June 11, 1963 W. D. PETERSON ETAL 3,093,478

PHOTOGRAPHIC RELIEFS MADE BY MEANS OF TRANSFER INTERMEDIARIES WHICH PRODUCE GAS UPON IRRADIATION

Filed Dec. 1, 1961 2 Sheets-Sheet 1

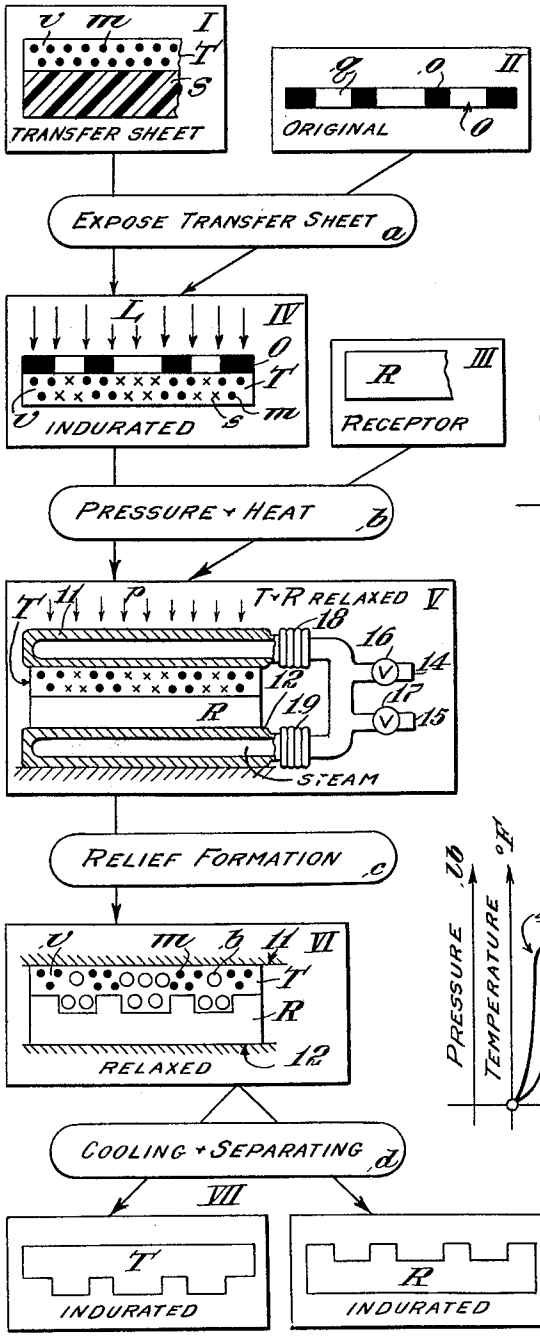

Fig. 1

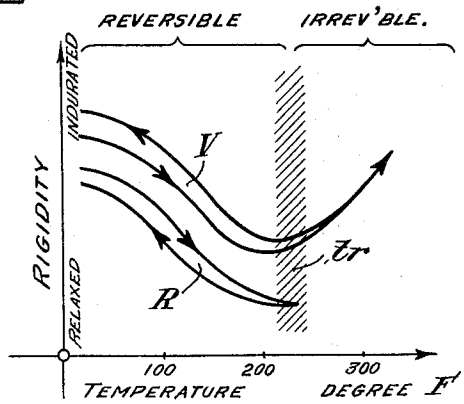

Fig. 2

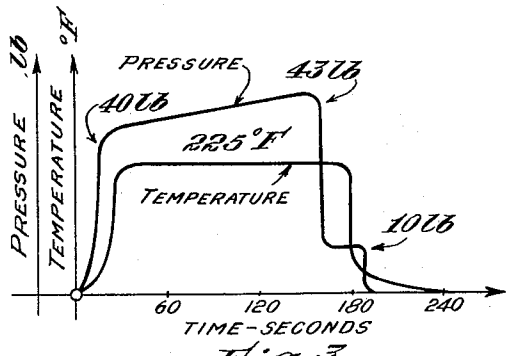

Fig. 3

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Filed Dec. 1, 1961 2 Sheets-Sheet 2

