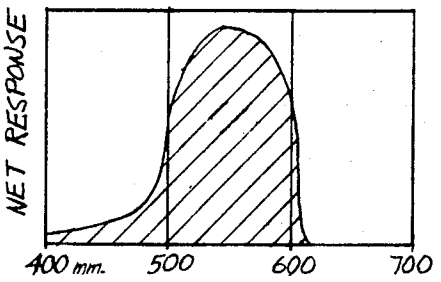


FIG. 22

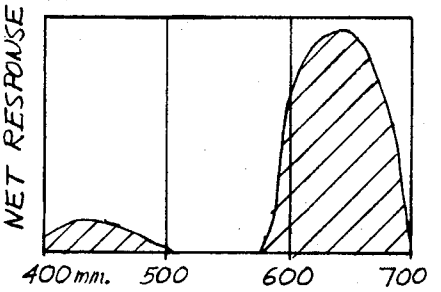


FIG. 23

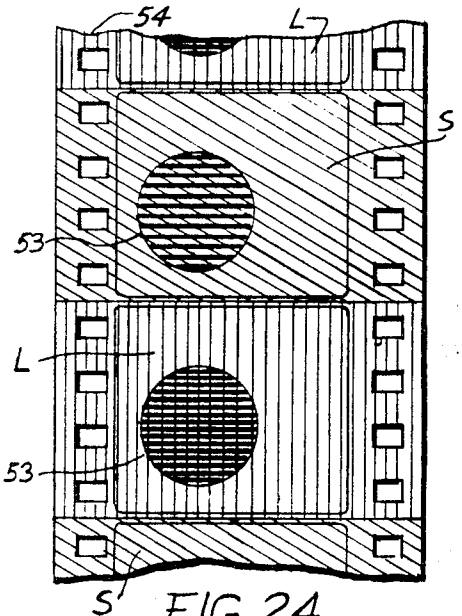


FIG. 24

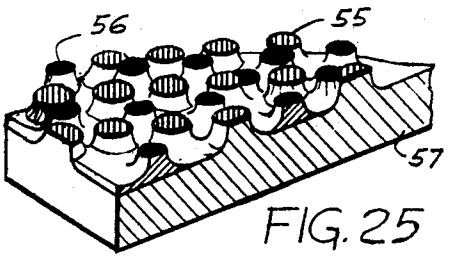


FIG. 25

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PROCESS FOR SINGLE-IMPRESSION MULTICOLOR PRINTING

This application is a divisional application of my earlier filed copending application, Ser. No. 754,168, now abandoned, filed Aug. 20, 1968.

My invention relates to the single-impression printing of multicolor pictures. Certain disclosures are also applicable to color projections and other optical color displays.

In *Scientific American*, May 1959, Dr. Edwin H. Land describes apparent colors whose perception is independent of the classical additive primaries. For example, an unexpected range of natural colors can be perceived merely by the use of red and white or two yellows, and black. By "natural" it is meant that the apparent colors are properly located in a picture and substantially correct in value and chroma. The article deals with projected and otherwise optically displayed pictures, but Land has also applied his findings to the printed page. I shall hereinafter refer to pictures such as Land describes and related phenomena as being "non-Maxwellian," inasmuch as they are at least in part distinct from the classical experiments of James Clerk Maxwell.

According to the existing art, a non-Maxwellian print requires either: (a) Two image-bearing plates to be printed in accurate register upon paper, either the paper or the illuminant or both preferably being of bluish tint (Land, U.S. Pat. No. 3,034,890); or (b) Accurate press register between a plurality of image-bearing plates, and use of an especially prepared single colored or multicolored patterned receiving surface (Land, U.S. Pat. Nos. 3,003,391 and 3,147,699). In his patents Land does not refer to his *Scientific American* article, but among his various embodiments are those clearly relating to phenomena described in the cited issue of *Scientific American*.

A principal object of my invention is to disclose means to print a natural multicolor picture in a single impression upon white or light-tinted paper and other plain surfaces.

Another object is to provide plates that will print a natural multicolor picture with but two inks, in one impression.

Still another object is to allow the single-impression printing of a natural multicolor picture simultaneously with other graphics, such as type matter, line work and halftones.

Yet another object is to permit incidental graphics accompanying a natural multicolor picture printed in one impression to be of dark tone and/or a particular color.

A further object is to provide for single-impression printing of natural multicolor pictures by means which eliminate color misregister on the press, which are adapted to high-speed rotary letterpress and planographic equipment (modified), which can utilize either an original or duplicate plate, and which are simple, economic and versatile.

Still a further object is to disclose means to enhance the fullness of gamut elicited by non-Maxwellian prints and optical displays; and

Yet a further object is to minimize the need for a tinted paper or tinted illuminant in non-Maxwellian prints and optical displays, respectively, or the depth of tint when such paper or illuminant is used.

Specific means to this invention and other objects thereof will become known from the accompanying drawings, which are enlarged, schematic and not necessarily to scale, wherein:

FIG. 1 shows a corner of a piece of paper upon which an apparently natural multicolor picture has been printed;

FIG. 2 shows a corner of a photographic composite image which can be used to prepare my printing plate;

FIG. 3 depicts a means of direct compositing/halftoning;

FIG. 4 shows the essential character of a "compositing screen";

FIG. 4*a* shows a possible section through the screen of FIG. 4, taken at the plane *a—a;*

FIG. 5 shows a corner of a plate which may have been used to print the picture shown in FIG. 1;

FIG. 5*a* shows a possible section through the plate of FIG. 5a, taken at the plane *a—a;*

FIG. 6 depicts an indirect means of forming a halftone composite image;

FIGS. 7 through 10 show stages in producing some types of my relief plate;

FIG. 11 shows a female mold which may be used to form duplicates of my relief plates;

FIGS. 12 through 16 show some types of my duplicate relief plate;

FIG. 17 shows stages in producing my "common" lithographic plate;

FIG. 18 shows stages in producing my "deep-etch" lithographic plate;

FIG. 19 shows stages in preparing my "magnetic" plate;

FIG. 20 shows stages in preparing a xerographic surface for printing a natural multicolor picture in a single transfer;

FIG. 21 shows stages in the preparation of my "electrostatic" plate;

FIG. 22 shows the suggested net response of a preferred short separation;

FIG. 23 shows the suggested net response of a preferred long separation;

FIG. 24 depicts specially-prepared positive transparencies for projecting a non-Maxwellian picture of improved gamut; and

FIG. 25 shows a "single-impression duotone" plate.

Broadly, and with exceptions, the means of my invention comprise: (a) Obtaining a photographic halftone image which is a composite of two selected color separations; (b) Utilizing the photographic composite to prepare a printing plate bearing a corresponding positive image; (c) Forming "field printers" on the plate contiguous to halftone dots of one particular component of the composite; (d) Utilizing plate materials and constructions that permit selective receptivity of inks or fluids generally applied across the whole plate surface; (e) Inking the plate with appropriate inks, which allows the composite image to accept ink of a "dark" tone and the "field printers" to accept ink of a selected color; and (f) Making a direct or offset impression onto paper or another receiving surface which, if not white, is of a selected tint or fuller color.

The "field printers" do not contain or print pictorial information, i.e., they comprise no "image" in the usual sense. Expressions involving the word "image" such as "composite image," "plate image," "ink image" refer only to that part of the plate or complete re-

production having pictorial content. The word "print" used as a noun refers to the reproduction as a whole. Numerals **12, 13** refer to a photographic image; notation **12', 13'** refers to the plate image; and notation **12'', 12''** refers to the printed image. Subscripts may be used for other forms of a composite image.

THE COMPLETE REPRODUCTION

A complete print, depicted shematically in FIG. **1**, comprises a positive halftone composite image **12'', 13''** printed in a "dark" ink upon paper or another contrasting receiving surface **14**. For clarity the halftone dots **12''** and **13''** are greatly enlarged and few in number, and no attempt has been made to actually represent a picture. The "dark" ink may be neutral or achromatic in tone, e.g., black or a value of gray as taught by Land, but preferably it is partially chromatic as described herein under the subject "Gamut Enhancement."

The printed composite image **12'', 13''** is accompanied by fields **10** of a selected color, e.g., a red, that are printed by "field printers" of the plate simultaneously with the image. These color fields **10** function as one of the two "stimuli" necessary for non-Maxwellian effects.

Receiving surface **14** may be white, tinted or of fuller hue. A feature of this invention is that surface **14** may more suitably be white or a very pale tint than has herebefore been wholly satisfactory for non-Maxwellian prints. Intervals of surface **14** between the color fields, where not occluded by halftone dots **13''**, function as the other of the two "stimuli" necessary for non-Maxwellian effects.

For best results the tint or fuller hue of the receiving surface is selected according to recommendations later given in the section "Gamut Enhancement," as is the specific color of the [color] fields. However, satisfactory results will be obtained when these "stimuli" are selected according to Land's teaching.

Color fields **10** are ordinarily distributed throughout the picture, but as an option they may be made absent from all or some highlight portions of the picture in addition to or in lieu of the absence of highlight halftone dots. Surprisingly, local absence of color fields is unnecessary for apparently true whites to be perceived (even if the receiving surface is tinted or of fuller hue).

When a print such as described and made as recommended is viewed in common illuminants or by daylight, a natural multicolor picture is perceived. Because all pictorial information resides in the "dark" image, because there is no desaturation due to physical color admixture as in "process" prints, and because there can be no loss of sharpness due to press misregister, the reproductions will have a crisp, bright quality rivaling reproductions made by conventional means. Also because the composite image contains all pictorial information and detail, the image strongly arrests the attention away from the composite pattern and color fields, which elements can be surprisingly large without becoming overtly noticeable as would coarse halftone dots.

THE COMPOSITE IMAGE

To form my printing plate I may first obtain a photographic composite image. As shown in FIG. **2**, this may comprise halftone dots **12** of a "long" color separation image and halftone dots **13** of a "short" color separation image upon a film **9**, of black-and-white nature. The "long" and "short" separations in their original negative form may, on black-and-white film, respectively record long-wavelength and short-wavelength colors of the original subject or copy, as described by Land. (A "short" separation can permissibly be an ordinary panchromatic image obtained without use of a filter; in claims where two color separations are mentioned, the use of such a panchromatic "separation" is within the intended scope.) The separations preferably have further characteristics disclosed herein under the subject "Gamut Enhancement." The photographic halftone composite image **12, 13** is assumed to be in positive form so that its correspondence to the printed image may more readily be seen. However, a photographic halftone composite image in negative form may be used when required for plate expsoure. A halftone composite image substitutes for the conventional platemaker's halftone image, and is used in an equivalent manner thereto.

Wherever I may mention or depict film, reference is actually to the emulsion on said film, and instead of a film support glass plate or equivalents may be used. While my photographs, as conventional in platemaking, are ordinarily black-and-white, it will be understood that the white (clear) portions may be dyed and that such a dyed image may nevertheless be equivalently used in forming an image upon a sensitized printing plate.

In further particulars, component areas L and S, respectively corresponding to portions of the long and short separations, are arranged in a sufficiently fine interlace or mosaic so that to casual inspection the two partial images appear as one. The two separations are, in effect, in interspersed register. [The composite pattern is quite satisfactorily coarser than the halftone screen.] While each component area L and S is shown as being of a size which will accommodate several halftone dots as they might more or less randomly fall, this is purely exemplary. Each component area might, in practice, be of a size which will accommodate one halftone dot or but part of a halftone dot. If desired, the halftone screen might be designed to locate each dot particularly with respect to component areas, e.g., central thereto.

A halftone screen may have the same angle for both separations, or may be differently angled for each. The angle(s) should be selected as to avoid moire effects with the color fields that will be present in the complete reproduction. For convenience in representation halftone dots **12** and **13** are shown as they may fall with single angling. An advantage of differential angling is that a composite so-made may be printed on rougher material with less apparent quality loss, than could a single-angled composite of equivalent screen fineness. Halftone dots **12** are shown as being different in size from dots **13**, indicative of tonal differences ordinarily occurring between separations; dots **12** are arbitrarily shown as being larger. In practice, halftone dots will not all be of circular shape, and may abut and cojoin with one another, and might solidly occupy individual component areas in shadow portions of the picture.

A mosaic of rectangular areas L and S has been chosen to facilitate understanding. However, any other composite pattern of order **2** may be used, for example: parallel strips; wavy strips; concentric rings; triangular mosaics; irregular mosaics; circles or other configura-

tions on a field (the field comprising one component and the configurations the other component). A preferred pattern is one that is in general regular, substantially nondirectional, and such that the two separations occupy roughly equal amounts of total picture area. As will later be understood, deliberate inequality of the total area of each separation may be introduced as a means of adjusting color balance, although other means are preferred and will be described.

