

[54] **THERMAL TRANSFER SHEET AND METHOD OF THERMALLY TRANSFERRING IMAGES**

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[52] U.S. Cl. **101/470, 346/76, 117/3.3**

[51] Int. Cl. **B41m 5/00**

[58] Field of Search.....101/463, 468, 470, 471, 473; 346/76; 250/65.1; 117/3.2, 3.3, 3.4; 178/5.2

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[57] **ABSTRACT**

This invention prevents an improved thermal transfer sheet and method of thermally transferring images. The transferability of images in a thermal transfer process is greatly improved by utilizing a thermal transfer sheet comprising a reticulated or discontinuous layer of transfer material.

10 Claims, 13 Drawing Figures

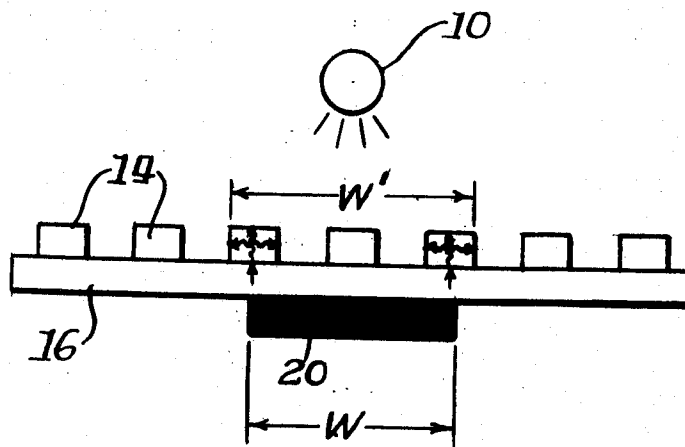


Fig. 1

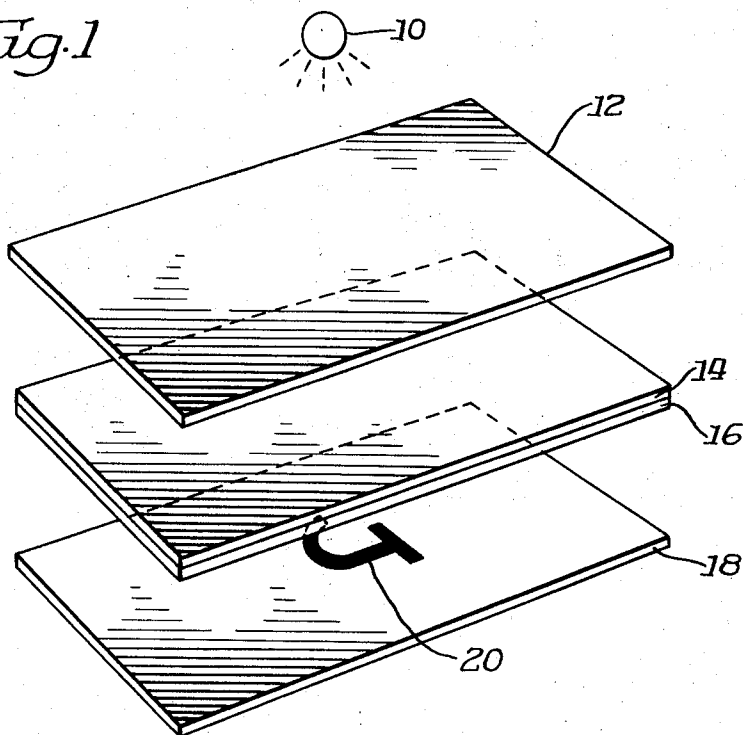


Fig. 2.