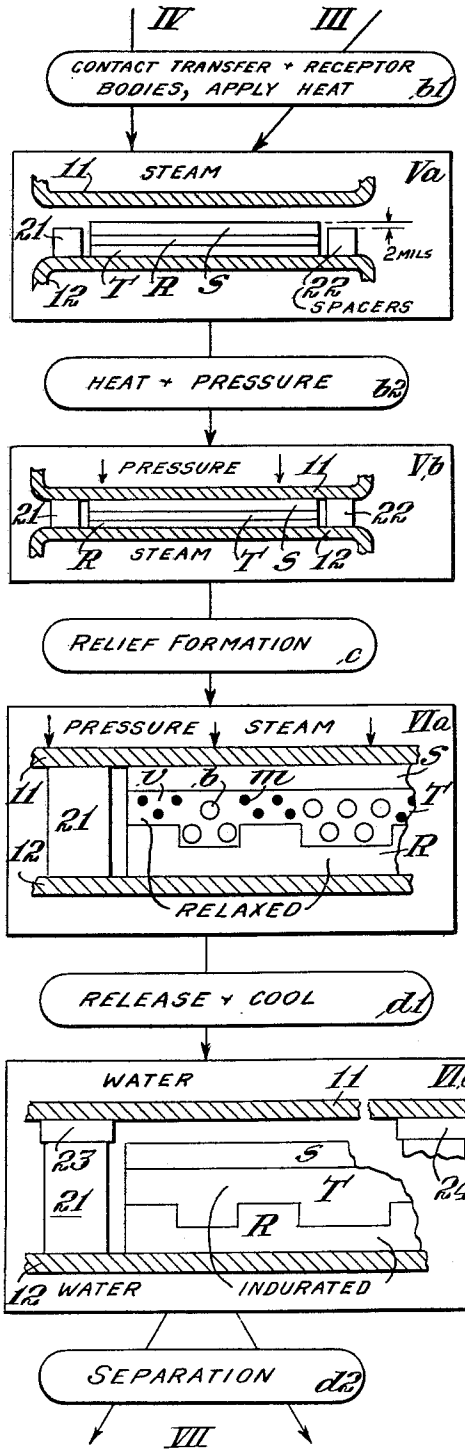

Fig. 4

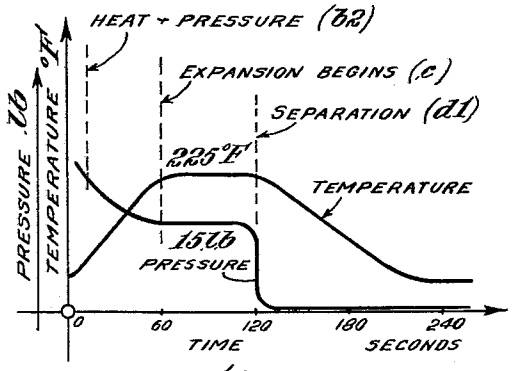

Fig. 5

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3,093,478

PHOTOGRAPHIC RELIEFS MADE BY MEANS OF TRANSFER INTERMEDIARIES WHICH PRODUCE GAS UPON IRRADIATION

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Filed Dec. 1, 1961, Ser. No. 156,437
15 Claims. (Cl. 96—35)

The present invention relates to a process of forming relief copies of records such as printed matter or pictorial representations by means of transfer intermediaries which produce gas upon irradiation, to material employed in such process, and to relief copies themselves.

It is a principal object of the invention to provide photographic reproductions in the form of reliefs, according to techniques which are extremely simple and inexpensive and yet fully satisfactory not only for letter press printing on an industrial scale but also for use in offices, libraries, drafting rooms and similar establishments where it is desirable to copy record material with a minimum of effort with unskilled labor and in minimum time. Reliefs made according to the present invention can be used not only for letter press forms or conventional line or halftone cuts, but also for relief offset printing as well as for continuous gradation reliefs for various purposes. The field of application is however not limited to printing reliefs but extends to the making of reliefs generally including Braille records produced from flat originals and decorative reliefs.

Another object is to provide such techniques which employ materials that are comparatively inexpensive, which stand up well through reasonably rough routine handling, and produce exact and permanent relief copies.

Further objects are to provide reproduction techniques which are dry throughout and do not require chemical treatment or rinsing baths, the only production controls being applied to pressure and temperature conditions within fairly wide margins of tolerance and not of unusual range and magnitude. For some purposes, positive and negative reliefs, both suitable for practical use including printing, can be obtained at the same time.

It has been proposed to produce photographic reliefs with the aid of light sensitive substances which upon illumination dissociate with development of gas. These attempts met with only indifferent practical success due to the fact that relief formation and surface texture as well as record pattern definition and contrast could not be controlled nor perfected to a degree sufficient for the intended purposes. In accordance with the present invention these factors can be controlled and perfected due to the recognition of the possibilities offered by the use of intermediary transfer and receptor bodies which have certain predetermined, preferably fairly similar properties and particularly also due to the discovery of certain optimum control conditions during the relief formation. For example, it was found that a technique of this kind is advantageously based on conceiving a set of relief imparting and relief receiving bodies (herein also referred to as transfer and receptor sheets or bodies) as a combination of correlated units, preferably with similar response to certain pressure and rigidity control factors, the latter being preferably a temperature adjustment applied to thermoplastic transfer and receptor bodies.

