April 1, 1969 D. A. NEWMAN 3,436,293

THERMOGRAPHIC DUPLICATING PROCESS

Filed Oct. 15, 1965

Fig. 1

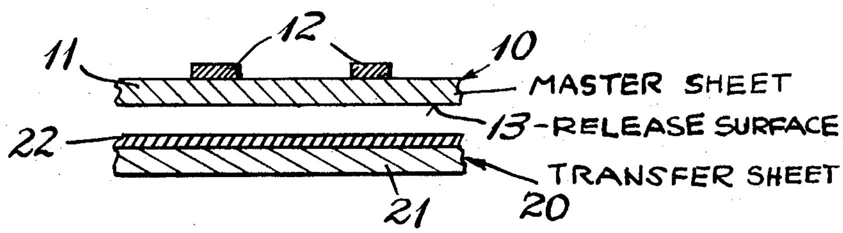


Fig. 2

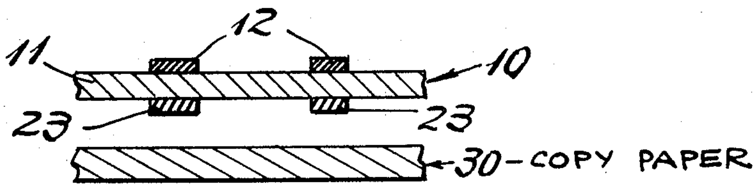


Fig. 3

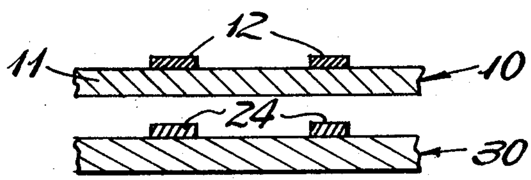
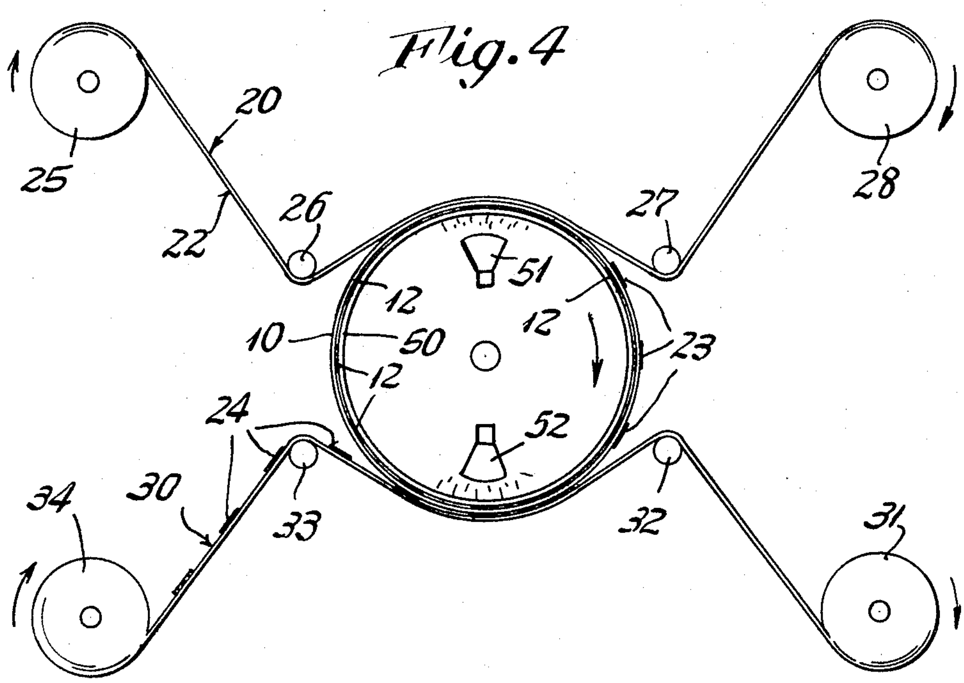