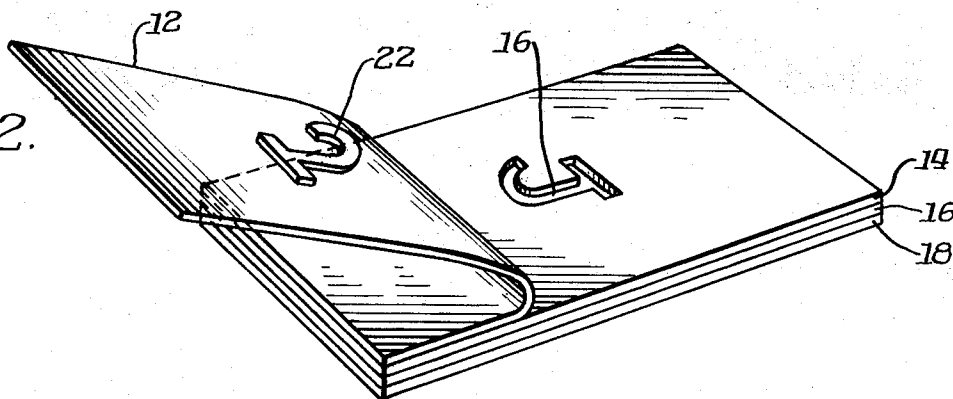


Fig. 3.

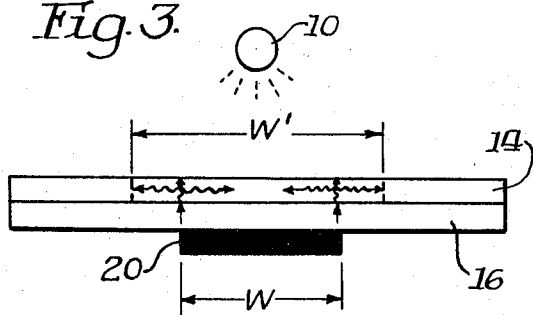
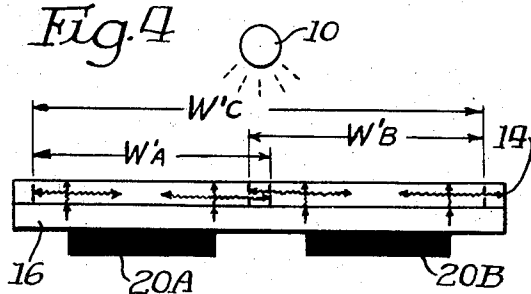


Fig. 4



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Fig. 5.

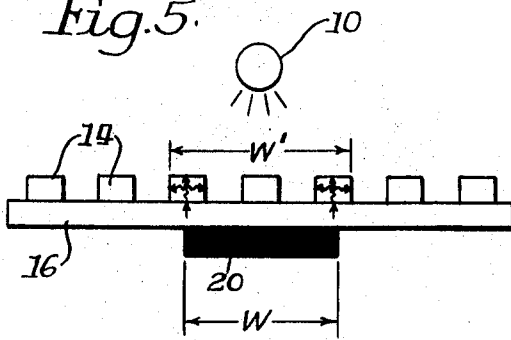


Fig. 7.

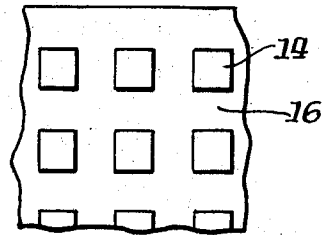


Fig. 6.

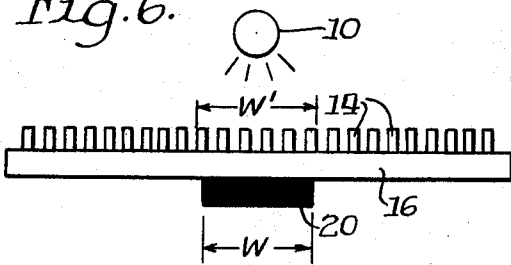


Fig. 8.

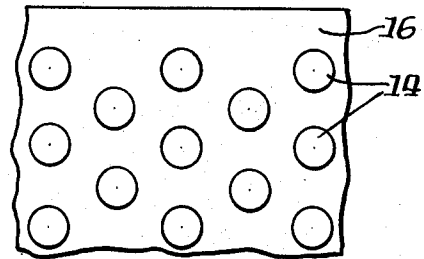


Fig. 11.

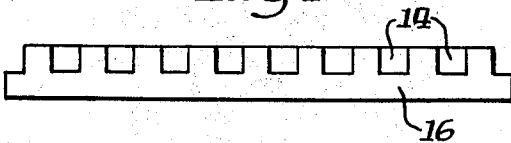


Fig. 9.