In accordance with the invention, relief records are made through the intermediary of transfer sheets of a plastic vehicle of controllable rigidity incorporating a sensitizer which is capable of liberating gas upon exposure to radiation, by exposing such a sheet in indurated condition to a radiation image thereby forming in the sheet a record

of the image in terms of gas sources which are restrained from effectively expanding by the rigid condition of the vehicle, by contacting the record carrying sheet with a plastic receptor body of controllable rigidity, and by pressurably restraining the contacted record carrying transfer sheet and receptor body with both sheet and body in relaxed condition while expanding the gas within the exposed areas of the relaxed transfer vehicle, causing the exposed areas of the sheet to penetrate transversely into the yielding body, forming two complemental reliefs. Upon separation of the transfer sheet from the body, two records in terms of relief are available; for most purposes the relief of the receptor body will be utilized for printing or other purposes such as Braille records, but in some instances the relief of the transfer sheet has a useful purpose for printing or otherwise.

In an important aspect of the invention, it was found that the loss of rigidity or softening of the transfer body should somewhat lag behind that of the relief receiving body during the relief forming period.

In a particularly important practical aspect of the invention, relief records are made through the intermediary of a flat transfer sheet comprising an organic colloid vehicle, such as gelatin or glue, incorporating a sensitizer which is capable of liberating gas upon exposure to radiation, by exposing such a sheet in indurated condition essentially at room temperature to a radiation image thereby forming in the sheet a record of the image in terms of gas sources which are restrained from effectively expanding by the rigidity of the vehicle, by contacting the record carrying transfer sheet at room temperature with a receptor body, the body being predominantly of thermoplastic cellulose which has a slight relaxation lead with rising temperature as compared to the transfer sheet, by applying to sheet and body a pressure of the order of magnitude of 40 lb. per square inch while applying a temperature of the order of magnitude of 225° F. to bring them into relaxed condition while expanding the gas within the exposed areas of the relaxed vehicle, which causes penetration of the exposed areas of the sheet transversely into the yielding body, by cooling and thus indurating sheet and body, and by separating the sheet from the body which now carry the image in terms of relief.

In another important aspect relief records are made by means of transfer and receptor bodies of the above characteristics by contacting the indurated transfer body which carries a record in terms of exposed sensitizer, with the receptor body, subjecting both to essentially constant pressure while in relaxed condition, and essentially simultaneously releasing the pressure and reindurating the bodies whereupon the bodies, each now carrying the record in terms of relief, can be separated.

In a further aspect the invention provides sets of sheet material for making relief records which comprise, as coordinated units, a transfer sheet made of a thermoplastic vehicle of controllable rigidity, such as gelatin or glue of suitable types, and incorporating a sensitizer which is capable of liberating gas upon exposure to radiation, combined with a thermoplastic receptor body of controllable rigidity, the rigidity characteristics of transfer and receptor bodies being of the same general character within the temperature range utilized according to the invention.

In a particularly useful embodiment, the process according to the invention employs sets of sheet material which comprise as coordinated units a transfer sheet made of an organic colloid such as gelatin or glue which relaxes with rising temperatures and incorporates a sensitizer which is capable of liberating gas upon exposure to radiation, combined with a receptor body of thermoplastic cellulose acetate with an admixture of a modifying thermo-

plastic resin, regulated to furnish with rising temperature a slight relaxation lag of the receptor body as compared to the relaxation of the transfer sheet undergoing an essentially similar temperature change.

Other objects, aspects and features will appear, in addition to those contained in the above statement of the nature and substance including some of the objects of the invention, from the herein presented outline of its theoretical basis and its practical possibilities together with a description of typical embodiments illustrating its novel characteristics. These refer to drawings in which:

FIG. 1 is a flow diagram illustrating an embodiment of the process according to the invention;

FIG. 2 is a diagram illustrating the behaviour of sets of transfer and receptor bodies according to a practical embodiment of the invention;

FIG. 3 is a diagram of the temperature and pressure conditions during the process according to FIG. 1; and

FIGS. 4 and 5 are a flow diagram and a temperature and pressure diagram corresponding to FIGS. 1 and 3, respectively, illustrating a second embodiment of the invention.

