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D. A. NEWMAN

3,119,014

NOVEL DUPLICATING SYSTEM

Filed Dec. 9, 1960

Fig. 1

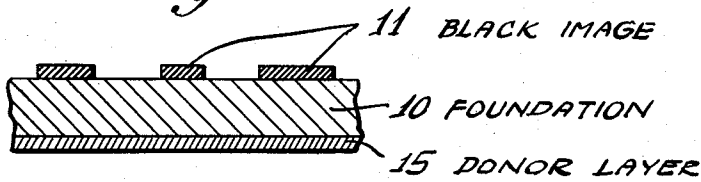


Fig. 2

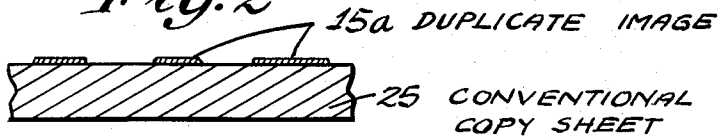


Fig. 3

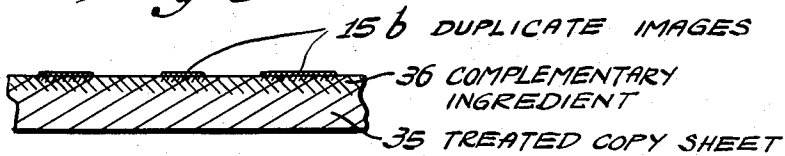
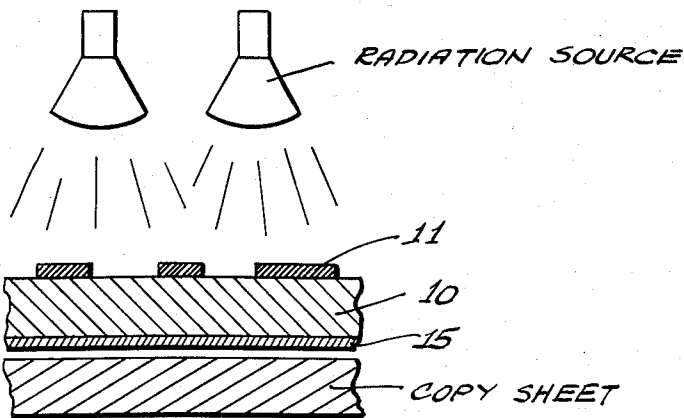


Fig. 4



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3,119,014

NOVEL DUPLICATING SYSTEM

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13 Claims. (Cl. 250-65)

This invention is concerned with novel sheets for effecting the production of exact copies directly from an imaged original sheet through the use of infrared radiation.

The necessity and advantage of automatically producing duplicate copies of an original sheet is well-known. To satisfy this need, many diverse methods have been developed and are in wide use today.

One such method depends upon the reaction of dye components or chemical salts contained in a heat-sensitive copy sheet as disclosed in U.S. Patent No. 2,740,896 to form the color in the heated areas. For instance, a copy sheet carrying colorless unreacted dye components is placed on top of an imaged original sheet and passed through a Thermo-Fax machine. Under the effects of heat generated by the imaged areas of the original sheet, the dye components react and form colored dye images on the copy sheet in areas corresponding to the imaged areas of the original sheet. Although such systems are suited for some needs, they have many disadvantages. Such heat-sensitive copy sheets are relatively expensive and may be used to form only a single copy. They must be so formulated as to be transparent and not to absorb infrared radiation and therefore are based upon a tissue or plastic foundation which makes them difficult to handle. The copies formed from such heat-sensitive copy sheets are neither sharp nor clear due to the natural dissipation of heat. Finally, such copy sheets have the disadvantage of remaining heat-sensitive even after imaging and thus must be stored away from heat or sunlight.

Another type of heat-sensitive copy sheet has been developed which consists of a colored foundation sheet having thereon an opaque blush coating which becomes transparent under the influence of heat to allow the colored foundation sheet to become visible. Such copy sheets are imaged by placing them under an imaged original sheet and subjecting them to infrared radiation. The principal disadvantages of these blush coated sheets are two fold. Most important is the fact that they are pressure-sensitive and thus subject to inadvertent marking during handling. Also, these copy sheets remain heat-sensitive and thus must be kept away from heat and sunlight.