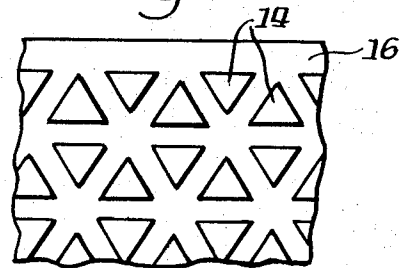


Fig. 12.

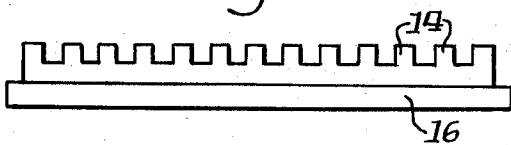


Fig. 10.

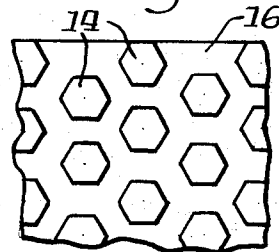
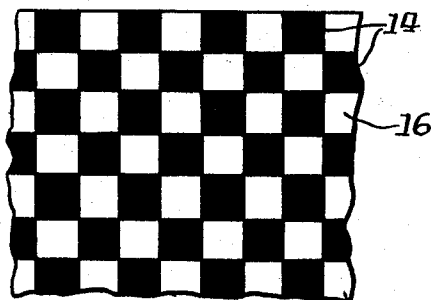


Fig. 13.



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THERMAL TRANSFER SHEET AND METHOD OF THERMALLY TRANSFERRING IMAGES

BACKGROUND OF THE INVENTION

The present invention relates generally to the field of thermographic copying processes. More particularly it relates to a new and improved transfer sheet for thermally transferring an original image to another surface either in like or mirror orientation with respect to the original image. The present invention provides a transfer sheet capable of transferring an image of much higher resolution, sharpness, and quality than previous thermal transfer sheets.

Thermal-transfer processes depend on relative differences in absorption of near infra-red radiation between the image to be transferred and the sheet or material supporting the image. Thus for instance, a replica of the letters on a typewritten sheet being more light absorptive than the sheet may be transferred to a second surface by a thermal-transfer process. Absorption by the image, i.e., the typed characters, causes them to become preferentially heated during an irradiation process. The paper or other substrate is relatively non-radiation absorptive. Normally, the imaged original, a transfer sheet and an image receiving sheet are assembled under pressure contiguous with one another, actually the image receiving sheet may be the reverse side of the imaged original. The transfer sheet typically consists of a thin carrier sheet possessing relatively low infra-red absorption characteristics and a transfer coating on the carrier sheet which is contiguous with the copy sheet in the above described assemblage. The transfer coating may also be infra-red light transmissive in certain applications. Irradiating the assemblage causes the image to increase in temperature. Heat from the image is conducted through the carrier sheet into the transfer layer. Thus the transfer layer becomes selectively heated in the same configuration as the image until it becomes plastic. These portions, corresponding to the image bond or adhere to the image receiving sheet. Upon separating the image-receiving sheet from the transfer sheet, plugs of the transfer material corresponding in shape to the original image will be carried by the image receiving sheet.

A thermal-transfer process is frequently used to make a copy or a master from which copies will be produced. Among the processes which may utilize a thermal-transfer technique are the following: spirit, hectographic or gelatin, chemical reaction, and lithographic or planographic.

In the spirit process, an image in mirror or reverse reading form is frequently affixed to a master sheet by a thermal transfer process. The transfer coating generally consists of a waxy material and an alcohol soluble dye incorporated into the waxy material. Subsequently the master is placed on a rotating drum and contacted with a succession of copy papers moistened with a volatile solvent to produce a number of copies in direct reading form.

In the hectographic or gelatin process, a thermal-transfer process is used to produce a direct reading image of hectographic ink on a master sheet. Again, a waxy substance and alcohol soluble dye comprise the image characters on the master sheet and have been

transferred from a transfer coating on a transfer sheet. Subsequently the master is contacted with a gelatin pad or roll thereby transferring the image in mirror form to the pad or roll. Copy papers moistened with a volatile solvent are then contacted with the pad or roll to produce the desired direct reading copies.