As indicated by the operational legends *a* to *d* which connect the step illustrating blocks I to VII of FIG. 1, the general procedure according to the invention is as follows. A rigid transfer sheet T is exposed to a radiation image defined by original O. Gas sources *s* are formed in the transfer sheet defining therein a record corresponding to the image. The transfer sheet and a receptor body R are then contacted under pressure and relaxed, the gas expansion within the transfer sheet and the relaxation of both bodies, T and R, causing relief formation of opposite sign in transfer sheet and receptor body respectively. Transfer sheet and receptor body are then again indurated and separated. Two relief records are thus obtained, the receptor body relief being in a material which can be selected as to suitability for a given purpose such as a particular printing technique although usable, especially if permanently indurated in the manner to be described below. It will be understood that the relief or reliefs may be used for other than printing purposes, such as Braille records or ornamentation.

As indicated above, the materials for carrying out the process according to the invention combine as coordinated units, each set including a transfer body and a receptor body. These are shown separately in blocks, I, III and VII respectively of FIG. 1, whereas blocks IV to VI show them in contact before, during and after relief formation. In accordance with the invention, the components have the following general characteristics.

The transfer sheet has a base or support S which can be of any suitable fairly rigid material and carries the transfer body proper T which comprises a vehicle *v* with sensitizer molecules *m* incorporated therein.

The vehicle for sensitizer substances of the type to be described in detail below, consists of suitable thermoplastic material, in the present preferred embodiment gelatin having the rigidity-temperature characteristic indicated at V of FIG. 2. This characteristic is reversible up to a critical temperature region *tr*, beyond which the gelatin becomes irreversibly hardened. This region is somewhat above 200°, as indicated in FIG. 2. While this irreversible hardening is not essential in many practical embodiments including that described hereinbelow, it becomes important if one intends to utilize the relief formed in the transfer gelatin.

The efficacy of the transfer body T depends primarily on the permeability of the vehicle for the gas formed therein, and on its rigidity. The permeability of the vehicle is instrumental in determining the character of the record formed therein in terms of gas sources or units. The rigidity of the vehicle controls the relief forming expansion of gas therein as well as the reaction to such relief formation of the receptor body in pressurable contact therewith. Permeability and rigidity are at least to some extent interdependent so that compromises may have to be accepted in order to obtain optimum utility; certain discoveries according to the invention tend towards this optimum of utility as will appear hereinbelow.

The vehicle permeability has two practical aspects, namely the internal permeability and the escape permeability both of which affect the efficiency as well as quality of record and relief formation.

The optimum internal permeability characteristic depends a good deal on the distribution of sensitive material, herein shortly referred to as sensitizer, and this distribution again depends largely on the manner of incorporating the sensitizer.

Generally speaking the radiation sensitive molecules are incorporated by way of solution as well as dispersion and physical agglomeration, the first within the liquid component of the vehicle for example the water or gelatin, and the latter two deposited by precipitation on the walls or within the interstices of the vehicle. Since the relief forming expansion of gas bubbles can only take place if a true gas is present, individual molecular gas sources must be permitted to combine to form gas units which for present purposes can be considered as the smallest possible bodies susceptibe to expansion upon heating, in the manner of the true gas. This unit formation depends on the internal permeability permitting more or less coalescence of gas sources.

The escape permeability is of the general nature of the internal permeability but has a somewhat different effect because it controls the escape of gas from the vehicle rather than the bubble formation. While the internal permeability controls mainly record definition and contrast through its effect on bubble size, number and distribution, the escape permeability effects the degree of relief formation by controlling, prior to contact with the receptor, the retention of gas within the vehicle.

The rigidity of the vehicle should be fairly high during exposure and transfer into contact with the receptor, in order to prevent bubble expansion so that a flat surface is preserved up to the contacting with the receptor body. The rigidity is then relaxed to permit expansion of the gas bubbles and relief formation. During this period, that is during contact of relief former and receptor, the rigidity can be more relaxed in the environment provided according to the present invention as compared to free expansion, since the expansion is counteracted by the contacting receptor body which is then in pressurable contact with the transfer sheet or relief forming body. Absence of restrictions on rigidity as by free relief formation, or relief formation against more or less liquid receptors, promote poor definition and other defects of the relief record in either transfer or receptor body, or both.

The sensitizing substance must be capable of solution or dispersion within the vehicle, sufficiently fine for purposes of the required definition as further controlled by the above-discussed permeability and rigidity characteristics of the vehicle. The gas formed upon decomposition of the sensitizer must be essentially inert relatively to the vehicle entrapping it. Compounds of the diazo type which upon irradiation liberate nitrogen were found to be especially suitable, but other compounds for example of the type which liberate carbon oxides can be used.