It is thus an object of the present invention to provide for the thermographic production of clean, stable duplicate copies without the disadvantages attendant to prior art methods.

It is another object of the present invention to prepare an original-donor sheet which may be duplicated up to 100 times on conventional paper stock.

It is still another object of the present invention to provide for the production of copies from an original sheet which are permanent in that they are resistant to the effects of heat and pressure.

These and other objects are accomplished according to the present invention as more fully explained herein.

The invention consists in employing specially prepared donor sheets having on one surface a donor layer which is

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preferably inconspicuous and is not subject to transferring under the effects of ordinary imaging pressure. Such donor sheets therefore preferably have the appearance of ordinary untreated white paper sheets and may be typed upon or otherwise imaged on their untreated surface without disrupting the donor coating on the opposite surface.

The donor coating is so formulated as to be partially heat-meltable at temperatures generated by infrared radiation which is absorbed by images placed upon the untreated surface of the donor sheet. Thus, when an imaged donor sheet is superposed with a copy sheet and subjected to a light source which is rich in infrared radiation, the radiation is absorbed by the images on the untreated donor sheet and converted to heat. This heat melts portions of the donor layer in areas corresponding to the imaged areas and causes the melted areas to act upon the corresponding areas of the copy sheet to form an exact duplicate copy of the imaged donor sheet.

As many copies of the imaged donor sheet as desired may be prepared by simply superposing the same donor sheet with a new copy sheet each time and subjecting the sheets to infrared radiation in the manner described.

The nature of the copy sheets used according to this invention varies depending upon the formulation of the donor layer with which the copy sheet is to be used.

The copy sheet is preferably an untreated sheet of conventional paper stock, in which case the donor layer of the donor sheet contains all of the color-forming or imaging material.

The copy sheet may, however, comprise a specially coated or otherwise treated sheet which cooperates with the melted donor layer in forming colored images on the copy sheet surface. In this instance, the copy sheet is coated or otherwise treated with a critical element such as a complementary chemical, a dye component, a catalyst, a dye solvent or the like, which brings about the formation of colored images on the copy sheet when contacted with the melted areas of the donor layer. It is advantageous in certain cases that the coating on the copy sheet also be heat-meltable so as to provide for quicker and denser imaging of the copy sheet.

Other features and advantages will hereinafter appear.

In the drawing:

FIGURE 1 is a diagrammatic fragmentary cross-section, to an enlarged scale, of a donor sheet according to the present invention, having a donor layer 15 and images 11.

FIG. 2 is a diagrammatic fragmentary cross-section, to an enlarged scale, of a conventional untreated copy sheet which has been imaged according to the present invention with duplicate images 15a.

FIG. 3 is a diagrammatic fragmentary cross-section, to an enlarged scale, of a treated copy sheet containing a complementary coating or impregnation 36 and which has been imaged according to the present invention with duplicate images 15b.

FIG. 4 is a diagrammatic fragmentary cross-section, to an enlarged scale, of a donor sheet and a copy sheet, separated for purposes of clarification, but superposed under the influence of infrared radiation according to the present process.

The present donor sheets comprise a suitable foundation 10, preferably paper, bearing a resinous donor coating 15. The donor coating contains imaging materials which are substantially non-transferable in solid form under the effects of ordinary imaging pressures but which

become transferable when heated to their melting point. This coating is preferably colorless or white so that its presence on the donor sheet is inconspicuous. This is important in cases where the donor sheet is to be used primarily as ordinary letter paper or the like.

The donor coating 15 has a porous spongy structure in which a film-forming base material is present in substantially non-transferable form as the sponge or continuous network adhered to the foundation, while the imaging composition is present in discontinuous form, transferable when melted, and dispersed throughout the pores or vacuities of the supporting network.

It is a critical aspect of the present invention that the donor coating 15 is not pressure-transferable and will not exude the imaging materials under ordinary imaging pressure. It is likewise critical that the continuous phase or supporting network, which is comprised by the film-forming material, is heat-resistant and heat non-transferable whereas the dispersed phase, comprising the imaging composition, is heat-meltable at a temperature of from 200° to 450° F. or above. Under the effects of such temperatures brought on by infrared radiation absorbed by images 11 present on the opposite surface of the donor sheet, an amount of the melted imaging composition exudes to the surface of the donor coating and wets the copy sheet which is in contact therewith. The copy sheet becomes wetted and thus imaged in areas corresponding to the imaged areas of the donor sheet as demonstrated by the accompanying drawing.