I may obtain a halftone composite on film by the direct means shown in FIG. 3. It is assumed that platemaking requires a negative. The face of a "compositing screen" 3 is placed in intimate contact with the emulsion of panchromatic film 9, preferably of high contrast. Compositing screen 3, here represented schematically, may actually be as shown in FIG. 4 comprising transparent polarized areas 1 and 2. Areas 1 and 2, respectively, positionally correspond to components L and S of the composite shown in FIG. 2. Areas 1 are polarized in one direction and areas 2 are polarized in a substantially opposite direction. As may be seen in section in FIG. 4*a*, polarized areas 1 and 2 may be formed as topical elements of polarized material, e.g., molecularly aligned dichroically stained polyvinyl alcohol, or a matrix containing aligned dichroic crystals, upon a support 3′ of glass or other transparent, preferably stable, material. Various other obvious constructions may be used, but concern here is for the optical characteristics of the screen.

A halftone screen 4, e.g., of the crossline type, is placed at "screen distance" in front of the film. This screen may be angled so as to avoid moire effects with the composite pattern. A first exposure to color copy 11 is then made through a long separation filter 5 and through a polarizing filter 6 oriented to polarize light so that it will only pass through correspondingly polarized screen areas, e.g., areas 1. Thus halftone dots 12 which represent the long separation will image on the film only behind areas 1, the image being atten-uated by areas 2. A second exposure is then made through a short separation filter 7 and through a polarizing filter 8 oriented to polarize light so that it will only pass through compositing screen areas 2. (Polarizing filter 8 may be polarizing filter 6 which has been rotated 90° in its plane.) This exposure images short record dots 13 behind compositing screen areas 2. The halftone composite thus obtained is free of any halftone dots which may incurse or protrude out of their proper composite areas, as reflected by the "clippped" appearance of certain dots. Incursion would distort tonal values to the detriment of colors perceived in the final reproduction. As mentioned previously, the halftone screen 4 may be angled differently for each exposure, this being optional. The two angles in such case would be selected to avoid moire effects with each other and with the composite pattern.

By another direct means also with reference to FIG. 3, I may substitute for polarized screen areas 1 and 2 colors corresponding to the desired separation filters. No independent separation filters 5 and 7 will then be required, nor will polarized filters 6 and 8 be needed. If areas 1 and 2 (which act as separation filters) have either substantially equal filter factors or a deliberate inequality in filter factor, only one exposure to color copy need be made. If there is an undesired difference in filter factor an appropriate compensating filter can be inserted into the optical path during part or all of the exposure, or separation filters 5 and 7 can be used as before for two exposures. Assuming that the respective colors of areas 1 and 2 are somewhat overlapping in transmission as is generally desired for separation filters, a certain amount of halftone dot incursion will occur. However, the incursion in this case will be substantially "correct," as the incursing portions of the dots will be partially attenuated and reduced in size proportionate to the degree of transmission overlap of the separation filters.

By indirect means shown in FIG. 6, I first obtain a desired pair of long and short separations L and S which have been halftoned. These may be in positive form. By successive exposures I first image one halftone separation and then the other upon film 9. The film in this case may be ordinary blue-sensitive film, and a polarized compositing screen 3 as before described is against the film. For each exposure a polarized filter 6 or 8 is respectively used, essentially as before described for direct compositing. If desired, separation L can have been given a different halftone screen angle than separation S. The halftone screen angle(s) should, as before, be selected to avoid moire effects. By this means a negative platemaker's composite is obtained which is wholly free of halftone dot incursion.

In a variation of the above indirect means, compositing screen areas 1 and 2 are of mutually-exclusive colors, e.g., a near blue and a far blue with no overlapping transmission. The use of two blues will permit ordinary film to be used. If one of the mutually-exclusive colors is green orthochromatic film must be used; if one of the colors is red panchromatic film must be used. Two exposures are made, but instead of polarized filters 6 and 8 a pair of color filters is used. One color filter must be such that light transmitted through it will only pass through screen areas 1, and the other color filter must be such that its transmitted light will only pass through screen areas 2. While the color filters must generally correspond in color to their respective compositing screen areas, exact correspondence is not required. Either the screen areas and/or the color filters can be mutually-exclusive. This means will result in a halftone composite image wholly free of dot incursion.

In the various above-mentioned compositing means, where successive exposures have been mentioned, the sequence may be reversed; alternatively, a reverse beam splitter may be incorporated into the optical system to allow simultaneous exposure of both separations onto the film 9. I do not limit the general practice of this invention to a halftone composite derived by the aforementioned means, providing the composite has the essential structure as described. Instead of dots halftone elements may be of a linear form, as when the halftone screen is of a parallel ruled type or the like; in such cases the composite areas L and S may also be linear. Generally, the use of a dot-type halftone structure is preferred.

In distinction to the halftoning means I have described a continous-tone composite image may subsequently be halftoned, but the resultant halftone composite will suffer from incorrect incursion that will distort colors in the final reproduction. Although such effects can be minimized by using a halftone screen which is very fine relative to the composite pattern, and/or by reducing shadow values, such corrective measures have obvious practical shortcomings. I am fully aware that halftoning is not always a last step in

photographic procedures prior to platemaking, and that direct halftoning from color copy is sometimes practiced. Yet I believe that the application of such halftoning techniques in conjunction with a compositing screen, for obtaining halftone composites free of incorrect incursion, were never practiced and remain unobvious a priori.

The use of a photographic composite for platemaking is merely a convenience, and I may directly substitute for film a suitably sensitized printing plate. As will be later understood, a compositing screen can also be used as a "light-stencil" for platemaking.

THE PLATE

A printing plate bearing a composite image may be as shown in FIG. **5** and in section in FIG. **5a**. The composite plate image **12'**, **13'** is accompanied by "field printers" **20.** The field printers may be coincident with either long or short image components depending on whether they are to be inked with a "warm" color or a "cool" color ink. The drawing shows the field printers **20** associated with long comonents and halftone dots **12'** respective thereto, as this particular association is preferred. For the section, the halftone dots have been slightly re-arranged to facilitate schematic representation. In this example the plate image **12'**, **13'** is formed wholly in relief in a body material **15.** The field printers **20** are also in relief, but have their printing surfaces flush with the faces of the halftone dots; in effect, the field printers are in planographic relationship to halftone dots **13'** respective thereto. The plate is shown in an un-inked state, but as will become understood, halftone printing elements **12'**, **13'** exclusively receive an ink of "dark" tone and field printers **20** exclusively receive an ink of selected color.

A plate that prints a complete reproduction in a single impression may be in relief (non-printing portions being recessed) or it may be planographic (printing and non-printing elements being nominally in the same plane). Within these two broad classes a plate may have various basic forms or "types" which may in turn have secondary variations. The plate of FIG. **5** and FIG. *5a* was shown mostly for purposes of introductory description and is but one of several embodiments hereinafter described. All other plate sections in their final form may be considered alternative sections a—a of FIG. **5.** With few exceptions the plates are shown uninked.

My relief plates will be described first as they generally respresent the simplest means of practicing this invention, although requiring more extensive description. Each type has particular obvious advantages and no order of preference is intended.

In the following descriptions, and throughout this specification, any material not described as being hydrophilic is to be considered grease-receptive or lipidophilic and also hydrophobic. "Hydrophobic" is not used in an absolute sense, but means that a material or surface is either poorly wettable or non-wettable by water or other "wet" fluids as later described. A hydrophilic material or surface is readily wetted by water and other "wet" fluids.

RELIEF PLATE, TYPE I (FIG. *7d* and FIGS. **5** and *5a*). This plate is characterized by having the composite image **12'**, **13'** formed wholly in relief in a body **15.** Then the field printers **20** are formed thereon of another material. Referring to FIG. *7a–d:*

a. A positive halftone composite image **12'**, **13'** is formed in relief in a body **15.** Any suitable means of formation may be used. For example: the relief may be an original etched engraving in metal; a molded or electrotype duplicate of an original engraving; a relief formed on a photo-electric halftone engraving machine.

b. "Fill" **16** is applied to all recesses of the relief image. The fill is applied nominally flush with the faces of the image or with topping **17** thereupon. Fill may be inorganic, e.g., metal or ceramic, or it may be organic, e.g., a natural or synthetic polymer. Inorganic fill and organic fill which is not or cannot be directly photosensitized may be coated with photoresist, as the fill must be selectively removable by photoforming means. As here assumed the fill is directly sensitized and organic, the sensitization being of the "negative" light-insolublized type. As also assumed, the fill is of a hydrophilic nature and remains hydrophilic even after it has been light-reacted, or can be re-rendered hydrophilic. Some such materials will be described later. Topping **17,** if used, may optionally be the resist used in etching the plate. Topping provides an expedient means to form the field printers **20** in slight (planographic) relief t relative to the face of the plate image. Preferably the amount of relief t and the corresponding thickness of topping **17** does not exceed roughly two-thirds the face dimension of a highlight halftone dot. The use of a slight amount of relief *t* is generally recommended, but is not necessary except for certain purposes as will later be understood.

c. Fill **16** (or photoresist thereon) where coincident with long components of the composite and contiguous to halftone elements **12'** respective thereto, is exposed to actinic light through a light-stencil **18.** The light-stencil may comprise transparent areas **18***a* and opaque areas **18b** on a transparent support **32,** or may be as later described and equivalent to a compositing screen.

d. Portions of fill **16** not reacted by the actinic light (or not protected by light-reacted photoresist) are removed, e.g., by solvent development. Topping **17,** if any was used, may be removed by solvent or reagent or other means non-destructive to remaining portions of fill. Suitable topping may be left on the plate as an ink-base for a lipid ink, and if necessary may be solvated or softened. The image **12'**, **13'**, with or without topping, will receive a lipid ink of "dark" tone. The residual fill **16'** forms the field printers **20,** which if not already hydrophilic are treated to render them so, and receive an aqueous or "wet" ink of selected color.

By variations in procedure and/or materials the relief image may be or be rendered hydrophilic to receive an aqueous or "wet" ink of "dark" tone, while the field printers receive a lipid ink of selected color.

RELIEF PLATE, TYPE II (FIG. *8f*). This plate is characterized by being formed partly as a lithographic plate, e.g., halftone elements **12'** and field printers **20,** and partly as a relief plate, e.g., halftone elements **13'**. (It is considered to be a relief plate because non-printing portions are recessed.) Referring to FIG. *8a–f:*

a. Positive halftone composite image **12'**, **13'** is topically formed on a plate **19.** The plate may be a lithographic metal with a grained surface **19'**. The image is in slight relief t perferably not exceeding roughly two-thirds the face dimension of a highlight halftone dot. The typical image may be metal such as copper, brass or zinc which has been electrolytically deposited

through a negative stencil after light counteretching (in the general manner of a so-called "deep etch" lithographic plate but wherein metal has been applied rather than ink-base). Photosensitized gum arabic may suitably be used to form the stencil. The image may be rubbed up with a hydrophobic and grease-receptive ink-base and/or etch resist prior to removal of the stencil.

b. Bare areas of grained surface **19'** are coated with a photoresist **21**, e.g., of the "negative" light-insolublized type, preferably of hydrophilic nature. Photoresist **21** may be applied flush with or in slight excess of the image.

c. Photoresist **21**, where coincident with long components of the composite and contiguous to halftone dots **12'** respective thereto, is exposed to actinic light through a light-stencil **18**, essentially as before described with reference to a Type I relief plate.

d. Unexposed portions of photoresist **21** are removed, e.g., by solvent development.

e. Bared areas of grained surface **19'** are etched in depth, e.g., by acid or electrolytic removal. The depth is sufficient so that recessed portions of the plate image will not print (about 3 mils for highlight regions of a 133-line halftone, taken as a reference).

f. Residual resist **21'** is removed, e.g., by solvent or reagent. The solvent or reagent preferably does not dissolve or remove ink-base or resist which has been applied to the image **12'**, **13'**. The underlying grained surface **19'** forms the field printers **20**, which because of the graining are receptive to an aqueous or "wet" ink. The "wet" ink applied to the field printers will be of a selected color, while the lipid ink applied to the plate image will be of a "dark" tone.

Instead of the plate image being of metal it may be of light-reacted photoresist; instead of a grained surface **19'** a hydrophilic surface may be obtained by deoxiding or chromate treatment of the base metal, by formation of a sodium silicate film thereon, and by other known means. In the case of a silicate treatment initially uniform upon the plate, and when a metal image **12'**, **13'** is used, the silicate film may be locally removed by light abrasive blasting rather than chemical etching, to permit good adherence of the metal image to the base metal.

By variations in procedure and/or materials, the plate image **12'**, **13'** may be hydrophilic, e.g., by virtue of silicate treatment, and the field printers **20** may be lipidophilic, e.g., by being formed of a resinous hydrophobic resist.