In the chemical reaction type processes, the characters or image are formed on a master sheet by the thermal-transfer process. Those characters are composed of a waxy material containing a chemical reagent that reacts with a chemical in or on a copy sheet placed in contact with the master sheet.

In the lithographic or planographic process a master sheet consisting of a hydrophilic material is imaged by a thermal-transfer process with characters of a greasy oleaginous material such as a fat or wax. The imaged master sheet is thus differentially receptive to water in the non-imaged hydrophilic area and to a greasy or oily ink in the imaged area containing the oleaginous lithographic material. Thus by moistening the master sheet successively with water and with ink, an inked image is developed thereon which can be transferred alternatively directly to a copy sheet or to a blanket for retransfer to a copy sheet. In the direct lithographic process, the characters or designs imaged on the master sheet are in mirror or reverse reading form so that when the master sheet is moistened and inked and brought into direct contact with a copy paper, the characters or designs are transferred in direct reading form to the copy paper. In the offset lithographic process, the characters or designs imaged on the master sheet are in direct reading form. In this process, the master is mounted on a duplicating machine in association with a rubber blanket, to which the inked image is first transferred and from which copies are offset upon further contact of the blanket impression with copy paper.

The specific methods of assembling the imaged original and the transfer sheet for each of the above processes will not be set out herein, for a complete treatment of that subject the reader is referred to U.S. Pat. No. 3,122,998, issued Mar. 3, 1964 to W. A. Raczyński et al for an "INFRARED TRANSFER PROCESS". It should be apparent that the widespread usage of the thermal-transfer processes lends great significance to improvements therein.

As stated above, the thermal-transfer process utilizes a transfer sheet with a coating thereon that becomes plastic in response to heating in a configuration identical with a contiguous imaged original in which the image possesses higher radiation absorption characteristics than the sheet upon which the image is supported. The term "plastic" as used herein describes a condition of material softening that permits adhesion or interminglement between the material and a contacting surface. Often the transfer coating will be partially or completely molten in the plastic or plasticized areas, but the molten condition is not necessary in all cases. Thus for our present purposes, a transfer material is said to be in a plastic condition when it intermingles with and conforms closely, under pressure, to a contacting surface so as to effect a bond or adhesion between the transfer material and the contacting surface.

To be a commercially useful item, the coating on the transfer sheet should not be plastic at normal shipping and storage temperatures. In general the minimum plasticizing temperature is approximately 110° F. at normal atmospheric pressures. However, this invention would be applicable to thermal-transfer processes in which the transfer sheets were kept at much lower temperatures than 110° F. and is not limited to that minimum.

Constant problems with thermal-transfer processes are the isotropic heat conduction nature of the transfer coating and mass transfer efficiency. Heated by an image subjected to radiation, the coating conducts heat in all directions. Each of these directions, other than those directly vertical or horizontal, will have both a vertical and lateral component of travel with respect to the original image plane. Lateral heat conduction within the transfer coating may extend the plasticized portion beyond the boundaries of the original image resulting in inaccuracies, fuzziness and a decrease in resolution and sharpness of the transferred image. Thus a significant disparity between transferred image quality and the original image quality may result from lateral heat conduction within the transfer coating.

A further source of transfer difficulties resides in the necessity of intimate contact between the transfer coating and image receiving sheet to effect proper transfer. Pressure is normally applied to urge them together. However, the surfaces are not microscopically smooth, and too high a pressure can cause image smearing and spreading. As a result, pressure is adjusted to minimize image smearing and permit reasonable image transfer. Consequently, parts of images are missed and are randomly distributed over the entire surface depending on the microscopic topography of the two surfaces.

SUMMARY OF THE INVENTION

The present invention improves the resolution of thermal-transfer processes by reducing the lateral thermal conductivity of the transfer coating on a transfer sheet and improving mass transfer efficiency. To accomplish this result, a discontinuous transfer coating is utilized, thereby presenting alternate portions of transfer coating and a material of relatively lower heat conductivity. In simplest form the coating may be scored or grooved to utilize air as the relatively low heat conductive material. By thusly decreasing the surface area of the transfer coating, for a given force application, the transfer pressure is correspondingly increased and further enhances the transferred image.