It is also critical that the present imaging composition is non-compatible with the film-forming base material employed so that the formed transfer layer is heterogeneous with the film-former and the imaging composition present at disunited and separate materials. The imaging composition serves at least two functions in the transfer layer. Firstly, it disrupts the continuity of the film and prevents the formation of a continuous sealed film which would not be heat-sensitive. Secondly, it provides for the formation of heat-meltable color-forming microdroplets which are dispersed throughout the film network or sponge which is itself non-heat-meltable at the temperatures employed.

The nature of the imaging composition depends upon the nature of the copy sheets with which the donor sheet is to be used. However, in general, the imaging composition contains a suitable solid binder material such as a hard wax which has a melting point of 50° C. and above together with the imaging material which is preferably white or colorless. The solid binder material must be a material which is not compatible with the film-forming base material and which, in its film-dispersed form, is not frangible or subject to being transferred under the effects of ordinary imaging pressures or temperatures, but which is heat-meltable at the temperatures generated by infrared radiation in the present process, namely temperatures ranging from about 150° F. to about 450° F. or higher. Suitable binders include conventional hard waxes such as carnauba wax, microcrystalline wax, Carbowax 4000 and 6000, raw montan wax, beeswax and the like and mixtures thereof, with each other or with minor amounts of oils such as animal, vegetable or mineral oil, or with minor amounts of resinous materials such as Indopol H-300 and Paraplex AL-111.

The imaging materials to be used vary greatly depending upon whether treated or untreated copy sheets are to be used with the donor sheet. If the donor sheet is to be used with untreated copy sheets, then the imaging materials carried by the donor layer must be capable of forming color per se under the influence of heat. If the donor sheet is to be used with specially treated copy sheets, then the imaging materials carried by either the donor layer or the copy sheet need not be capable of forming color per se but must be capable of forming color upon heat contact with each other.

Among the suitable imaging material systems are the

following: Colorless azo dye intermediates and coupling components which react with a change in the pH or in the presence of a catalyst as taught for instance by U.S. Patents Nos. 2,634,677, 2,748,024, and by my copending application Serial No. 732,461, now Patent No. 2,967,784, granted January 10, 1961. In such a system either the dye intermediate, the coupler or the pH adjusting agent or catalyst is present on the copy sheet; Complementary chemical compounds which react to form a color when heated in the presence of each other, such chemicals being described for instance in U.S. Patent Nos. 2,663,657 and 2,813,042, and in my copending application Serial No. 838,922, now Patent No. 3,011,905, granted December 5, 1961. In such a system the coreactive chemicals may both be present in the donor layer in colorless unreacted form or, if desired, the donor and copy sheet may each contain one of the coreactive chemicals; Colorless nitrogen derivatives of dyestuffs such as crystal violet lactone which become colored when placed in adsorption contact with polar substances such as clay, silicon dioxide, magnesium carbonate or the like, as described in U.S. Reissue Patent No. 23,024 and U.S. Patent No. 2,443,092. In this system the polar substance is present as a coating on the copy sheet surface.

As is obvious, there are any number of substantially colorless color-forming systems as mentioned above which may be employed according to the present invention. The question of which system to employ depends upon the color of the duplicate copy which is desired, as well as upon the question of whether specially treated copy sheets are to be used.

It is not critical to this invention that the imaging composition be colorless since excellent results have been obtained in cases where a colored dyestuff is used as the imaging material. In such cases, it has been found preferable, though not necessary, that the copy sheets carry a heat-meltable coating containing Carbowax, cetyl alcohol, or the like, which functions as a dye solvent when liquefied, as taught by my copending application, Serial No. 36,951, now Patent Number 3,088,028, granted April 30, 1963. Still another variation comprises the use of the above-named non-volatile dye solvents in the donor layer to be used together with copy sheets which carry a surface coating comprising substantially colorless or only slightly tinted undissolved dyestuffs or derivatives thereof such as crystal violet lactone and the like.

As can be seen from the foregoing, the essential discovery of this invention resides in the preparation of a donor sheet-copy sheet system which responds to heat development but not to pressure.