The receptor body can be selected independently of permeability considerations but its rigidity properties are quite important with a view to optimum relief formation by interpenetration of the portions raised from the transfer body and impressed into the receptor body, transversely of both bodies. It was found that roughly speaking the rigidity characteristics of the two bodies should be congruous or analogous so far as possible in view of their somewhat different function, namely radiation-responsive record formation and gas bubble expansion in the one case, and expansion restraint and relief reception

in the other. However, it was further found in accordance with an important practical aspect of the invention, that relief quality is promoted if the receptor body has a certain relaxation lag, that is, if it remains somewhat softer than the transfer sheet with relaxation of the unit as a whole, as indicated at R of FIG. 2.

According to a further important aspect of the invention, the rigidity-pressure relation during the contact period, and the duration of the latter itself are fairly important. As will be discussed in detail with reference to FIG. 3, the pressure is in an especially successful embodiment slightly raised during contact and the application of heat, and reduced shortly before the system is again cooled and the bodies finally indurated.

Materials especially suitable in accordance with the above principles will now be discussed, with several specific examples incorporating such materials.

As mentioned above, gelatin was found to be very well suited as a material for the vehicle of the transfer sheet, although substances of similar thermoplastic characteristics can be used. Specific examples will be given below, for gelatin and glue.

Among the sensitizing substances which liberate nitrogen upon irradiation, para-diazo dimethyl aniline zinc chloride was found to be especially valuable, but the following substances were also found to be useable.

p-Diazo diphenylamine sulfate, p-diazo diethylaniline zinc chloride, p-diazo ethyl hydroxyethylaniline zinc chloride, p-diazo ethyl methyl aniline zinc chloride, p-diazo diethyl methyl aniline zinc chloride, p-diazo ethyl hydroxyethylaniline zinc chloride, 1-diazo-2 oxy naphthalene-4 sulfonate, p-diethyl amino benzene diazonium chloride $ZnCl_2$, 4-benzoylamine-2-5-diethoxy benzene diazonium chloride, p-chlorobenzene-sulfonate of 4-diazo-1-cyclohexylaniline, p-chlorobenzene-sulfonate of 4-diazo-2-methoxy-1-cyclo-hexylamino benzene, tin chloride double salt of 4-N-methyl-cyclohexylamino-benzene diazonium chloride, p-acetamino benzene diazonium chloride, 4-dimethylamino benzene diazonium chloride, 3-methyl 4-diethylamino benzene diazonium chloride, 4-morpholino benzene diazonium chloride, 4-piperidyl 2-5-diethoxy benzene diazonium chloride, 1-dimethyl amino naphthalene-4 diazonium chloride, 4-phenyl amino diazo benzene diazonium chloride.

Substances which liberate carbon oxides upon irradiation and which are useful for purposes of the invention are for example iron salts in conjunction with organic acids such as ferric ammonium citrate and oxalic acid.

The sensitizing compound can be dissolved and in that state mixed with a solution of the gelatin, and the mixture dried in the form of a film applied to a support. Up to certain concentrations which depend on the particular gelatin, such vehicles contain the sensitizer most likely dissolved in the gelatin water. Above such concentrations the sensitizer is probably also dispersed in precipitated form, as discussed above with reference to the vehicle structure.

The support can be of any suitable material, which will withstand the slight stress applied thereto during contact with the receptor body, and the operational temperatures required. Glass, acetate film, metal, and similar substances are satisfactory.

The material for the receptor body has to be selected in accordance with the above outlined principles, namely essential similiarity of its rigidity-temperature function to that of the transfer sheet and, preferably, incorporation of the above mentioned slightly different rigidity response to temperature change. In addition the receptor body material must have characteristics of mechanical strength, elasticity and surface texture which enhance its use, such as for a printing plate, without any further treatment after its separation from the transfer body.

Among the materials available for that purpose, thermoplastics such a scellulose acetate were found to be particularly suitable. Admixture of adjusting, such as other

thermoplastic substances is often expedient for the purpose of coordinating the rigidity characteristics of the receptor body to those of the transfer sheet.

The following examples are characteristics of the above described materials.

Example I

Transfer sheet:—100 g. of high grade unhardened dry gelatin such as sold under the trade designation "Kodak Peabody Gelation," 250 Bloom, prepared by alkaline pretreatment, is soaked for two hours in 1900 ml. distilled water of 30° C. The solution is then heated to 40° C. under constant stirring, and filtered. For the purpose of establishing a pH of about 3.0, 8 g. critric acid C.P. is added. Thereupon is added 10 g. of the sensitizing substance sold under the trade designation "Edwal Compound #8," which is a zinc salt of para diazo dimethyl-aniline. This is then diluted to make 2000 ml. The resultant emulsion is maintained at 40° while being coated by conventional means on plass plates or cellulose film of the types use for purposes of commercial photography. The dry thickness of the emulsion is about 1 to 4 mls, depending upon the desired height of relief. In order to establish the thermoplasticity of the transfer bodies according to the present invention, the colloid sheet is dried and stored under controlled humidity conditions. Humidities of from 20 percent to 55 percent found to be workable for the herein described gelatin transfer body; a value of 30 percent was found to be satisfactory under average ambient conditions. It will be understood that optimum thermoplasticity can be obtained by mutually adjusting the above mentioned variables, namely pretreatment, Bloom, hardness, pH, moisture contents as determined by storage conditions.