RELIEF PLATE, TYPE III (FIG. 9*c*). This type of plate is characterized by having the composite image **12'**, **13'** and the field printers **20** formed of the same material differentially treated. Referring to FIG. 9*a–c:*

a. A latent positive halftone composite image **12, 13** is optically formed in depth in a photosensitized hydrophilic organic material **23**, e.g., sensitized gelatine, which material is preferably on a stable support **22**. Material or layer **23** is at least thick enough to accommodate highlight dots of the relief image which will later be formed in part for halftone elements **13** (about 3 mils for a 133-line halftone, taken as a reference). The exposure may best be made by contact printing through a negative halftone composite $12_n,13_n$ on a film **9**, using slightly divergent light rays. A full exposure is made to assure the maximum degree of insolubility, as the exposed portions must be receptive to a lipid or greasy ink.

b. Photolayer **23**, where coincident with long components of the composite and contiguous to latent halftone dots **12** respective thereto, is exposed to actinic light through a light-stencil **18**. The stencil may be as before described with reference to a Type I relief plate. The exposure is best made by contact printing, with the rays of light slightly divergent. This exposure is partial, sufficient to enable selective removal only of totally unexposed portions of the photolayer, sufficient to prevent ready solubility of partially exposed portions **24** when they are wetted by an aqueous or "wet" ink, yet not so much as to cause a total loss of the hydrophilic property of portions **24**.

c. The plate is solvent or wash-off developed sufficiently to only remove totally unexposed portions of photolayer **23**. Partially exposed portions **24** form the field printers **20** which receive an aqueous or "wet" ink of selected color, and fully exposed portions **12,13** become the plate image **12',13'** which receives a lipid ink of "dark" tone.

It will be noted that image elements **12'** are in true planographic relationship with field printers **20**. This is optional. To obtain a slight relative relief *t* (as shown in other drawings) I may counterremove part of the field printers after they have first been formed flush, e.g., by etching or by fluid erosion, so they are in slight intaglio relative to the plate image. (As will be understood, when slight relative relief t is desired either the field printers or the composite image may be in relief relative to the other.) While it is convenient to utilize the same material for the composite image and the field printers I do not limit myself to such practice. After the composite image is optically formed and developed into high relief, I may employ a wholly different material to form the field printers.

RELIEF PLATE, TYPE IV (FIG. 10*d*). This plate is characterized by having preformed field printers **20** in relief on or integral with a support or body **26**. The composite image **12',13'** is subsequently formed thereon, partly in relief (dots **13'**) and partly planographic (dots **12'**). It is deemed obvious from the drawing and from prior descriptions how the composite image may be formed of photosensitized material. Therefore the procedures here given will relate to a bimetallic embodiment. Referring to FIG. 10*a–d:*

a. Obtain a starting material. The starting material may comprise a body **26** having preformed appended or integral relief elements **25** which will become the field printers **20** (FIG. 7d). The relief elements **25** either are metal or are plated with a thin metal layer **27**, as here shown. A metal layer **27** may also be applied to relief elements of a different metal. Hereinafter in referring to relief elements **25** it should be understood that said reference includes any plating **27** thereon.

Relief elements **25** have a height nominally equal to the maximum depth of the composite relief image that will later be formed (roughly 3 mils for a 133-line halftone, taken as a reference), and they are, in plan, of such shape and distribution as will enable them to coincide with long components of the composite image.

Upon this structure is provided a flat-surfaced metal layer **28** which is of a metal selectively removable relative to underlying material. Thus, assuming the use of a mild acid etchant or electrolytic removal, layer **28** can, for example, be magnesium or zinc and layer **27**

may be copper, silver or gold or other less electrolytically active metal. (The plate substructure can be reusable.) Layer **28** is in slight excess t above relief elements **25.** The excess t preferably does not exceed roughly two-thirds the face dimension of a highlight halftone dot of the intended composite image.

Photoresist **29** is applied to layer **28.** Sensitization of this resist may suitably be of the "negative" light-insolublized type, and the resist is preferably of hydrophilic nature. Before application of the resist **29** the surface of layer **28** is rendered hydrophilic, e.g., by formation of a sodium silicate film **30** thereon.

This starting material may be a ready-made manufactured product (possibly with a sensitized topping **29**) intended for use with a composite image of standardized pattern.

b. By use of a photographic halftone composite instead of a usual platemaker's halftone, a positive halftone composite image $12_r,13_r$ is formed of light-reacted resist **29,** and unexposed portions are removed, e.g., by solvent development. The resist image $12_r,13_r$ must be in accurate register with the relief elements **25** so that long components of the composite image and halftone dots 12_r respective thereto are coincident with elements **25.** Because elements **25** are not visible, various indirect means must be used to secure such register. For example, the excess t of layer **28** could be locally removed beyond the actual picture format of the plate. The exposed elements **25** can then be visually aligned with a corresponding reference beyond the actual picture format of the photographic composite image. Alternatively, resist topping **29** may have a non-imaging, e.g., light blue, pattern printed thereon which corresponds to the underlying pattern of relief elements.

c. The resist image $12_r,13_r$ is formed in its various degrees of relief, e.g., by abrasive blasting, chemical etching, electrolytic removal or by combinations of such means. Halftone dots 13_r in particular must be eteched to their full depth so that bottom printing will not occur from recesses therebetween.

d. Resist image $12_r,13_r$ is removed by a suitable reagent or solvent; corresponding underlying faces of layer **28** thereby become the composite plate image **12',13'.** Relief elements **25** function as the field printers **20,** where not occluded by halftone dots **13'.** Unlike other embodiments of relief plate that have been described at length, in this case the image **12',13'** is hydrophilic and will receive a "wet" ink of "dark" tone, and field printers **20** will receive a lipid ink of selected color. By means that will be understood from a general discussion later given, the field printers **20** may be rendered hydrophilic instead of the plate image.

In a variation, layer **28** is not originally formed in slight excess *t*, but is flush with the faces of relief elements **25,** the photoresist **29** being commonly applied to both the layer **28** and the relief elements. The resist image $12_r,13_4$ is left on the plate to directly become the plate image **12',13',** etching taking place only around dots 13_r. The plate image **12',13'** receives a lipid ink of "dark" tone. Field printers **20,** which are the parts of relief elements **25** not occluded by halftone dots **12',** must be or be rendered hydrophilic and receptive to an aqueous or "wet" ink of selected color.

GENERAL CONSIDERATIONS

As might already be understood from the description of my relief plates, two immiscible inks are used—one being lipid, and the other aqueous or "wet". While I explain my invention in terms of a lipid ink and a "wet" ink, I do not exclude the use of other pigmented or dyed fluids which ae immiscible each with the other. Preferably the lipid ink is the "dark" ink and the wet ink is the color ink. Accordingly, in all the examples of plate construction except for a Type IV plate, the field printers are ordinarily shown and described as intended for receiving the wet ink.

By "wet" ink I mean any colored or toned fluid behaving essentially as water relative to a lipid or greasy fluid, e.g., an aqueous solution or suspension whether thin or mucilaginous, a low viscosity polyvinyl alcohol, a simple alcohol solution or suspension, or combinations of such fluids. By "alcohol" or "simple alcohol" I mean to include methyl, ethyl, propyl or butyl alcohol, isopropyl alcohol and isobutyl alcohols, and mixtures of these with each other or with water. It will be understood that a wet ink will be non-reducable or miscible with a solvent or thinner for the lipid or greasy ink.

By "lipid" ink I intend to include greasy or hydrophobic resinous ink such as is common to lithography and letterpress, whose vehicle is reducable in an aromatic or aliphatic hydrocarbon solvent, and any other colored or toned fluid substantially insoluble or immiscible in water and/or alcohol. Those lipid inks most readily soluble in the aromatic hydrocarbon solvents are generally preferred. The term "lipid" is not solely intended to relate to oleoaginous substances, but is here meant to include hydrophobic polymers and resins in a fluid state.

To permit selective reception of the two inks, two different plate materials are ordinarily used, but as will later be understood from a discussion of duplicate plates, the two plate materials may be exactly identical whether formed separately or at the same time, yet may be selectively inked. Ordinarily though, one material is or can be rendered hydrophilic and readily wettable, while the other material is hydrophobic and but poorly wettable. Reference to wetting solely relates to wetting by water and the like, unless specifically stated otherwise. In nature, hydrophobic materials are grease-receptive of lipidophilic. Therefore, unless otherwise stated, a lipidophilic surface or material is also assumed to be hydrophobic.

As was mentioned, the term "hydrophobic" is not used in an absolute sense. Virtually all platemaking metals, natural resins and synthetic polymers, and surface films natural thereto, e.g., common oxide films, are adequately hydrophobic, and receptive to lipid inks in the letterpress and lithographic consistencies herefor employed. Thus elements intended to receive lipid ink and resist wetting will require no special selection or surface treatment. It is nevertheless desirable to apply a lipid ink-base to such surfaces during an appropriate stage of plate preparation, essentially as conventional, to further promote their receptivity to lipid ink and rejection of wet ink.

Somewhat more care must be exercised in selecting materials to receive the wet ink. While I rely much upon general knowledge in the platemaking arts as to the various surface properties of materials and means to enhance their wettability, some means of enabling wettability will be reviewed here.

It is known that metals may be rendered hydrophilic by abrading, graining, de-oxiding and formation of a hydrophilic silicate film thereon. The amphoteric metals are most amenable to the latter treatment, which may suitably be as described by Jewett, U.S. Pat. No. 2,714,066. However, I do not limit treatments to flat surfaces or sheet stock as is conventional, but may treat my plates in any appropriate stage of their completion. Rubber and many other elastomers may be rendered hydrophilic by oxide removal such as by chromic acid, mild abrasion or a reducing flame, but are often sufficiently hydrophilic for use herein even without such treatment. Gelatine, casein, gum arabic, hydrolyzed cellulose esters, hydrolyzed shellac, polyvinyl alcohol and other organic materials are known to be hydrophilic, and by various known means these materials may be mixed with each other and compounded and mixed with different substances to give them further properties desired in plate materials, e.g., insolubility without loss of wettability, durability, etc. Instead of being limited to thin, perhaps monomolecular, films of hydrophilic silicates, I may employ such materials in thick section for plate elements. I may also form hydrophilic plate elements of a light-reacted photosensitized hydrolyzed organic ester, e.g., of cellulose acetate, which, after formation is surface re-hydrolyzed to restore its wettability. Such surface re-hydrolyzation has never been practiced in platemaking, to the best of my knowledge. Alternatively, I may but partially expose a photosensitized organic hydrophil, as was described in the examples, so that it remains wettable. By a further alternative I may form hydrophilic plate elements of a photosensitized hydrophil which remains wettable after a full exposure, contrary to most such materials. Photosensitive materials with such properties are described by Oster, U.S. Pat. No. 3,097,096 column 7, line 53. In the claims where a plate material or element has hydrophilic surface character, or is topical and hydrophilic, I am concerned solely with surface properties regardless of underlying structure however thick or thin, which underlying structure may or may not also be hydrophilic.

In discussing plate materials or elements I am specifically concerned with those materials or elements which receive ink, whether lipid or wet, and not with non-participating materials or elements that may be employed as a support or for strength, or to build up the plate in overall thickness. While I have shown at least one material for each type of relief plate as being metal (except for a Type III plate), I do not limit myself to such practice. Plate materials will vary in their suitability for various modes of printing. Metal is preferred for each of the two plate materials when durability is especially important, as in direct printing. Rubber and other elastomers may suitably be used for both plate elements for printing on rough and inelastic materials such as glass and sheet metal. For offset printing, use of a photosensitized light-reacted organic material for one of the plate elements, regardless of the other plate material, is suitable for printing runs of average length and simplifies plate preparation, and for offset printing duplicate plates later described are also adequately suited as regards durability. As will later be described, field printers may be formed (on a Type I plate) of materials which do not have to be capable of selective removal whether by photoforming or other means, some such materials being platable metals, amalgams, ceramics and non-photosensitized organics; the latter three categories can include materials which are naturally hydrophilic without special treatment.