Among the suitable film-forming materials having the critical properties outlined hereinbefore are the following: vinyl resins such as vinyl chloride, vinyl acetate and copolymers thereof, polyvinyl alcohol, polystyrene, polyvinylbutyrate, polyvinylidene chloride, polyacrylic acid; hydrocarbon polymers such as polyethylene and polypropylene; and hydrophilic or water-dispersible colloid materials including zein, gelatin, albumin, casein, carboxymethyl cellulose, methyl cellulose, hydroxyethyl cellulose, starch, gum arabic, tragacanth and other equivalent colloid materials.

In preparing the donor sheets of the present invention, a suitable foundation sheet such as white paper is coated with the donor composition carried by a volatile solvent and then dried to evaporate the solvent and form the porous layer. The selection of the volatile solvent depends of course upon the particular film-forming material employed, it being within the skill of the artisan to select a suitable solvent. For instance, when employing a vinyl resin or hydrocarbon polymer, then organic solvents such as ethyl acetate, methyl ethyl ketone, acetone, toluol and the like are suitable; when employing hydrophilic or water-dispersible colloid materials, then water is a suitable volatile solvent.

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Depending upon the particular film-former, the imaging material and binder selected, there will be substantial variations in the proportions of the ingredients which will produce the optimum results. The best proportions will in each case, however, be readily determinable by anyone skilled in the art of heat transfer compositions. As a guide to suitably selecting the proper proportions, it may be pointed out that in most cases they will lie within the ranges indicated by the following table.

Ingredients:	Parts by weight
(1) Film-forming material.....	10.
(2) Imaging composition binder..	7.5 to 35.
(3) Imaging material.....	3 to 75.
(4) Volatile liquid vehicle.....	Amount sufficient to render the mixture readily coatable (usually between about 45 and 120).

Illustrative examples of duplicating systems according to this invention are as follows.

Example 1

Donor composition:	
Ingredients—	Parts by weight
Vinyl chloride-vinyl acetate copolymer (Vinylite VYHH)	10
Carnauba wax	11
Mineral oil	4
Gallic acid	15
Ethyl acetate	45
Toluol	15

The copy sheet, to be used with a donor sheet carrying the above composition, may be impregnated with a suitable chemical salt, complementary to gallic acid, such as ferric chloride. Preferably, however, the copy sheet is coated with a composition including the iron salt, a humectant such as glycerine and a binder such as cellulose acetate or the like, as disclosed in U.S. Patent No. 2,872,863 and as exemplified by FIG. 3 of the drawing.

Example 2

Donor composition:	
Ingredients—	Parts by weight
Zein	10
Microcrystalline wax	10
Beeswax	5
Crystal violet lactone	15
Isopropyl alcohol	35
Water	25

The copy sheet, to be used in connection with a donor sheet carrying the above composition, has a surface coating of clay or the like, as disclosed in U.S. Reissue Patent No. 23,024, or a coating comprising a solid dye solvent such as cetyl alcohol, Carbowax, stearic acid, etc. as taught by copending application, Serial No. 36,951, now Patent Number 3,088,028.

Example 3

Donor composition:	
Ingredients—	Parts by weight
Polyvinyl butyrate	10
Microcrystalline wax	12
Indopol H-300	3
Nickel palmitate	4
Barium sulfide	4
Stearic acid	7
Ethyl acetate	45
Toluol	15

Donor sheets having the above composition, or that of Example 4 following, produce copy on ordinary untreated record sheets.

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Example 4

Donor composition:	
Ingredients—	Parts by weight
Casein	10
Ammonium hydroxide (28% aqueous) (hardening agent)	2
Carnauba wax	10
Montan wax	8
Paraplex AL-111	2
Crystal violet	18
Water	50

The preceding examples are given by way of illustration and should not be considered limitative.

Variations and modifications may be made within the scope of the claims and portions of the improvements may be used without others.

I claim:

1. A donor sheet adapted for the production of duplicate copies of infrared radiation-absorbing heat-generating images carried on one surface thereof which comprises a flexible foundation sheet having on one surface thereof a donor coating which is substantially non-transferable under the effects of ordinary imaging pressure, said coating comprising a solid resinous base material and an imaging composition containing a solid wax binder, which is non-compatible with said base material and which is meltable at the temperatures generated by said images under the effects of infrared radiation, and a quantity of imaging material.