Receptor body:—85 parts by weight of the cellulose aceto-butyrate sold by Eastmen Chemical Products, Inc., of Kingsport, Tenn. under the trade designation "Tenite II" are mixed with 15 parts of the thermoplastic phenol formaldehyde resin sold by the Valid Corp. of New Orleans, La., under the trade designation "Valite." It is understood that "Valite" is obtained by the process described in United States Patent 2,394,000. The mixture is by conventional method formed into sheets approximately 50 to 70 mils thick, care being taken to obtain a smooth surface for contact with the transfer sheet. The rigidity of this receptor material can be adjusted to conform to that of the transfer body in accordance with the above outlined principles, by slightly changing the basic proportion. The usual shop experiment with each new bath of transfer and receptor materials units will determine the optimum composition of the set for a given purpose.

Example II

Transfer sheet: —50 g. gelatin, as above, are compounded with 1000 ml. water. To this are added 2.5 g. ferric chloride and 2 g. oxalic acid. The emulsion is coated on a support, as above.

Receptor body:— 90 parts of "Tenite II" are combined with 10 parts of the methyl phthalyl ethyl glycollate sold under the trade designation "Santicizer M–17," and formed into sheets as outlined for Example I.

Example III

Transfer sheet:—Glue available under the trade designation "Light Colored Hide Glue," of gram strength 252, viscosity 80, and pH 5.75 of a 12.5 percent solution is dissolved to form a 12.5 percent solution. To this solution 14 g. citric acid per 100 g. of glue are added to assure stability. This glue solution is combined with sensitizing substance, coated, and dryed as above described with reference to the gelatin transfer body of Example I.

Receptor body:—Either one of the receptor bodies of Examples I or II can be used with glue transfer sheets.

Two specific embodiments of the relief forming tech-

nique according to the present invention will now be described.

In FIG. 1, block I indicates a transfer sheet or body of the type described above as Example I, namely a gelatin vehicle carrying a diazo sensitizer. The support S is for example a sheet of glass. Block II indicates an original record O such as a halftone diapositive, wherein the opaque portions *o* indicate the dark dots and the portions *q* the transparent interstices. In this particular embodiment half-tone diapositives made with a 65 line screen are quite satisfactory giving a good relief about 3 mls high. Block III shows a receptor body R, compounded and prepared in accordance with Example I.

In order to obtain a relief defining record in the transfer sheet T, it is exposed in contact with the original O as indicated in block IV by light rays L. A gaseous discharge lamp of the BH6 air-cooled type was found satisfactory for contact printing of the transfer sheet, for about three minutes at a distance of eighteen inches from the lamp within a conventional aluminum reflector. The exposure takes place preferably at room temperature, provisions being taken if necessary, to avoid appreciable heating of the transfer sheet. It should be noted in this context that the diazo compound in the present embodiment is mainly sensitive in the region from 3500 to 4500 A., which includes the maximum emission range of the BH6 lamp. This combination of exposure light and sensitizer has the considerable advantage that such a transfer sheet is practically insensitive to ordinary daylight, which permits particularly easy handling. As indicated at *s*, the irradiated molecules form gas sources in a pattern reproducing that of the original O. The vehicle *v* being in indurated condition, the gas sources *s* are able to form gas units capable of later expanding as a true gas, but as yet prevented from doing so by the condition of the vehicle.

It will be evident that the exact exposure time depends a good deal on the character of the original and the transfer sheet batch in question, so that it is desirable to perform the usual shop experiment for each batch of emulsion. A good indicator of complete exposure at a certain distance and light intensity is the disappearance of the yellowish cast of the diazo sensitizer in the transfer sheet vehicle.

Regarding exposure time it should be noted that the height of relief above the original base line on the transfer body increases with exposure time up to a certain maximum beyond which all sensitizer is exhausted. It depends a good deal upon conditions at hand, for example requirements of record definition and height of relief, whether or not the transfer sheet should be fully exposed and also whether or not the full potentiality of relief formation by way of bubble expansion should be utilized; excessive bubble expansion might lead to loss of definition, so that height of relief and definition will have to be balanced for any particular job.