BRIEF DESCRIPTION OF THE DRAWINGS

The features of the invention will become more apparent in the following description of the preferred embodiments and drawings in which:

FIGS. 1 and 2 depict a thermal transfer process.

FIGS. 3 and 4 depict lateral heat conductivity in a thermal transfer process.

FIGS. 5 and 6 are thermal transfer sheets constructed in accordance with the principles of the invention.

FIGS. 7-13 illustrate some of the preferred embodiments of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

To better illustrate the operating principles of this invention, a general treatment of the thermal-transfer process will now be given. FIG. 1 shows an exploded assemblage of an image sheet 18 with an image 20 thereon, a transfer sheet comprising a carrier sheet 16 and a coating of transfer material 14 overlying the imaged sheet 18, an image receiving sheet 12 placed contiguous with the transfer coating 14 and under normal operating conditions the assemblage would be clamped together under pressure. Irradiating the imaged sheet 18 through 12, 14 and 16 heats the image 20 and heat therefrom passes into the transfer coating 14. When the transfer coating 14 has increased in temperature beyond its plasticizing point, the irradiation may be stopped and the image receiving sheet 12 will carry with it a plug 22 of the transfer coating 14 in the shape of the original image 20. Thence the image receiving sheet may be utilized in any of the appropriate aforementioned duplicating processes.

It must be emphasized that the image receiving sheet may be a master sheet or a copy sheet. A wide assortment of assemblages and radiation impingement techniques may be utilized as set out in the aforementioned U.S. Pat. No. 3,122,998. That patent also describes means and methods of applying pressure to the transfer assemblage during the irradiation process. Since this invention is equally applicable to all thermal-transfer techniques a complete recitation thereof is unnecessary herein.

FIG. 3 schematically illustrates one of the causes of the decrease in image quality previously inherent in the thermal-transfer process. Heat from the image 20 passes through the carrier sheet 16 and into the transfer coating 14. Being isotropically thermally conductive, the coating 14 conducts the heat equally well in all directions, each of which will have a vertical and lateral component as represented by the arrows. It should be apparent that FIG. 3 is merely schematic and in fact heat will be conducted into the coating 14 across the entire width W of the image 20, not only at the edges as illustrated. But the edge conditions are most relevant here because as shown, the plasticized width W' of the transfer coating 14 is greater than the actual image width W due to the lateral heat conductivity of the coating.

This phenomenon is in and of itself undesirable because the transferred image does not correspond to the actual image with exactitude. But the effect becomes even more severe when as in FIG. 4 two images 20_A and 20_B lie closely together. Here the plasticized widths W'_A and W'_B of the transfer coating overlap one another and therefore will be transferred to the image receiving sheet as a single unit of width W_C. Of course, in this case the original character of the image has been lost completely due to the lateral conductivity of the transfer coating. Ideally the ratio of vertical conductivity to lateral conductivity would be infinite in which case the resolution and quality of the transferred image would for all practical purposes be perfect. This invention presents a transfer sheet that may closely approximate the ideal infinite ratio of conductivities.

An additional problem is a ragged edge resulting from thermal spread of image. Most printed letters have edges which are somewhat nonuniform because mechanical or pressure imprinting is not perfect. The imperfections are small and not objectionable in the original. However, when the image spreads, these non-uniformities are amplified so that they become visible and annoying because they produce a "fuzzy" image. Furthermore, microscopic surface irregularities in the transfer coating and the image receiving sheet can cause total lack of adherence by a plasticized portion of the transfer coating. For example, portion of letters in the original may be completely lost in the transferred image.

FIG. 7 shows a transfer sheet in accordance with the principles of this invention. A network of transfer material islands 14 are supported by a carrier sheet 16. The islands 14 may be formed in any number of ways such as by deposition through an appropriate stencil or by scoring a continuous coating after deposition. The salient feature of the transfer sheet is the discontinuous nature of the transfer material, thereby presenting alternating areas of transfer material 14 and areas of much lower thermal conductivity material, in this case air.