Although the use of a mucilaginous or somewhat thickened wet ink is within the scope of this invention, the wet ink should in general be as thin a fluid as possible without losing its ability to film-wet the plate surfaces receiving it. Film-wetting is necessary to keep a wet ink from running into the image recesses of a relief plate and from being thrown off the plate at high printing speeds. Film-wetting need not be absolute—a wet ink may permissibly have a slight tendency to creep provided it remains substantially as a film for the short duration until the plate has been impressed. The more hydrophilic the plate material, the less mucilaginous and tacky need be the wet ink. Thus, by using a suitably mucilaginous wet ink many metals and polymeric materials not usually considered to be hydrophilic may nevertheless be used to receive a wet ink. A mucilaginous wet ink can also be used when a gloss or semi-gloss is desired on the printed page. The term "mucilaginous" is herein used as a description of tackiness or viscosity, and does not necessarily imply that the mucilage be constituted of vegetable gums or heteropolysaccharides as is common. For example I may use as a mucilaginous ink a colored or dark toned viscous solution of sodium or potassium silicate (water glass), or I may add such material to another wet ink. Casein and other proteinous materials in aqueous suspension are readily formulable in viscous consistencies, and with appropriate coloring or toning may be used as a wet ink of mucilaginous consistency or thinner consistency. Heretofore to my knowledge, relief printing with wet inks has, as in flexography, been limited to use of slow-oxidizing organic materials such as rubber or of rubber-like nature, excluding metals and other directly etchable or formable materials. I contemplate making conventional relief plates of metal and other materials which may not be especially hydrophilic and inking them with a mucilaginous wet ink. As will later be understood, such plates may be used in conjunction with my single-impression multicolor plates. Of course I may also form such conventional reliefs of more readily hydrophilic material, e.g., gelatine or soft rubber, as is known, and apply a wet ink whether thin or mucilaginous thereto, and I may also use such plates in conjunction with my single-impression multicolor plates. When such conventional but wettable relief plates are used alone the wet ink may be very thick and tacky, but a wet ink cannot be excessively thick or mucilaginous for the present single-impression multicolor plates as it will lose its immiscibility with the lipid ink. However absolute immiscibility is not required.

When the plate material for the wet ink is but poorly wettable and a relatively thick mucilaginous ink is indicated, immiscibility with the lipid ink may be enhanced by using dye rather than pigment for one or both inks. The lipid ink in such case can advantageously have suspended particles of wax or solid silicone polymer. This will help it remain immiscible with the mucilaginous wet ink, by making the lipid ink more stiff and waxy. As conventional the wax additive may be dissolved, but the use of a solid wax additive is preferred. Whenever two dyes are used, it is desirable that one be an acid dye and the other be a basic dye, and that these be mordanted to their respective fluids. (I consider two or

more dyes acting subtractively, and in the same fluid, to be equivalent to a single dye.)

The lipid ink ordinarily has substantially greater body or viscosity than the wet ink, being in the nature of letterpress ink or at least of lithographic ink. It is within the scope of this invention to use a reversed system wherein the lipid ink is thin and the wet ink very thick, but such practice is not preferred. In the latter mode of printing it is preferably the lipid ink which is colored and the wet ink which is "dark." With either mode of inking a slight amount of bleeding of the color ink is permissible on the paper or other receiving surface. Such bleeding can create a vignetted effect that will soften the apparent contrast of the color fields against the background of paper. This will not be detrimental to the crispness of the print if slight, as all the detail and pictorial information is in the "dark" composite image. Vignetted color fields may be slightly larger than would otherwise be satisfactory. Emphasis is again made that the color fields may be in general surprisingly large without being casually discernable in the incomplete reproduction, e.g., they may be of the order of 32 per linear inch, interspersed by portions of the paper.

The reason why a lipid ink of letterpress consistency can be used with an aqueous or like fluid for purposes of this invention, whereas a reduced consistency lipid ink is conventionally used in lithography in conjunction with an aqueous fountain or dampening solution, is that the aqueous fluid is herein intended to print and transfer to the paper. The wet fluid or ink may therefore be applied somewhat more liberally than can the wetting solution used in lithography. If, with the sparse wetting common to lithography a more full-bodied lipid ink was employed, the lipid ink would tend to take to the non-printing areas of the plate. Single color lithography or monotone is not done with a thick lipid ink and more generous water although such practice might thus seem feasible, because so much of the average plate is non-printing that the total amount of water carried to the paper would be excessive. With this invention only a small percentage of the picture is printed in a wet ink, and what moisture is transferred and might cause paper distortion can be ignored because no subsequent impressions are necessary. When a lipid ink of lithographic consistency is employed for my plates the wet ink is preferably not at all or but slightly mucilaginous, and the plate material therefor is preferably highly hydrophilic. A thin wet ink may suitably be merely dyed alcohol and/or water. Modern dyes are sufficiently intense so that only sparse inking with the wet ink will be needed.

It should be understood that I do not limit hydrophilic surfaces only to the reception of a wet ink whether thin or mucilaginous, as such surfaces if dry can suitably receive a lipid ink. This fact will be appreciated from a later discussion of duplicate plates some of which depend thereon for their operation.

As particularly regards a Type I relief plate, various kinds of fill which may be used can be applied to recesses of the plate image by any means appropriate to its nature. Photosensitized and non-sensitized organic fill may be originally in liquid, paste or plastic form which is poured, rolled or wiped on. It can then be doctored flush with the plate image or topping thereon while fluid, or scraped flush after it has set. The actual photosensitization may be done before or after application. Thermoplastic materials may be melted on and then doctored flush, and similar procedure may be used for low melting alloys. Platable metals may be electrodeposited, any excess being mechanically removed as by surface planing. Where a fill applied in solvated form may "sink" due to loss of solvent by evaporation, the application may be repeated as necessary to secure a flush surface, or the fill may be applied in excess and allowed to dry, after which it is finished flush. Photosensitized fill materials applied as a liquid need not necessarily have set prior to exposure under a light-stencil. Some such materials that may be exposed while in the liquid state are described by Oster, U.S. Pat. Nos. 2,875,047; 3,074,794 and 3,097,096 and these are also sensitive to visible light and have certain advantages both as fill and as photoresist which will later be discussed. As was mentioned, Oster also describes hydrophilic resists which remain hydrophilic after a full exposure. Materials that may not be readily receptive to hydrophilic fill in liquified or semi-liquid form may be made adequately receptive by phosphate or chromate treatment or by other known means commonly employed when depositing hydrophilic photoresists upon metal plates and other supports of generally hydrophobic poorly-wettable nature.

Fill materials that cannot be directly photosensitized may, as described, coated with photoresist and selectively removed by photomechanical means. Alternative to such procedure these materials when desired as field printers may be formed as follows: First a directly sensitized fill is applied and is exposed under a reverse or "negative" light-stencil wherein areas **18*b*** are transparent and areas **18*a*** are opaque, except if the sensitization of the fill is of the reversal or light-detached type. In the latter case the usual light-stencil can be used. Unexposed or light-detached portions of fill are then removed. The residual portions of fill are used as a stencil for the application of the desired non-sensitized fill fill which forms the field printers after the stencil has been removed. Some materials suitable for field printers formed by the aforementioned means include platable metals, amalgams, sodium silicate grout, lime and other hydraulic cements, and natural and synthetic polymers. Thus, field printers may be formed which may be of material that does not have to be selectively removable relative to the plate image, and which can be naturally hydrophilic for reception of a wet ink, if the latter property is desired.

For all relief plates and for other plates later described, whenever a light-stencil is required it will be equivalent to use a compositing screen, and especially advantageous when the compositing screen is the very same as was originally used to form the composite image. Accurate register between the image and the field printers will thus be more readily assured. When a compositing screen is substituted for a light-stencil only one set of screen areas is caused to be attenuating to the actinic light, these areas corresponding to light-stencil areas **18b** in function. For this purpose either a polarized filter or a color filter is inserted into the optical path, depending on the particular type of compositing screen. Use of a color compositing screen as a light-stencil will also require that the photosensitive material on the plate be responsive to the color of light transmitted by the screen. Most photosensitized materials are blue sensitive; obviously such materials will not be usable when the actinic light is otherwise colored. For the

latter case, Oster's photosensitive materials are particularly useful.

If it is desired that color fields not be present in the highlight portions of a complete print, their corresponding field printers may either be kept from formation or locally removed from the finished plate Local removal is most readily performed on a Type I PLATE, E.G., by use of selective etchants or reagents. "Removal" need not be complete, it being sufficient merely to reduce the field printers below a printing height, and a vignetted effect is readily achieved. Field printers may be locally kept from formation by painting out on the light-stencil or equivalent. As was mentioned, local absence of color fields is surprisingly unnecessary for apparently true whites to be perceived.

DUPLICATE RELIEF PLATES

The relief plates hereinbefore described may be used to prepare duplicates which will have an identical composite image and pattern of field printers, although differing in structure. It is necessary for such purpose to use an original plate which has a slight amount of relief *t*. As was mentioned, either the field printers or the plate image may be in relief t relative to the other although the former is preferred. In all cases the relief t is sufficiently slight as to maintain a nominal planographic relationship between field printers and halftone dots respective thereto. Within this limitation, the amount of relief should be as generous as is possible. When an original plate is intended expressly for the purpose of being used as a master for making duplicates, the plate materials need not be selected with particular consideration as to their working properties, and might only be suited for proof inking. The materials of construction can be selected for their ability to withstand the rigors of moldmaking. An original plate that contains hardenable material, e.g., a partially exposed organic resist, may, after running proofs, have such material further hardened by appropriate physical or chemical means. Original plates containing frail or elastomeric material not ordinarily suited for use as a pattern in moldmaking, may have duplicates made therefrom by means here described instead of more conventional moldmaking procedures.

In general, an original relief plate of my construction may be considered equivalent to an ordinary relief in the sense that non-printing portions are recessed (and only in said sense). Any conventional duplicating method may therefore be employed which involves the making of a female mold from the original or master and then obtaining one or more positive male duplicates therefrom. Similar techniques may thus be used as are employed in making electrotypes, stereotypes, plastiplates, "duplicate originals" and rubber plates. As will be seen, my duplicates may be formed of many conventional materials as well as many less common materials.

However, to my knowledge, conventional moldmaking methods involve subjecting the original to considerable heat and/or pressure. Thus, such means cannot be well-used on those of my original plates which may contain frail or elastomeric or thermoplastic material, or which are in other words "fragile." As shown in FIG. 11, for duplicating fragile originals I prefer that the female mold 31 comprise a metal shell 32 which is electroformed upon the original. When the shell 32 has reached a desired thickness it may be backed up with any suitable rigid or semi-rigid material 33 for strength, e.g., with epoxy resin or a cold-set plastic. This female mold is then used to make either electrotype duplicates or cast or molded duplicates.

Duplicates obtained from molds of my original relief plates will differ from ordinary duplicate reliefs. My duplicates are, regardless of an essentially homogeneous structure as first formed, amenable to selective inking or treatment of only certain printing surfaces. The various basic types of duplicate now described do not relate to the "types" of original relief plates but are a distinct notation. Each type has its own obvious advantages and no special order of preference is intended.

DUPLICATE RELIEF PLATE, TYPE I (FIG. 12). This duplicate is molded of naturally hydrophilic material 40. The material 40 must set firm and still be hydrophilic, and must not be dissolved by wet ink at ordinary operating temperatures. Among suitable organic materials are hydrolyzed gelatine, hydrolyzed cellulosics, hydrolyzed casein, hydrolyzed shellac, rubber, vinyl and acrylic latexes and soft rubber; among inorganic materials are sodium and potassium silicates, hydrocal plaster and lime cement. Hydrophilic organics, in particular, may be compounded or admixed with other materials, partially polymerized and otherwise rendered less readily soluble and more durable. I do not limit this type of duplicate only to organic and inorganic hydrophils in their most simple or common forms. For my wet ink I may use simple water and/or alcohol dye solutions or I may employ another wet ink related thereto, e.g., a mucilaginous ink, casein ink, shellac ink, or a water-dispersed latex. Pre-press preparation may be as follows:

When the freshly molded duplicate is dry, water or another thin wet fluid is applied only to the slightly raised field printers 20. This may be done by impressing the duplicate upon a wetted platen or other flat surface. The fluid film on the platen must be shallow, and the platen stiff, as the degree of relief t is very slight. If necessary, repeated light impressions, slightly displaced, may be made to assure full coverage of the field printers and no other portions of the duplicate. Before the wet fluid has dried the composite image 12',13' is conventionally rolled up with lipid ink-base. The wetted field printers will reject the lipid ink-base. By alternative procedure, first a lipid ink-base is applied only to the field printers 20. Subsequently the plate is rolled up with a wet fluid to which the ink-base is repellant.

In the aforementioned preparatory procedures one or both fluids may be colored or toned, and could be the actual inks used in the press.

DUPLICATE RELIEF PLATE, TYPE II (FIG. 13). This duplicate has a metal facing, preferably of an amphoteric metal such as magnesium or aluminum. The facing 36 may be electrolytically deposited upon a molded body; conversely, the duplicate may comprise an electroformed facing or shell 36 to which a backing has been applied. Regardless of how the duplicate body 37 is formed, the metal facing or shell 36 is subsequently given a topical treatment to render it hydrophilic, such means having been previously reviewed. The treated layer of the facing 36 may be very thin, perhaps monomolecular in the case of a silicate film, and is not separately shown in the drawing because the exaggeration necessary would make this duplicate difficult to compare with other duplicates and original plates.