The next step is the contacting of transfer sheet and receptor body preparatory to relief formation in the vehicle of the transfer sheet and in the receptor body. The transfer sheet T on its support S and the receptor body R, both still at room temperature and hence in indurated condition, and both essentially flat are superimposed and contacted with their flat surfaces as indicated in block V. These are thus contacted in a transfer press which is schematically indicated as two platens **11** and **12**, both hollow and connected to a system for alternately supplying steam of controllable temperature and cold water. In block V these provisions are schematically indicated as steam and water supplies **14**, **15**, respectively, with cocks or valves **16**, **17** for controlling the steam and water supply. Flexible connections **18**, **19** lead from the valves to the platens. A predetermined degree of pressure is then applied between the rigidly supported bottom platen **12** of the press and its top platen **11**, as indicated by arrows *p*. At the same time, steam of a temperature of approximately 225° F. is supplied to the platens while the pressure is approximately 40 lb./square inch. For about 2½ minutes this pressure is gradually increased to about 42 lb., that is approximately 10 percent, while maintaining the temperature at about 225° F. For about 20 to 30 seconds the pressure is then reduced approximately three quarters, to about 10 lb./square inch, for a period of about 20 seconds, the temperature being still maintained at about 225° F. Thereafter, that is after approximately 3 minutes from the beginning of the cycle, the steam supply is disconnected and cold water injected in the platens so that the temperature decreases rapidly. The rigidity-temperature relations of transfer sheet and receptor body respectively in this embodiment are those illustrated in FIG. 2, and the entire cycle is schematically indicated in FIG. 3 which needs no further explanation in view of the above detailed description of the cycle.

Block VI of FIG. 1 indicates how the relief formation takes place, namely by expansion of the gas units into gas bubbles *b* which transversely expand the vehicle of the transfer sheet T into the receptor body R upon relaxation of both bodies according to an essentially analogous characteristic, preferably with the above discussed lag of the receptor body.

After about 1 minute, that is after about 4 minutes constituting a complete cycle, the platens are separated and transfer sheet and receptor body removed. They can now be separated and carry the record of original O in terms of negative and positive reliefs respectively as indicated at VII. The gelatin transfer sheet T and the receptor body R are again indurated, due to their having been cooled after the increase to the softening temperature. The gelatin relief can be irreversibly hardened by further heating, as described with reference to FIG. 2.

Instead of applying the transfer pressure by way of continuous adjustment as above described, it can be preset by mechanical means directly at the combined transfer and receptor bodies. A transfer technique of such type which is sufficiently exact for many purposes, will now be described with reference to FIGS. 4 and 5.

Transfer and receptor bodies may be of any of the above described types, but it is assumed for purposes of the following description that the same material is used as in the technique according to FIGS. 1 and 3, so that blocks I to IV of FIG. 1 apply also to this technique. The flow diagram of FIG. 4 therefore begins with step *b*1 which varies from step *b* of FIG. 1 in that pressure is not yet applied to the sandwich consisting of transfer and receptor bodies upon putting it on the lower platen **12** of a press of the above described type, supplied with steam of approximately 225° F. As indicated at V*a*, bearers or spacers **21**, **22** are placed on the platen **12**, which bearers are somewhat lower than the sandwich of receptor and transfer sheet. A difference in height of about .002 inch was found to be satisfactory for the material described above with reference to FIGS. 1 to 3. The platens can be supplied with steam when receiving the sandwich, so that the transfer and receptor bodies will begin to heat up at that time.

As indicated at *b*2 and V*b*, the upper platen **11** is then lowered until it rests on the bearers **21**, **22**, applying to the sandwich a pressure which is believed to decrease, so far as it has been possible to determine, from about 40 lb./per square inch when the upper platen first contacts the sandwich in comparatively cool condition, to about 15 pounds when resting on the bearers with the transfer and receptor bodies in hot, relaxed condition.

Depending upon the dimensions and material of receptor and transfer bodies, values of from 1.5 to 4.5 mils are optimum for the height difference between bearers and sandwich. It will be understood that the customary shop tests have to be taken for any new batch of transfer material, since in view of the nature of the plastic materials involved, and of the many controlling factors

which come into play, exact predictions as to these dimensions cannot always be made.

The sandwich is kept under pressure for approximately two minutes from the lowering of the upper platen. As indicated in block VI*a*, relief formation now takes place in the manner described above with reference to block VI of FIG. 1.