FIG. 5 shows a transfer sheet embodying the structure shown in FIG. 7 in operating relationship with an image 20 and a radiation source 10. Focusing again on the heat transfer characteristics of the transfer material 14 at the edges of the image 20, it may be seen that heat entering the islands 14 may be conducted laterally only until the heat reaches the boundaries of the islands. Of course, some heat will be conducted into the interstices between the islands but the rate of flow will be greatly diminished if the interstitial material is properly selected. In this case air provides the low thermal conductivity interstitial material and is quite effective in retarding lateral heat flow. It should be pointed out that any relatively insulative interstitial material may be utilized. For purposes of clarity in explaining the invention it shall be assumed that the retardation of lateral heat flow is sufficient to prevent plasticizing of islands of other than those directly overlying the image 20. It should be clear that if the islands are spaced closely enough and the irradiation continued for a sufficient period of time some islands adjacent the image boundaries could be plasticized, but the benefits of this invention although somewhat diminished would still be present. The plasticized width and thus the transferred image width W' in FIG. 5 is substantially less than that of the continuous coating described previously in conjunction with FIGS. 3 and 4.

By more closely spacing the islands as shown in FIG. 6, greater decreases in transferred image width W' may be effected. The concurrent benefits, of course, include greater sharpness in the transferred image and highly improved resolving capacity of the thermal-transfer process, i.e., adjacent images may be more closely spaced and still retain their distinctness in the transferred image.

From the foregoing theoretical and operational analysis, it should be clear that conceptually this invention covers a broad spectrum. It is desirable that the discontinuities be of small enough thickness that they are not discernible to the viewer in the end product. The

drawings herein have greatly exaggerated the sizes of the islands and interstices and should not be considered as exemplary other than for purposes of explaining the principles of the invention. Conveniently, the islands may be about 1.7 mil square separated by about 1.7 mils from each other. That size corresponds to the resolving power now needed with most printing processes. Practical considerations dictate that the maximum spacing between islands and the maximum lateral dimension of the island do not exceed about 01". Otherwise the benefits of this invention would be greatly reduced as that dimension corresponds to the point at which lack of resolution becomes unacceptable to most users. Theoretically, the smaller the islands and interstices may be formed, the greater the benefits of the invention.

Reticulating the transfer coating decreases the total surface area of the transfer coating. If square islands are uniformly spaced from one another by a distance equal to the length of one side thereof, the decrease in surface area is approximately 75 percent. In a given transfer process with a given transfer force, the pressure generated at the surface of the transfer coating increases 300 percent. Therefore, reticulation provides the additional benefit of enhancing the contact between the transfer coating and the image-receiving sheet without additional application of force. Further pressure is uniform and size of islands is small enough to permit infinite contact with a part of image-receiving sheet which is not smooth.

The small size of the transfer islands and the sharp delineations of their edges combine to add a degree of sharpness heretofore unobtainable with dye-wax techniques. Continuous coatings did not present a clear line of demarcation between the plasticized portion and the solid or unplasticized portion and ragged edges inevitable resulted. However, if the reticles are small enough, the entire reticule will normally be transferred and thus the tearing problem at the plasticized boundary substantially eliminated. A sharp edge will, therefore, be transferred to the image receiving sheet.

It should be apparent that a regular array of islands is not critical to the invention. It may be desirable to form the islands in a regular pattern to maintain consistency of resolution throughout the transfer sheet and a myriad of regular arrays are possible. FIGS. 8-10 suggest a few shapes that could be utilized: circular, triangular, and hexagonal respectively.

As suggested previously, the interstitial material need not be air. As seen in FIG. 11 the transfer material 14 could be easily separated by the carrier material 16 if its thermal conductivity is significantly lower than that of the dye wax layer. Additionally, to achieve improved results in accordance with the teachings of this invention, the discontinuities need not completely isolate islands of transfer material. FIG. 12 illustrates a transfer sheet wherein the transfer materials 14 is discontinuous at the surface which bonds to an image receiving sheet. While the benefits obtained are not maximum, semi-isolation of transfer material would improve the transferred image quality in accordance with the teachings of this invention.