Although the whole metal facing is treated including the recesses, by a variation only the faces of the field printers **20** can be treated. This may be done by lightly impressing the metal-faced duplicate against a platen or the like which has been sparsely wetted with treating solution or abrasive, repeated slightly displaced impressions or mild rubbing being used as required.

The molded body or backing **37** may be of any material commonly used for such purposes, e.g., polyvinyl chloride, a phenolic resin or any other suitably structural material to which a metal facing may be firmly applied or which will adhere well to a metal shell. Ordinarily it is irrelevant whether the backing is hydrophobic or hydrophilic.

Pre-press preparation may be essentially as described for a duplicate, Type I. However, if only field printers **20** were given a hydrophilic treatment, after the duplicate is dry the first-applied fluid should be wet.

By a variation in construction, after the whole facing including the recesses has been given hydrophilic treatment, the facing may be locally removed from the faces of the field printers. This will expose the underlying material **37** which, in this case, must be hydrophobic. Removal of facing only from the field printers may be accomplished by abrasive or chemical etching against a prepared platen, much as before described. Initial preparation is thus simplified, it being safe to merely roll up the duplicate with a thin wet fluid and then roll it up with a lipid fluid.

DUPLICATE RELIEF PLATE, TYPE III (FIG. **14**). This duplicate is of hydrophobic material **39** which can be topically rendered hydrophilic by physical or chemical treatment. Among suitable materials are: cellulose esters such as cellulose acetate, cellulose acetate proprionate and cellulose acetate butyrate; rubber, polyvinyl chloride; reversibly-insolublized forms of gelatine, casein or shellac; and metals, especially amphoteric metals. Treated layer **38** is intended to represent an oxide-free surface on rubber, polyvinyl chloride and like materials; a surface-hydrolyzed region of cellulose esters and other topically hydrolyzable organic materials; a topically re-solublized region of materials such as the suggested proteinous organics gelatine, casein and shellac; a hydrophilic silicate film upon metals; and a roughened, grained, or oxide-free region of metals and materials in general. It will be noted that the whole surface, including the plate recesses, is given a hydrophilic treatment. Chemical treatment may employ flooding with a treating solution or exposure otherwise to a suitable reagent. Physical treatment means may include abrasive blasting or exposure to a reducing flame.

Pre-press preparation may be essentially as was described for a duplicate, Type I.

DUPLICATE RELIEF PLATE, TYPE IV (FIG. **15**). This duplicate may be of hydrophobic convertible material **39** similar to that of a duplicate, Type III. A characteristic difference of this type of duplicate is that the hydrophilic layer **39** is only local to the field printers **20.** To only treat field printers, the duplicate may be lightly impressed upon a platen or the like which has been sparsely wetted with treating solution, or is abrasive, essentilaly as before described for other duplicates. Also among metals which may be used for this duplicate are those which can be amalgamated, e.g., copper. An electroformed copper duplicate may, for example, be lightly rubbed against a superficially mercurialized nickel platen, and mercury will be taken up by the slightly relieved field printers. The mercurialized field printers will be receptive to a wet ink and repellant to a lipid ink.

Generally, pre-press preparation may be as before described, whereby the treated field printers are first given a wet fluid before the composite image **12',13'** is rolled up with a lipid fluid. However, a freshly mercurialized duplicate might safely have the lipid fluid applied first.

DUPLICATE RELIEF PLATE, TYPE V (FIG. **16**). This duplicate may be of hyprophobic convertible material similar to that usable for a duplicate, type III, but which is amenable to topical hydrophilic treatment by chemical means rather than physical means. The slightly relieved field printers **20** are first carefully coated with a resist **41** which will be protective against treating solutions. Resist **41** may be applied to the field printers by lightly impressing the duplicate upon a platen or other flat surface which has been thinly coated with the resist. Several repeated slightly displaced impressions may be made to assure that the field printers have been adequately coated. Te duplicate may then be immersed in or flooded with an appropriate treating solution which will render unprotected portions hydrophilic. As may be seen in FIG. **16***a* the treated layer or region **38** also includes the recesses. If resist **41** is not also suitable as a base for the lipid ink, or cannot be rendered so, it is removed with appropriate solvent or reagent.

By alternative means shown in FIG. **16***b* the duplicate can be given a hydrophilic layer **38** only upon the composite image **12',13'**. As before, the field printers **20** are first coated with a resist **41.** Then treating solution is applied with a slightly elastic roller, or the duplicate is inverted and carefully and lightly impressed into a thin film of treating solution. The embodiment of FIG. **16b** is preferred for use with very thin wet inks, as the hydrophobic recesses will tend to prevent accumulation of wet ink therein.

Pre-press preparation for either embodiment will require that the composite image rather than the field printers receive the wet fluid while the field printers receive a lipid fluid. The hydrophobic field printers enable the composite image to be wetted or inked first, e.g., by roller application of the "dark" wet ink.

In describing pre-press preparation and topical hydrophilic treatments as they may specifically relate to duplicate reliefs, it is understood that generally similar procedures may be used to prepare original plates prior to their placement on a press if the original plates do not embody materials already selectively receptive to respective inks, or which have not had ink-base applied during some phase of platemaking.

On the press, the respective inks are applied across the whole of the plate surface, e.g., by the use of rollers, but only take to their respective plate elements (or to ink-base thereon). Either the wet ink or the lipid ink may be applied first, between impressions, whichever sequence is found most satisfactory for a particular plate and for the press. It may be found practical for certain applications to emulsify the two inks into a single composite ink which is singly applied, the emulsified components taking only to their respective plate elements. An emulsion may, for example, have a form somewhat as described by Mehl, U.S. Pat. No. 1,958,311, but wherein his oridinarily colorless phase containing sodium hyposulfite (sodium thiosulfate or

"hypo"is appropriately colored or of "dark" tone. A suitable emulsion might also be obtained merely by physical agitation. Except that the inks are generally applied across the whole plate surface, I do not limit practice of this invention to specific modes of inking.

PLANOGRAPHIC PLATES

The relief plates hereinbefore described provide a basis for the ready understanding of planographic equivalents. A planographic plate made according to this invention comprises three topical phases: a "dark phase" which (when inked) prints the composite image in a "dark" ink; a "color phase" which (when inked) prints the color fields; and a "3rd phase" which (usually) is un-inked and non-printing although it may be wetted. One of these topical phases may be the surface of the plate body, the other topical phases may be in slight relief thereon. In common with other planographic plates such slight relief is insufficient to keep any of the plate phases from contacting the paper in the case of direct printing, or from contacting the transfer blanket in the case of offset printing.

Although there are three topical phases not all of my planographic plates require a system of three immiscible fluids, as might seem necessary. Those plates which do use three fluids are referred to as "lithographic" plates to distinguish them from other planographic plates.

As regards my lithographic plates: for use on the "dark phase" I may employ a "dark" tone lipid ink of letterpress consistency or of the usual lithographic consistency; for use on the "color phase" I may employ a polyvinyl alcohol ink of a viscosity roughly midway between water and that of the lipid ink, but preferably closer to that of the lipid ink with which some slight and slow mingling is tolerable; for use on the "3rd phase" I may employ water or an aqueous wetting solution (which will be colorless when the 3rd phase is not intended to print). The preceding phase assignments are preferred.

Assuming the "3rd phase" to be non-printing, I may interchange the assignment of my three fluids—whichever is used upon the "3rd phase" will be colorless; whichever is used upon the "color phase" will be of a selected color; and whichever is used upon the "dark phase" will be of "dark" tone. When the "3rd phase" is to print, whatever fluid is used thereon will be of an appropriate tint or color as later explained. The "3rd phase" will usually have the largest area whether printing or non-printing, and for economic reasons water or an aqueous fluid is best used thereon. Instead of using polyvinyl alcohol as one of the three fluids any other functional equivalent may be substituted which is suitably immiscible with water and with lipids, and instead of the particular combination of fluids mentioned other mutually immiscible fluids may be used. My plates will, however, be described as they may use the preferred phase assignments and lipid, wet, and polyvinyl fluids.

The three immiscible fluids do not have to exhibit selective affinity for the respective plate phase with which they are associated, although such properties are desirable for one or more of the fluids. The selective receptivity of the three fluids on the plate is more directly a result of the mutually repellant properties of the fluids themselves, not of "repellancy" properties of plate materials. As will be appreciated from the procedural descriptions, the first fluid applied during plate preparation will reject the next fluid to be applied, while both the former fluids will repel the third fluid. My lithographic plates may be as follows or be variations thereon:

LITHOGRAPHIC PLATE, "COMMON" TYPE (FIG. 17*d*). This plate is prepared similarly to a common lithographic plate, inasmuch as the plate image is in slight (planographic) relief and formed of resist. Referring to FIG. 17*a–d*:

a. A positive halftone composite plate image **12',13'** is photoformed in slight relief *t* upon a body **43** which may be a lithographic metal, e.g., aluminum or zinc. As conventional the plate surface **43** is hydrophilic, e.g., by virtue of silicate treatment or graining, and the photoformed resist image **12',13'** is hydrophobic and lipidophilic. Use of a diazo-sensitized, silicate treated aluminum plate described by Jewett in U.S. Pat. No. 2,714,066, previously cited, is preferred and here assumed. As recommended by Jewett, and in keeping with general good practice, the image after exposure may be rubbed or rolled up with a lithographic "development" ink. However, for convenience in making a second exposure herefor necessary, the development ink may be of a kind which drys or is non-sticky but which may later be re-rendered tacky, e.g., by partial solvating, to assist in ink-up.

b. The plate is now re-coated with a photosensitized hydrophil **44.** It is permissible for photocoat **44** to be applied in slight excess above the image **12',13'**, or flush as is shown and preferred.

c. Portions of photocoat **44** coincident with long components of the composite image and contiguous to halftone dots **12'** respective thereto, are exposed to actinic light through a light-stencil **18** or equivalent, essentially as before described. To assist in receptivity of polyvinyl alcohol ink which will be used upon light-reacted portions of photocoat **44,** the exposure is partial. (As mentioned, the polyvinyl alcohol ink or fluid has a viscosity giving it properties roughly midway between a wet fluid and a lipid fluid.) The partial exposure is sufficient to render exposed portions poorly water-wettable without being completely hydrophobic, and substantially insoluble in a polyvinyl ink or alcohol. It will now be understood that many common hydrophilic light-insolublized photoresists may be used for photocoat **44,** e.g., of gum arabic, gelatine, shellac (hydrolyzed), casein (hydrolyzed), or mixtures of these with each other or other materials and compounds. Also useful for photocoat **44** are the visible-light sensitive materials described by Oster in U.S. Pat. No. 3,097,096, previously cited, particularly as mentioned in column **7,** line **53,** which remain hydrophilic after a full exposure. These can be specially tailored for present purposes, i.e., made less complete hydrophils, by including an amount of monomer which forms a hydrophobic polymer in replacement of an equal amount of the usual monomer.

d. The plate is developed by a suitable solvent to remove unexposed portions of the photocoat **44.** Prior to this development, the plate should be rolled up with the polyvinyl alcohol ink or an equivalent. This may be done while the development ink on the composite image is tacky. After development, a light counter etch may be given to rid areas **43'** of any residue.

Remaining portions **44'** of the photocoat now act as the field printers **20** or the "color phase"; the composite image **12',13'** comprises the "dark phase"; and

areas 43' are the "3rd phase" and will be wetted with water or other aqueous fluid ordinarly colorless.

LITHOGRAPHIC PLATE, "DEEP-ETCH" TYPE (FIG. 18*d*). This plate is prepared similarly to a so-called "deep-etch" lithographic plate, inasmuch as the image is in slight intaglio. Referring to FIG. 18*a–d*:

a. A positive composite halftone image 12',13' is obtained in slight intaglio (about 1 mil) by wellknown means, on a plate 52 which has a grained surface 51' or on a silicate-treated plate. In the latter case it will be desirable to "deep etch" the plate through the stencil image by means of light abrasive blasting rather than chemical means. As conventional the image is of lipid ink-base.

b–c. (Not shown) the plate is re-coated and exposed essentially as in (b) and (c) for a negative plate.

d. The plate is developed as in (d) for a negative plate. The final plate has only the field printers 20 or "color phase" in slight relief.

In preparing a "common" lithographic plate, instead of re-coating the plate with a second sensitized material 44, unexposed portions of the original photocoat (if it be of hydrophilic material) may be allowed to remain for use as of the second material. The plate may be rinsed after the initial exposure and application of development ink, just sufficiently to float off development ink from the portions other than the image dots. If necessary after such rinsing, the remaining unexposed material may be re-sensitized by a brief bath in a sensitizing solution. For this alternative procedure the original photocoat may be somewhat thicker than is usual.