The press is then opened sufficiently to permit insertion of additional bearers or shims **23** or **24**, as indicated at VI*b*. This shim is somewhat thicker than the initial height difference between sandwich and bearers **21**, **22**. The platens are now again closed and, being separated by bearers **21**, **22**, **23**, **24**, leave a slight gap between the sandwich and the upper platen. At the same time the steam has been turned off and cooling water or oil admitted to the press, which fairly rapidly cools off transfer and receptor bodies, the former by way of the gap between its support S and the upper platen **11**. It is not absolutely necessary to lower the upper platen again and in many instances the cooling action of the ambient air and the lower platen **12** will be sufficient for reindurating the bodies within a comparatively short time.

Receptor and transfer bodies can now be separated as discussed above with the reference to block VII of FIG. 1.

The above technique is illustrated in FIG. 5 which is quite similar to FIG. 3 and needs no further explanation in view of the above description. It will be noted that the expansion begins when relaxation conditions are fully reached and the pressure is approximately stabilized, which condition is reached after about one minute from the beginning of the transfer process.

Generally speaking, the relief height is mainly dependent upon the final pressure on the sandwich, at the transition point from relaxed to reindurated condition. It will be noted that this pressure is approximately 10 to 20 lbs. in both embodiments above described.

It should be understood that the present disclosure is for the purpose of illustration only and that this invention includes all modifications and equivalents which fall within the scope of the appended claims.

This application is a continuation-in-part of the application filed September 10, 1952, and now abandoned, Serial No. 308,898.

What is claimed is:

1. A method of producing a relief image comprising dispersing a matrix material selected from the group consisting of gelatin and glue in water, dissolving in the water of this dispersion a sensitizer capable of liberating gas upon exposure to radiation, applying the thus sensitized dispersion to a support, drying the sensitized dispersion to an induarted rigid photo-sensitive record medium, exposing said medium to light so as to form in the sheet a record of the image in terms of gas sources which are restrained from effectively expanding by the said rigid condition of said record medium, contacting the record medium with a thermoplastic receptor sheet comprising a thermoplastic cellulose ester which becomes softened under conditions of temperature and pressure substantially the same as but somewhat lower than does said record medium pressurably restraining said record medium and said receptor in contact between rigid platens, heating the resulting sandwich to soften the said record medium and said thermoplastic receptor sheet while expanding the gas within the exposed areas of the said record medium to develop a relief image in said record medium and impress a complementary relief image in said thermoplastic receptor sheet, and cooling the sandwich to indurate the respective layers, whereupon they can be separated, each carrying said images in terms of relief.

2. A method as set forth in claim 1 in which the thermoplastic receptor sheet comprises cellulose acetate.

3. A method as set forth in claim 1 in which the thermoplastic receptor sheet comprises cellulose acetate butyrate.

4. A method as set forth in claim 1 wherein the thermoplastic receptor sheet comprises a mixture of cellulose acetate butyrate with a phenol formaldehyde resin.

5. A method as set forth in claim 1 in which the thermoplastic receptor sheet comprises a mixture of about 85 parts by weight cellulose acetate butyrate and about 15 parts by weight thermoplastic phenol formaldehyde resin.

6. A method as set forth in claim 1 in which the thermoplastic receptor sheet comprises a mixture of cellulose acetate butyrate and methyl phthalyl ethyl glycollate.

7. A method as set forth in claim 1 in which the thermoplastic receptor sheet comprises a butyrate mixture of 90 parts by weight cellulose acetate butyrate and 10 parts by weight methyl phthalyl ethyl glycollate.

8. A method as set forth in claim 1 wherein said receptor sheet is always, at any given temperature, softer than said record medium.

9. A method as set forth in claim 1 wherein said rigid platens are movable with respect to each other.

10. A method as set forth in claim 9 wherein the pressure applied by said rigid platens is gradually raised during the softening of said sandwich.

11. A method as set forth in claim 10 wherein said gradual pressure raising is carried to approximately 10% above the initial pressure.

12. A method as set forth in claim 9 including lowering the pressure during the concluding part of the period of contact between said record medium and said receptor sheet.

13. A method as set forth in claim 1 wherein said matrix material comprises gelatin and said thermoplastic receptor sheet comprises cellulose acetate, the pressure applied between said rigid platens being about 20 to about 60 pounds per square inch, and about 10 pounds per square inch during a short concluding period during the period of contact between said receptor sheet and said record medium.

14. A method as set forth in claim 1 in which said sandwich is heated to a temperature of about 200 to 250° F. for softening the record medium and the thermoplastic cellulose ester.

15. A method as set forth in claim 14 in which said sandwich is heated to about 225° F. for approximately two to three minutes while the pressure applied thereto is increased about 10%, then the pressure is reduced to about 10 pounds per square inch for about ten to thirty seconds while the temperature is maintained at about 225° F., and then the sandwich is cooled to room temperature while releasing the pressure applied thereto.

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