FIG. 13 depicts yet another preferred embodiment of the invention. The islands of transfer material 14 are arranged in a checkerboard array. Since the islands 14

touch only at their edges, lateral heat conductivity has been greatly reduced. This embodiment does not completely take advantage of the invention, but is a substantial improvement over a continuous coating.

Turning now to particular materials which may be utilized in fabricating the transfer sheet of this invention, the carrier sheet is preferably of low infra-red absorption characteristics and thin to enhance anisotropic thermal conductivity. Furthermore, a degree of pliability is required to permit close conformation to the imaged and image-receiving sheet. Paper, cloth, plastic, mylar, glass, wood and many other materials are suitable.

The transfer material differs depending on the function transfer sheet is ultimately to perform. Therefore the formulation and type of wax, dyes and oils will be varied accordingly. The waxes may be naturally occurring waxes selected from the classes of petroleum wax such as paraffin wax, vegetable wax such as carnauba, animal waxes such as spermaceti, insect waxes such as beeswax, and mined waxes such as montan wax; or they may be synthetic waxes such as carbowax. The dyes for use with the spirit type duplication processes are the alcohol soluble type from the group of xanthene dyes, such as triphenyl methane and diphenyl methane derivatives typified by crystal violet, methyl violet, rhodamine or nigrosene dyes. Included in the group of dyes suited for transfer sheets used in the preparation of facsimile copy and suited for transfer sheets used in the preparation of lithographic masters are the oil soluble dyes such as the Azo dyes, for example Azo Oil Blue B. The oils used are absorbed by the dyes and serve as a plasticizer for the formulations. Suitable oils may be selected from the group of mineral oils, unsaturated vegetable oils and animal oils among others. For a more detailed treatment of materials and formulations thereof the reader is again referred to U. S. Pat. No. 3,122,998.

The invention is not to be limited to or by details of construction of the particular embodiment thereof illustrated by the drawings, as various other forms of the device will, of course, be apparent to those skilled in the art without departing from the spirit of the invention or the scope of the claims.

I claim:

1. A thermal-transfer sheet for use in a duplicating process in which an original image is irradiated while in contact with the thermal-transfer sheet and transfer material on the thermal-transfer sheet is transferred to an image receiving sheet in the form of the original image comprising:
a carrier web; and

a regular array of minute transfer material islands disposed on said web over an area larger than the original image, said transfer material islands having a greatest lateral dimension smaller than 0.01 inch and having high radiation absorption characteristics relative to said web and being capable of becoming plastic upon the absorption of heat such that upon becoming plastic said transfer material islands may be physically transferred from said web to an image receiving sheet in the form of the original image.

2. The transfer sheet set forth in claim 1 wherein the discontinuities of transfer material between adjacent islands do not exceed 0.01.

3. The transfer sheet set forth in claim 2 wherein said islands are substantially square.

4. The transfer sheet set forth in claim 2 wherein said islands are substantially square and disposed in a checker-board array.

5. The transfer sheet set forth in claim 2 wherein said islands are substantially circular.

6. The transfer sheet set forth in claim 2 wherein said islands are substantially triangular.

7. The transfer sheet set forth in claim 2 wherein said islands are substantially polygonal.

8. A method of transferring an original image comprising;

forming a multi-layer assemblage of an original image, a transfer sheet and an image receiving surface, said transfer sheet comprising a carrier web and a regular array of minute transfer material islands having a greatest lateral dimension smaller than 0.1" disposed on said web over an area greater than the original image, said image receiving surface being contiguous with said transfer material islands;

irradiating said multi-layer assemblage with sufficient energy to plasticize only the said transfer material islands which are superimposed with said original image;

applying pressure to said assemblage;

and separating said image receiving surface from said multi-layer assemblage whereby the plasticized transfer material islands are disposed on said image receiving surface in the form of said original image.

9. The method set forth in claim 8 wherein the discontinuities in said transfer material between adjacent islands do not exceed 0.01 inch.

10. The method set forth in claim 9 wherein said islands are substantially square.

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