For use with three immiscible fluids bi-metallic and tri-metallic lithographic plates can be made, the former including one phase of non-metallic material, e.g., an organic resist. A bi-metallic plate may, for example, be obtained merely by electrodepositing upon a grained aluminum base, a lipidophilic metal such as copper in place of the ink-base image of a "deep-etch" plate. By a slight variation, the metal image may be slightly raised. A tri-metallic plate may comprise a base metal and two other metals selectively applied through stencils. The base metal may suitably be grained to be hydrophilic, and may act as the "3rd phase." Assuming selective application, copper may be electrodeposited through a negative stencil of resist to form a grease-receptive composite image or "dark phase", and for the "color phase" zinc may be analogously applied. The base metal may also be zinc, which has been grained. For each deposited metal an appropriate ink-base or development ink should be applied before removal of the stencil. Various other combinations of metals may be used. By employing various known means of selective removal, bi-metallic and tri-metallic plates may initially be in the form of flat sheets of laminar structure.

By means now disclosed I may obtain a planographic plate that does not require the use of three mutually immiscible fluids:

MAGNETIC PLATE (FIG. 19*d*). This plate 45 embodies a composite halftone image 12',13' formed of magnetized hydrophobic material, and field printers 20 formed of non-magnetized hydrophobic material. The plate body 45 is non-magnetic and has a hydrophilic surface 45'. The usual operation of this plate will be understood after a further description of its construction, major procedures for which are shown in FIG. 19*a–d*.

FIG. 19*e–f* shows steps in pre-press inking. Referring to FIG. 19 in its respective parts:

a. A positive halftone composite image 12',13' is photoformed of magnetizable hydrophobic material upon a support 45, e.g., of a lithographic metal 45 which has been grained or otherwise rendered topically hydrophilic. It is here assumed that support 45 is aluminum with a sodium-silicate layer 45'. The magnetizable material and means of forming a plate image thereof may be as described by Hamm in U.S. Pat. Nos. 2,819,963; 2,823,999 and 2,856,284. The magnetizable material may initially be hydrophilic, but must become hydrophobic after exposure to actinic light.

Although the magnetized image 12',13' is shown in slight relief *t*, it may instead be embedded in the plate body in the manner of ink-base used in a "deep-etch" plate. In such case the magnetizable material need not be photosensitized, being formed through a stencil as is ink-base. Preferably, as described by Hamm and here assumed, the actual magnetization takes place subsequent to the photo-formation of the image in the plate, but may less suitably be done while the image material is still a uniform layer.

b. The plate is re-coated with a photosensitive material 46 which is hydrophobic in its final form, if not before. Material 46 is here assumed to be of a "negative" light-insolublized type.

c. Photocoat 46 is exposed to actinic light where coincident with long components of the composite and contiguous to halftone dots 12' respective thereto. A light-stencil 18 or equivalent may be used, essentially as before described for other plates.

d. Photocoat 46 is developed so that only exposed portions 46' remain. These form the field printers 20. Bare areas of layer 45' are (usually) non-printing and thus will receive a colorless fluid, e.g., water. However, the water will contain suspended or floated particles of black iron or a black ferrous oxide. These particles separate out from the aqueous carrier and enable the water on bare areas of layer 45' to be clear. The particles are magnetically attracted only to the magnetized composite image 12',13'. The composite image 12',13' also receives a lipid ink as do the field printers 20, the same lipid ink being applied to both and being of a selected color. Inking may be as follows:

e. After the plate has been given an overall wetting, e.g., by sponging with clear water, it is rolled up with a lipid ink of the same color that will be used in the press run to print the color fields. As may be seen, this ink covers the field prints 20 as well as the composite image 12',13'.

f. The plate is next flooded lightly with a clear aqueous fluid carrying finely divided back magnetically-susceptible particles 48, e.g., black ferrous oxide Fe_3O_4. The particles 45 (which may themselves be magnetic although this is best avoided) are attracted to the magnetized plate image 12',13' even though the plate image has a coating of lipid color ink. The clear fluid carrier re-wets bare areas of layer 45' which are non-printing. It can be helpful if the particles 48 are of blue-black or greenish-black tone rather than neutral black or of arbitrary dark tone. Toning may be accomplished by chemical agents, individual coating of the particles, and by other means which may be obvious to metallurgists. When an impression is made from this plate, the colored lipid ink on the composite image 12',13' acts as a binder for the particles 48. However, the requisite

"dark" tone for the printed image is obtained because the deep tone of the particles **48** dominates the chromaticity of the colored lipid ink. The utilization of ink as a binder is in particular distinction to means of binding or fixing as employed by Hamm.

Instead of an aqueous vehicle for particles **48**, and for wetting non-printing areas, I may use an organic solvent immiscible with water, e.g., carbon tetrachloride; for the field printer and composite image I may then use materials which will not be dissolved thereby and which remain receptive to wet ink, e.g., hydrophilic materials which are or have been treated as described to remain hydrophilic. My color ink will accordingly be wet so as not to bleed with the organic solvent, and also of film forming, e.g., mucilaginous nature to bind particles **48.** The plate will need no special surface treatment in order to be "wetted" by carbon tetrachloride or like fluid.

I may form all printing elements in substantially high relief to function as a "magnetic" relief plate. In such case the only fluid which the press need apply is the color ink; particles **48** can be dusted on or equivalently applied.

For either my planographic or relief "magnetic" plate, instead of dusting, particles **48** may be caused to transfer to the plate from a magnetized roller weaker in strength than the plate image, or from a bed or reservoir, said roller or bed being closely proximitous but not in actual contact with the plate. When particles **48** are to be carried by a fluid, they may equivalently be floated upon a film of such fluid or may be carried by a foam, and the plate may make grazing contact with said film or foam.

XEROGRAPHIC PLATE (FIG. **20***b*). In common with other xerographic "plates" or surfaces, and with known xerographic techniques for forming two (or more) differently-colored unfixed ink images upon a single photoconductive surface prior to their simultaneous transfer to paper or other fuel receiving surface, I may proceed as follows with reference to FIG. **20***a–b:*

a. By known xerographic means, using a "dark" unfixed electrostatic xerographic ink **51,** a positive halftone composite image **12',13'** is deposited upon a photoconductive surface **49.**

b. By known xerographic techniques of re-imaging and double-inking, field printers **20** are formed of an unfixed electrostatic xerographic ink **52** of selected color, deposited on the photoconductive surface **49.** The field printers **20** are in register with predetermined components of the composite, e.g., with the long components as is generally preferred, and are contiguous to halftone dots respective to said components, e.g., halftones dots **12'.** To deposit the color ink field printers in register with the desired image components, the photoconductive surface is selectively discharged by exposure through a negative or reverse light-stencil as has been previously described. This stencil is in lieu of the usual picture image which would be used for forming a second ink dposit on the plate or surface. The color ink will not take to or overprint the "dark" ink previously deposited; such non-occlusion is inherent in the known technique of forming a double-inked xerographic surface. It is understood that the photoconductive surface **49** is upon an electrically conductive support **50,** which is grounded.

The unfixed inks on the xerographic "plate" or surface are now ready to be electrostatically transferred to a receiving surface whether paper or other material of an electrically insulating nature, said transfer being simultaneous and analogous to a single impression. For purposes of the appended claims, the respective deposits of dark ink and colored ink on a xerographic surface, are considered equivalent to photomechanically formed relief and planographic elements that otherwise would receive dark and color inks for transfer to paper and the like.

ELECTROSTATIC PLATE (FIG. **21**). This plate comprises an electrically conductive support **52** upon which is first formed, in slight relief t, a positive halftone composite image **12',13'** (FIG. **21***a*). Subsequently, field printers **20** are formed coincident with long components of the image and contiguous to halftone dots **12'** respective to said components (FIG. **21***b*). Various means of photoforming these elements will be obvious from prior description and from known platemaking art, except that particular materials are employed.

The composite image and the field printers are of different respective materials, each being electrically nonconductive and triboelectric. They are selected to have the mutual property that, when rubbed by a particular other material one plate material will assume a negative elestrostatic charge and the other plate material will assume a positive electrostatic charge. Alternatively, two different rubbing materials may be used, as will be explained. Virtually all non-conductors will exhibit the property of assuming a static charge when rubbed, this being known as the triboelectric effect. The electrical sign of the charge on a rubbed material will depend on the two materials which are being rubbed, that is, on the particular plate material and the particular rubbing material(s) acting upon it. To my knowledge the triboelectric properties of materials have not been summarized in physical texts, patent literature or elsewhere, but simple experiment can determine which material combinations may be best suited for commercial applications of this plate. Some materials will be suggested.

The single rubbing material may take the form of a brush or roller bearing lightly against a cylinder upon which my plate may be mounted. The brush or roller may comprise, for example, hair or flannel or like organic material. One plate material may be hard rubber, a resin or polymer of rubbery consistency, or another dry organic substance or composition; the other plate material may be glass, finely-divided glass particles suspended in a sodium-silicate or potassium-silicate matrix, or another cermaic or inorganic dry and nonconductive substance or composition. The rubbery or resinous organic material will assume a negative static charge when rubbed, and the glassy or ceramic material will assume a positive static charge when rubbed. The positive charge will be weaker than the negative charge, but while equality in strength of the respective charges is desirable, it is unnecessary. Instead of rubbing with hair or flannel or the like, I may rub the plate elements with silk or the like. This will result in the glassy or ceramic plate material assuming a positive charge which is stronger than the negative charge on the rubbery plate material. To secure a more equal balance of respective charge intensities, I may rub the plate with a blend of flannel and silk, or a blend of other materials, or a single material specially selected to have equivalent rubbing properties as a blend. Where two different rubbing materials are used I may

form each into a separate brush or roller; then I may, with two rollers or one roller and one brush, equalize the respective charges on the plate materials by differentially regulating the rubbing speeds of the two rollers or of the one roller relative to the fixed brush. With rollers, rubbing may suitably be counter-rotary to the direction of the plate cylinder.

The functional assignment of the two triboelectric plate materials is arbitrary. I may, for example, employ the rubbery or resinous material for the composite image **12',13'**, and the glassy or ceramic material for the field printers **20.** The composite image will thus become negatively charged, and the "dark" electrostatic ink applied must be positively charged, relative thereto, so it will only be attracted to the plate image. The field printers will become positively charged, and therefore the color electrostatic ink must be negatively charged, relative thereto. Means to charge and apply electrostatic inks are well-known. After both inks have been applied to the plate they may be simultaneously transferred to paper or another receiving surface. These electrostatic inks may most suitably be in the nature of xerographic inks, being comprised of fine solid particles which are binded or fixed by heat after electrostatic transfer to a dry non-conductive receiving surface such as paper. Less suitably, the electrostatic inks may, respectively, be fine droplets of a fluid ink which droplets have been given an electrostatic charge, as in electrostatic paint spraying. The latter practice will require plate-charging means other than rubbing, as will be described later.

It is not necessary that triboelectric materials be chosen which assume respective charges opposite in sign. Charges of the same sign but of differing intensity are, as is well-known, equivalent in an electrical sense to an absolute difference in sign. In such case, the charges given to the respective inks may both be of a common sign opposite to the sign common to the charges on the respective plate materials, but of proportionately different intensities.

Instead of rubbing, I may charge my different plate elements from a single corona spray apparatus, analogously as in xeroprinting. In such case, the different plate materials will both assume the same sign, but of different intensity. In a claim where I may refer to a difference in charges, it is not necessarily meant to imply a difference in sign.

Instead of employing two plate materials which are caused to assume differential charges, I may for one or both substitute an "electret," as defined in the International Encyclopedia of Chemical Science, published in 1964 by the D. Van Nostrand Company, Inc., Princeton, N.J. When the composite image is of an electret material and the color fields are of an electret material, the image can be given a permanent electrostatic charge of one sign, and the field printers can be given an electrostatic and permanent charge of opposite sign. The same electret material may be used for both plate elements. The different permanent charges are caused by allowing each of the two plate elements to crystallize or set while in the presence of a strong electrostatic field of respective sign. When both plate elements have a permanent charge the need for rubbing or induction otherwise is completely eliminated. If only one plate element is formed of an electret material, it may by similar means be given a permanent charge opposite in sign from that which the other plate material will assume when rubbed or externally charged.

In all the given examples of plate construction it has been assumed that the field printers are associated with the long components of the composite image, as such association is generally preferred. Field printers may as readily be formed in association with short components of the image contiguous to halftone dots **13'**, by employing a light-stencil or equivalent in which (for an ordinary or positive stencil) areas **18*a*** and **18*b*** are positionally reversed. For a plate so-formed, the field printers must be given an ink of selected "cool" rather than "warm" color. It will be generally understood that because the color field pattern bears no pictorial information, the same light-stencil or compositing screen may be used for widely differing subject matter. Thus, with suitable industry or shop standards only the copy and composite image need vary for each different printed picture. Also, if a particular color is decided upon for the color fields, e.g., a red, as generally recommended, a printer need not change inks for the printing of different pictures. On the same press a printer might run conventional work in either the "dark" or the particular color field ink.