2. A donor sheet adapted for the production of duplicate copies of infrared radiation-absorbing heat-generating images carried on one surface thereof which comprises a flexible foundation sheet having on one surface thereof a donor coating which is substantially non-transferable under the effects of ordinary imaging pressure, said coating comprising a solid hydrophilic colloid base material and an imaging composition containing a solid wax binder, which is non-compatible with said base material and which is meltable at the temperatures generated by said images under the effects of infrared radiation, and a quantity of imaging material.

3. A donor sheet comprising a flexible foundation sheet having on one surface thereof images which absorb infrared radiation and convert it to heat and on the opposite surface thereof a donor coating which is substantially non-transferable under the effect of ordinary imaging pressure, said coating comprising a solid film-forming base material and an imaging composition containing a solid wax binder material, which is non-compatible with said film-forming material and which is meltable at the temperatures generated by said images under the effects of infrared radiation, and a quantity of imaging material.

4. A donor sheet according to claim 3 in which the imaging material comprises a substantially colorless color-forming ingredient.

5. A donor sheet according to claim 3 in which the imaging material comprises a dyestuff.

6. A donor sheet according to claim 2 in which the resinous base material comprises a vinyl resin.

7. A donor sheet according to claim 3 in which the hydrophilic colloid base material comprises zein.

8. The method of preparing a donor sheet which comprises applying to one surface of a flexible foundation sheet a coating composition comprising a film-forming base material, a solid wax binder material which is non-compatible with said film-forming material, a quantity of imaging material and a volatile solvent and drying said coating by evaporating the volatile solvent to form a coating which is substantially non-transferable under the effects of ordinary imaging pressure but which exudes said wax binder material and said imaging material when heated to temperatures in excess of about 150° F.

9. The method of preparing a donor sheet which comprises applying to one surface of a flexible foundation sheet a coating composition comprising a resinous base

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material, a wax binder which is non-compatible with said base material, a quantity of imaging material and a volatile organic solvent and drying said coating by evaporating the volatile solvent to form a coating which is substantially non-transferable under the effects of ordinary imaging pressure but which exudes said binder and said imaging material when heated to temperatures in excess of about 150° F.

10. The method according to claim 9 in which the resinous base material comprises a vinyl resin.

11. The method of preparing a donor sheet which comprises applying to one surface of a flexible foundation sheet a coating composition comprising a hydrophilic colloid base material, a wax binder which is non-compatible with said base material, a quantity of imaging material and an aqueous solvent and drying said coating by evaporating the volatile solvent to form a coating which is substantially non-transferable under the effects of ordinary imaging pressure but which exudes said binder and said imaging material when heated to temperatures in excess of about 150° F.

12. The method according to claim 11 in which the hydrophilic colloid base material comprises zein.

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13. The process of producing duplicate copies of a donor sheet having on one surface thereof infrared radiation-absorbing images and on the opposite surface thereof a donor coating which is substantially non-pressure-transferable and which contains a solid film-forming base material and an imaging composition containing a solid meltable binder material and a quantity of imaging material, which comprises superposing said donor sheet together with a copy sheet so that the donor coating is in surface contact with said copy sheet, and directing a sufficient quantity of infrared radiation against said images to generate a temperature sufficiently high to melt the imaging composition of said donor coating and cause it to wet and image said copy sheet in areas corresponding to the image areas of said imaged donor sheet.

References Cited in the file of this patent

UNITED STATES PATENTS

Re. 24,554	Clark et al. -----	Oct. 21, 1958
2,769,391	Roshkind -----	Nov. 6, 1956
2,800,077	Marron -----	July 23, 1957
2,939,009	Tien -----	May 31, 1960

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,119,014

January 21, 1964

Douglas A. Newman

It is hereby certified that error appears in the above numbered patent requiring correction and that the said Letters Patent should read as corrected below.

Column 3, line 34, for "at" read -- as ---; column 6, line 58, for the claim reference numeral "2" read -- 1 ---; line 60, for the claim reference numeral "3" read -- 2 ---.

Signed and sealed this 23rd day of June 1964.

(SEAL)
Attest:

ERNEST W. SWIDER
Attesting Officer

EDWARD J. BRENNER
Commissioner of Patents