Although I have described use of a light-stncil or equivalent thereof by itself, a stencil or equivalent may be superimposed with a photographic composite image and an exposure may then be made through such joint assembly. By such means any photocoat which may be atop previously formed composite image plate elements **12',13'** will not be exposed. It will also be possible by such procedure to form the field printers first, and then to form associated composite image dots in voids left in the field printing elements, in addition to the composite image dots which fall between the field printing elements.

I do not intend to restrict any lithographic and magnetic plates to use of a metal body or base material, as was described. Many non-metallic substitutes for lithographic metals are known; commonly used for such purposes is a surface-hydrolyzed cellulose ester, e.g., cellulose acetate.

Wherever I have given actual dimensions or figures, these are provided with the sole intention of indicating a general order of magnitude and should not be construed as being limiting.

While all my plates are shown as being flat, they may be curved at any suitable stage in their preparation for use on rotary equipment, with due consideration as to their particular materials. With reference to my lithographic plates and my magnetic plate, wherever nonprinting areas are mentioned they may be caused to print by using a non-colorless fluid thereon. Such a fluid may be tinted or of fuller hue selected as hereinafter described in the section "Gamut Enhancement," such practice being useful in lieu of the optional use of tinted or colored paper or other receiving surfaces. As described for my relief plates, fluids used on my lithographic plates can be emulsified, e.g., the lipid fluid and the aqueous fluid where these are two of three. The press need only have two fountain and distribution systems in such case, one for the emulsion and one for the third fluid which will be separately applied. I do not exclude use of a three-phase emulsion and but one active fountain and distribution system on the press. A suitably formulated semi-polar polyvinyl alcohol ink might

act as an emulsifier or intermediate between an aqueous wetting fluid and a lipid ink.

My relief plates may be run on a lithographic press, whether direct or offset, which has been modified to accommodate the slightly greater thickness ordinary to relief plates by virtue of the relief, and which uses a rubber or like roller for the wet ink instead of the more common molleton or cloth-covered roller usually used for the aqueous fluid. Ordinarily, my relief plates are usable on letterpress equipment that has additionally been provided with a fountain and distribution system for the wet ink. Here also, the roller for the wet ink is best not cloth covered, as the nap will tend to apply the wet ink to the image recesses. For use on flat-bed or platen presses my relief plates may be made "type high" by attachment to a suitably thick backing. Generally, my relief, lithographic and magnetic plates are best used for indirect or offset printing employing an intermediate transfer surface such as a rubber blanket.

My lithographic plates may be used on lithographic equipment, whether direct or offset, which has been provided with a third active fountain and distribution system for the third fluid, except if two or all three of the fluids have been emulsified. A molleton or cloth covered roller, if used, is best limited to the fluid having the least viscosity.

It will be possible to lock up a relief plate of my construction in a form along with conventional relief printing elements such as type, line cuts and ordinary halftones. Such supplemental graphics may, if conventionally made, receive the same lipid ink used in printing the multicolor picture. However, all or some of these supplemental graphics may be formed in whole or part of hydrophilic material or material of hydrophilic surface (by means derived from general disclosures herein), which parts once wetted, will thereafter receive the wet ink. When ordinary type is among the supplemental graphics, it will usually be necessary that the lipid ink be the "dark" ink, except if it is permissible for the type to print in color. By such provisions, the multi-color picture may be printed simultaneously with other graphics whether pictorial or otherwise and which may be in monotone or "single-impression duotone," e.g., respectively either in black or in red, or in black and red. Obviously, a jobber may without modification of the press or inking system thereof, run ordinary monotone or "single-impression duotone" work alone.

As is known, a duotone may be a line cut, a combination of line and halftone elements, or be wholly in halftone, and my "single-impression duotone" may comprise similar elements. A "single-impression duotone," comprising two whole halftone images (whether one or both are color separations) in general superposition upon a single plate, and wherein one is hydrophilic and the other is hydrophobic each receiving a respective colored or toned ink, is considered to be an obvious derivative of this invention. Two conventional halftone photographs would be used to form the respective plate elements, instead of using one halftone (composite) photograph and a lightstencil or equivalent. With a "single-impression duotone" a variety of color effects may be achieved, some of which may be somewhat natural-appearing, e.g., as when complementary colors are used, and even with red and black or other dark ink. Such a plate may be substituted for plates hereinbefore described, and many of the general advantages of my invention may be had.

A "single-impression duotone" comprised of two whole halftone images may be as shown in FIG. **25.** The halftone images may be color separations in positive form. Use of a green separation and a red separation is here assumed. Preferably first, halftone elements **55** corresponding to the positive green separation (in its entirety) are formed in relief in a body material **57.** Subsequently, halftone elements **56** corresponding to the positive red separation (in its entirety) are formed in relief of "fill" material which has been applied to the recesses of the first plate image **55.** This formation is analogous to the formation of field printers for my other relief plates. Assuming that body material **57** is of metal, e.g., copper, and will be hydrophobic and receptive to a lipid ink, the plate image **56** is photoformed of hydrophilic material, e.g., of a partially-exposed photosensitized hydrophilic organic such as gelatine, which will be receptive to wet ink. Many other combinations of materials, and the use of various surface treatments, will be obvious from preceding parts of this specification. Instead of a relief plate as shown here, lithographic, magnetic, xerographic and electrostatic equivalents may be made.

The particular color separations here given by way of example, are as described by Land in U.S. Pat. No. 3,034,890. Also in accord with Land's teachings therein, halftone elements **55** for the positive green separation are inked with a red ink, and halftone elements **56** for the positive red separation are inked with an ink of dark tone. (I do not limit myself to the neutral tone Land prescribes, or to a substantially pure red.) Because of the particular assignment of hydrophobic and hydrophilic plate materials given by way of example, the red ink will be lipid and the dark tone ink will be wet.

By means of the aforementioned plate I am able in one impression to obtain an apparent multicolor print which by other means would require two impression, two plates, and unorthodox and judicious press register. It will be appreciated that by first forming the image which is to receive color ink, I am able to minimize the need for reduced density in the image that receives the dark ink (as recommended by Land). This is because the first-formed image, on a random basis precludes or prevents the complete facial formation of many individual halftone elements of the second image. Though I have shown my "single-impression duotone" as it may be utilized to print an apparent multicolor picture such as Land describes in U.S. Pat. No. 3,034,890, I do not limit my duotone plate to use of particular color separations or to particular colored or toned inks.

For rotary letterpress, and lithographic and other planographic plates, where a single large plate is used instead of various graphic elements locked in a form, such plates in addition to a natural multicolor picture may also print equivalent supplemental graphics, whether in monotone or duotone, using the inks necessary for the multicolor picture. The various options herebefore described are considered an indirect advantage of my intention when commercially practiced.

For convenience, only major and exemplary plate-making sequences have been given. It will be realized that even for conventional plates procedures will vary in different shops and as described by different texts. Variations in my procedures yielding an equivalent

functional result or product, and substitutions of materials whether equivalent or superior if determinable merely by experiment or by ordinary expert knowledge, are considered to be within the present scope.

GAMUT ENHANCEMENT

Non-Maxwellian prints and projections or other optical displays (especially prints) have heretofore suffered from chromatic inadequacies, generally a weakness of color from one or another primary region of the spectrum, and a corresponding weakness or absence of certain secondary colors somehow dependent thereupon. Thus, while the range of apparent colors has in all cases been more than would classically be expected, the overall effect was less than could be obtained by conventional "full color" reproduction processes. It has not been obvious how such inadequacies can be avoided or further minimized, or that improvement is theoretically possible without progressing from two to three stimuli.

The general practice of this invention need not employ the means of gamut enhancement here disclosed, as the selection of separations and stimuli as taught by Land will yield satisfactory results for most purposes. As does Land, I would usually use a red long separation and a green short separation although the use of other color separations is permissible. Thus, as Land describes and is also satisfactory for this invention, an Eastman Kodak Wratten filter No. 24 or No. 25 may be used to obtain a long separation on a panchromatic emulsion, and a No. 57 or No. 58 (whose transmission Land presumably shows in *Scientific American*) may be used to obtain a short separation on a panchromatic emulsion, and generally related filters may be used instead. I am aware of no Eastman Kodak Wratten filter No. 69 as Land mentions in U.S. Pat. No. 3,034,890 column 2, line 59. I do not limit myself to any particular values of gamma, as such values and other processing procedures for photographs are best determined in practice by simple and obvious means. For regulating the relative intensity of the long and short components of the composite image, and as a means of color balance which avoids need for inequality of size between the color fields and spaces of the receiving surface therebetween, I may process the respective separations to different densities or obtain different densities at the time of exposure. Generally I would make both separations slightly more dense than is usual, particularly in positive highlights, and make the short separation slightly denser than the long separation, but I do not limit myself to such practices. Color balance can also be affected by use of appropriate color compensating filters during photography of the separations, and, in the final reproduction, by use of differential gloss or texture between the color ink and/or the "dark" ink relative to the receiving surface.

The use of a white stimulus is of particular advantage inasmuch as white paper can be employed. Color fields of a "warm" color, e.g., a red, printed on white will prove somewhat more effective than color fields of a "cool" color, e.g., a green. As Land mentions, a white paired with a warm stimulus may with advantage be of a cool tint. I recommend that a white paired with a cool stimulus be of a warm tint. The particular warm and cool tints may be as later described. Land defines his use of the terms "warm" and "cool" by reference to *Webster's New International Dictionary*, 2nd Edition Unabridged, which definitions are also acceptable for purposes of this specification.

If in conjunction with other of my enhancement means the white is cool-tinted, the tint is preferably greenish rather than the bluish tint recommended by Land. Similarly, a white which is warm-tinted is preferably reddish rather than yellowish. When such specific tinting is done conjunctive with other of my enhancement means to be described, the tint may be very pale yet yield satisfactory results. However, I do not exclude use of receiving surfaces of deeper tint or fuller hue correspondent to my preferred tints. When my complete enhancement means are not to be employed, tinting or fuller coloring, if used, may more freely be of any warm or cool hue appropriate to the printed color fields.

In non-Maxwellian prints made according to the existing art, and which use the two stimuli red and green, red and cyan, red and white, green or cyan and white, red and a cool tint, or green or cyan and a warm tint, which pairs are generally more effective than other possible pairs, the color deficiency in the apparent gamut will occur in the blues. There will be a noticeable weakness or absence of true blues, blue objects appearing at best a deep turquoise or deep cyan. This is not wholly unsatisfactory for in nature and man-made objects large expanses of true blues are rare, and deep turquoise and like tones have come to be popularly accepted as blues. However, a degree of naturalness is lost, because blue is present in varying amount in most common colors and objects. Secondary colors classically dependent on blues will be either absent or degraded, e.g., purples, which if present at all will seem wine-colored or reddish. My gamut enhancement means are therefore primarily directed toward the enhancement of blues. Because my enhancement means are simple and might appear to be obvious, I will review other attempts at the same.

It might seem that by using a full blue-green (cyan) separation in conjunction with a red separation, a fuller rendition of blues would take place in the final print. The short separation filters Land suggests do not transmit broadly in the blue region of the spectrum. However, the use of a full blue-green taking filter does not prove satisfactory in practice; this is probably because no more than two packets of color information, "long" and "short," are presented to the eye in the final print regardless of the bandwidth of the stimuli or the broadness of the separations, as Land has theorized. In the same sense, classical 2-color or complementary systems such as red and cyan or blue and yellow fail to reproduce the full gamut, although in theory all colors should be encompassed. Thus, Land acknowledges that his green taking filter does not transmit blues too satisfactorily (U.S. Pat. No. 3,147,699 column 7, line 30), but with good reason he does not propose to increase its transmission of blues.

To enhance perception of blues, Land proposes the use of a cool-tinted illuminant or stimulus of pale blue, rather than an achromatic white or a warm tungsten or yellowish white (3,003,391 column 7, lines 19–23). Such means does enhance blues, but by default, as it desaturates other colors at the same time. Equivalent would be the use of a blue-tinted screen for projected non-Maxwellian pictures.

Specifically as regards a print rather than a projected picture, Land recommends that the viewing light and-

/or paper be of cold bluish tone in order to yield satisfactory blues (and greens), and that the densities of the neutral tone image be soft grays and of reduced contrast rather than deep blacks (U.S. Pat. No. 3,034,890 column 3, lines 54–62). As mentioned I prefer a greenish tint, and am not solely dependent upon the short stimulus for blue enhancement as will be seen.

In further attempt to enhance blues Land proposes use of a third stimulus of blue and a blue separation (U.S. Pat. No. 3,003,391 column 6, line 24–36). Such means, while fully operative and satisfactory for projected pictures because there is no halftone structure or inherent limitation to the relative intensities of the illuminants or stimuli, is undersirable for the printed page. The use of only two stimuli on a printed page, particularly when one is white or of a pale hue, results in greater overall brightness and improved color resolution. The latter is due to the greater number of color field repeats within a given area for color fields of a given size.

It might seem that for subject matter rich in blues a blue short separation could be used instead of a green separation or a blue-green separation. This does not prove satisfactory for reasons of uncertain nature; probably because the red-green visual mechanism is dominant.

Of course, Dr. Land's "short wave reversal" combination of stimuli might be used, e.g., employing both blue paper and printed blue color fields. However, for printed reproductions the brightness and contrast would be low, except possibly with the fluorescent pigments or dyes he proposes; in the latter case the viewing illuminant must be rich in ultraviolet.

My gamut enhancement means may best be understood by assuming, for the moment, that the long separation records no blues or greens, that the short separation records no blues or reds, and that the composite image printed on the paper is in black ink, e.g., in a neutral or achromatic tone as specified by Land. The original copy is assumed to contain all colors, black and white. Black ink dots of the long component (dots 12') will thus represent the quantity of "minus red" or cyan in the copy, or the total absence of light. Black ink dots of the short component (dots 13') will represent the quantity of "minus green" or magenta in the copy, or the total absence of light. As cyan is blue-green and magenta is blue-red, it will be realized that the black ink of both components carries "minus blue" information. It will be understood that the terminology "minus blue" does not imply that no blue is present in the copy corresponding to each and every halftone dot, but only that the separations (in their original negative form) have not recorded blue, even if present. A halftone dot 12' may actually represent blue, green, cyan, or black; a halftone dot 13; may actually represent blue, red, magenta or black. The halftone dots, in regulating the reflectances from color fields and receiving surfaces therebetween, merely represent the absence of stimuli. This is equivalent to projected non-Maxwellian images, wherein the dark portions are the mere absence of illuminant or stimuli to greater or less degree depending on the neutral densities of the projection positives. The same is true for all other 2-color or 3-color pictures made by additive superimposed synthesis, such as the classical experiments of James Clerk Maxwell. An essential of my gamut enhancement means is that the halftone dots not be the mere absence of stimuli, and that the "minus blue" quantity be replaced with a positive blue quantity of slight and uniform amount.

My complete gamut enhancement means generally comprises: (a) Printing my composite image in a partially chromatic blue, alternatively purple, tone; (b) Using a short separation that has recorded greens most strongly, but has with less strength also recorded substantially throughout the blues without being a true cyan record; (c) Using a long separation that has recorded reds as well as possible, and has with less strength also recorded substantially throughout the blues without being a true magenta record; (d) Using a short stimulus which is either white or of greenish tint or a fuller green hue; and (e) Using a long stimulus which is red, or (if the short stimulus is a relatively full value of green) is either white or of reddish tint. As is generally preferred, the receiving surface is best made to function as the short stimulus. By these combinative means blue objects will more readily be perceived as blue while other colors are not desaturated, secondary colors dependent on blue will be perceived, and apparently true black, gray and white will be perceived. I do not limit practice only to the combinative use of all such elements, as lesser degrees of enhancement can be had by use of but some elements, e.g.: the short separation need record no blues or the long separation need record no blues; one or both stimuli may be other "warm" and "cool" colors than as recommended.

Although the "dark" ink is everywhere partially chromatic and uniformly toned with blue (or purple), bluishness becomes manifest only in proper portions of the picture. This effect, which I call "induced bluing," is a phenomena probably due to simultaneous contrast in conjunction with brightness ratios and other effects active when a picture is viewed rather than isolated spots of light in a surround. Because my preferred separations are able to distinguish density-wise between blue and black, halftone dots for a blue object will not be quite so large or dense as halftone dots for a black object. The small amount of short and long stimuli not obscured by these printed halftone dots will give rise to a sensation of deep yellow or orange, which sensation is sufficient to bring out the blueness of the immediate dots by phenomena of simultaneous contrast. The dominance of the local blue sensation rather than the yellow or orange sensation, is likely due to non-Maxwellian phenomena together with "constancy" effects. General reference is made to Wallach, "The Perception of Neutral Colors," *Scientific American*, January 1963, as regards constancy. Similar reasons may account for the perception of apparently true blacks and grays even though there is a blue quantity in the image at all points.

To allow for the use of either a black or gray achromatic or neutral image as specified by Land, or, as preferred, a partially chromatic blue-toned or purple-toned image, I have employed the term "dark" as all inclusive. When the "dark" image is color-toned, the color-toning need not be so pronounced as to make the image readily discernible as being a non-neutral tone. Thus my color toned image affords a practical substitute for black ink when type matter may be printed along with the multicolor picture. When purple toning is used, probably only the blue component of the purple is active in a psychological sense, although no reason for this is known.

FIG. 22 suggests the general net response of my preferred short separation, and is not to be confused with transmission of a filter or filters which may be used to obtain it. The curve is merely indicative of the general relative amounts of green and blue recorded and the general spread. In practice it may be approximated to various degrees, depending on particular film-illuminant-filter(s) used. Such a short separation may be obtained by a partial and principal exposure through a green filter, e.g., Wratten No. 52, No. 57, No. 58 or No. 61, and a partial and minor exposure through a blue filter, e.g., Wratten No. 48, or through a blue-green filter, e.g., Wratten No. 65. The combinative successive use of filters is not imperative, but is a practical expedient in the absence of a single commercial filter of suitable character. Various other means will be obvious to phototechnicians, e.g., the combinative simultaneous use of a blue-green filter and a yellow filter to attenuate the blues. The use of an orthochromatic or panchromatic emulsion is understood.

FIG. 23 suggests the general net response of my preferred long separation, and is not to be confused with the transmission of a filter or filters which may be used to obtain it. As with my short separation curve, the curve of response is merely indicative of the general relative amounts of red and blue recorded and the general spread, and in practice it may be approximated to various degrees. Such a separation may be obtained by a partial and principal exposure through a red filter, e.g., Wratten No. 24 or No. 26, and a partial and minor exposure through a blue filter, e.g., Wratten No. 48. As with the short separation, the combinative use of filters is but a practical expedient, and various other means will be obvious, e.g., the combinative simultaneous use of a magneta filter and a yellow filter which will attenuate the blues. It is understood that a panchromatic emulsion would be used.

My preferred stimuli are deliberately not identical to the separation colors. Thus, while the separations may each record some blue, my stimuli preferably have little perceptible blueness. Where red is specified as a stimulus color, Process Red (magenta) should be avoided; where green is specified as a stimulus color, Process Green (cyan) should be avoided; where white is a stimulus it should not have a bluish cast; and where a cool tint is used the tint preferably is greenish and not bluish or bluish-green. When color fields are printed in either red or green on a white or tinted receiving surface, I do not exclude these color fields from also being pale and of light value although this is generally not recommended. When specifying red color fields or a red stimulus I do not mean to exclude the use of orange-reds, or reds containing a small amount of blue such as occurs naturally in most red pigments and dyes.

It will be appreciated that my gamut enhancement means synthesizes a red-green-blue 3-stimulus system of primaries without resort to a separate third set of color information in the form of an additional separation record and additional color fields. In such respect it is believed unique from Land and from other prior art.

Land defines his use of the terms "neutral" and "achromatic" in U.S. Pat. No. 3,003,391 column 1, lines 22–27; in U.S. Pat. No. 3,034,890 column 1, lines 53–59; and in U.S. Pat. No. 3,147,699 by its being a continuation-in-part of U.S. Pat. No. 3,034,890. In instances of the specification of U.S. Pat. No. 3,147,699, e.g., column 1, line 21, Land uses the phrase "neutral or monochrome" with reference to his two or more positive separation images. The only example given of the use of a monochrome image is in the paragraph beginning column 8, line 31. There he describes only one of the two component separations as being of color, which color is intended to be in contrast with its black background and as luminous and chromatic as possible. Thus, Dr. Land has contemplated printing one of his pair of separations in a color, e.g., red, but from the general context of his disclosures it is clear that he has seen no particular advantage in toning such as I have described.

It is to be understood that I may, as Land teaches, use other combinations of stimuli than those I prefer for maximum gamut. For example, I may use yellow-green paper as the short stimulus and I may print yellow-orange color fields thereon as my long stimulus, and one or both of these stimuli may be pale.

My enhancement means may also be applied to projected non-Maxwellian pictures and other optical displays as described by Land. The two separations (continuous-tone positive transparencies) and the stimuli (illuminants or color filters associated therewith) will, however, be chosen as for my enhanced prints. Accordingly, the short separation (in its original negative form) may have most strongly recorded greens and less strongly recorded a broad band of blues; the long separation (in its original negative form) may have most strongly recorded reds and less strongly recorded a broad band of blues. For purposes of projection and the like, the short stimulus is most suitably a blue-green rather than a green. As before recommended, the long stimulus may be red. One or the other of my stimuli may be white or a tint of the fuller color it would otherwise have. To synthesize my dark partially chromatic printed composite image the neutral densities of one or both of the positive transparencies are replaced with deep blue or deep purple dye, preferably the former. It is not imperative that developed silver be completely removed. Chemical toning may be employed instead of dyeing, whereby the toning will appear blue or purple by transmitted light. The toner might be dichroic, appearing another color by reflected light.

It is known that the long and short projection positives may be alternate frames on a cinema film **54**, as shown in FIG. **24**. According to my improvement, the "long" frame L can have deep blue or purple densities **53**. To provide a red (as preferred) long stimulus without need of a colored illuminant or a separate color filter, frame L may be overprinted with red as indicated by the vertical shading. The "short" frame S can also have deep blue or purple densities **53**. To provide the short stimulus, e.g., blue-green, frames may be overprinted with blue-green as indicated by the oblique shading. Instead of overprinting my stimulus colors I may color the film support.

It will be realized that the red on the "long" frame L, by virtue of its absorbtion, will prevent blue of the densities **53** from reaching the screen. The densities will thus show as black. If purple densities were used, only a deep red will reach the screen. It will also be realized that use of a blue-green dye or ink on the "short" frame S will only allow blue of densities **53** to reach the screen, and will absorb red if the densities were purple. Assuming the use of deep purple densities for all frames, red and blue from respective "long" and

"short" frames will be additively superimposed on the screen and might become too luminous to satisfactorily represent shadows. In such case extra deep chromatic densities must originally be used to compensate. If blue densities are used for both the "long" and "short" frames, it is irrelevant that the red on the "long" frames will completely attenuate its blue densities rendering them as black. Thus it becomes feasible to similarly process all frames on the film **54**, whether to impart blue densities or purple densities; similar processing is a practical advantage although not required. For other displays wherein the separations are each on a separate film, e.g., viewing devices employing a semi-transparent mirror, one separation may have its densities in deep blue and the other may have its densities in deep purple, or one separation may have neutral-tone densities. Obviously, the subtractive action of stimulus dyes, filters or illuminants must be kept in mind in determining the particular chromaticity respective densities are to have.

Instead of using a full blue-green stimulus for the short frames I may use a blue-green tint, or I may use a pale green stimulus if I exaggerate the blueness of the densities to allow for attenuation of the blue which will occur. When a relatively full blue-green is used as the short stimulus, I may use but a tint of red or no tint (white light) as my long stimulus.

Having described my invention to the best of my ability, I rely fully upon the doctrine of equivalents for all variations, alternatives and derivatives within the scope of the appended claims, and having features and elements therein regardless of any additional features or elements.

What I claim is:

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

a. by use of a composite separation screen having inter-spersed 1st and 2nd filter areas which transmit substantially red and substantially green information, respectively, of said multicolored picture, photomechanically forming upon a printing surface halftone printing elements of a composite image having correspondingly interspersed 1st and 2nd information areas respectively for said red and said green information, all said halftone printing elements being receptive to a dark ink of substantially neutral tone;

b. photomechanically forming field printing elements upon said printing surface only in portions of said surface corresponding to said 1st information areas, said field printing elements providing background to said halftone printing elements occurring within said 1st information areas, said field printing elements being receptive to a substantially red ink;

c. inking said halftone printing elements with said dark ink and said field printing elements with said red ink; and

d. simultaneously transferring inks upon said printing elements to a receiving substrate of selected pale color.

2. Process according to claim **1** wherein said 1st and 2nd inks are mutually immiscible,

3. Process according to claim **1** wherein said 1st ink is black, said 2nd ink is bright red, and said receiving surface is white.

4. Process according to claim **1** wherein said 1st ink is blue-black, said 2nd ink is bright red, and said receiving surface is greenish white.

5. Process according to claim **1** wherein said printing plate has text printing areas, and said text printing areas receive said 1st ink together with said 1st and 2nd plate images.

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