Fig. 4



INVENTOR.
Douglas A. Newman
BY
Johnson and Kline
ATTORNEYS

United States Patent Office

3,436,293

Patented Apr. 1, 1969

1

3,436,293

THERMOGRAPHIC DUPLICATING PROCESS

Douglas A. Newman, Glen Cove, N.Y., assignor to Columbia Ribbon and Carbon Manufacturing Co., Inc., Glen Cove, N.Y., a corporation of New York

Filed Oct. 15, 1965, Ser. No. 496,527

Int. Cl. B41m 5/26

U.S. Cl. 156—240 9 Claims

ABSTRACT OF THE DISCLOSURE

A thermographic duplicating process in which infrared radiation-absorbing images present on a plastic film master sheet are reproduced on a succession of copy sheets. The unimaged side of the master sheet is smooth and impervious and accepts wax imaging composition in areas corresponding to the original images and cleanly releases such composition to a copy sheet under the effects of heat, so that the master can be reimaged to produce as many copies as desired.

The duplicating process of this invention is characterized as a direct thermographic process and employs a true thermographic master sheet as opposed to a thermographically-imaged master sheet which relies upon conventional duplicating processes for the production of multiple copies therefrom.

In the conventional thermographic process for imaging duplicating master sheets, an original sheet bearing infared radiation-absorbing images is superposed with a transfer sheet carrying a layer of heat-transferable duplicating composition and a master sheet and the superposed sheets are exposed to infrared radiation. The radiation heats the original images to generate a heat pattern which is conducted to the transfer layer, causing transfer thereof to the master sheet in the heated areas. The master sheet, which is either a hectograph master or a planographic plate, is then used in either the hectographic or planographic processes to produce multiple copies.

Aside from having the disadvantage of requiring the use of a second expensive duplicating system, these known thermographic master-imaging processes have an inherent disadvantage which limits the quality of copy which can be produced. These processes require that either the infrared radiation must penetrate the master and transfer sheets to reach the original sheet, in the case of the reflex method, or that the heat generated by the original images must pass through the master sheet to reach the transfer sheet, in the shoot-through method. In either case, some of the radiation and heat is reflected and dissipated so that the outline of the images transferred to the master is broader and less sharp than the outline of the original images.

It is the object of the present invention to provide a true thermographic duplicating process for the imaging of a master sheet which subsequently images numerous copies, all under the effects of infrared radiation.

It is another object of this invention to provide a thermographic duplicating process in which a great number of copies of original subject matter can be produced, each copy having better qualities of sharpness and clarity than heretofore possible with known thermographic processes.

These and other objects and advantages of the present invention will be clear to those skilled in the art in the light of the following description, including the drawing, in which:

FIGURE 1 is a diagrammatic cross-section, to an enlarged scale, of a master sheet and a transfer sheet superposed and ready for exposure to infrared radiation against the original images, the sheets being separated for purposes of illustration.

2

FIG. 2 is a diagrammatic cross-section, to an enlarged scale, of the master sheet imaged according to FIG. 1 and superposed with a copy sheet ready for exposure to heat or infrared radiation, the sheets being separated for purposes of illustration.

FIG. 3 shows the sheets of FIG. 2 after exposure and separation, illustrating the complete transfer of images **23** from the master sheet to the copy sheet.

FIG. 4 is a diagrammatic illustration of an apparatus for the continuous production of multiple copies of an imaged master sheet according to the present invention.

The objects and advantages of the present invention are accomplished by the present process in which special plastic film master sheets and special transfer compositions are used for the thermographic formation of sharp, clear duplicate images on the surface of the master sheet opposite to the carrying the original images, and for the thermographic retransfer of such duplicate images to a copy sheet to form sharper and clearer duplicate copies of the original images than heretofore possible. The master sheet is reimaged and the new images are retransferred as often as necessary to produce as many copies of the original subject matter as may be required.

One of the important advantages of the present invention is the fact that the present master sheets are not damaged in the present process and may be stored and reused from time to time as necessary to provide as many copies as may be desired at any given time.

The most important advantage of this process is the quality of the copy produced. The excellence in quality is due to the fact that the original images are exposed directly to the radiation source, and the transfer composition is in intimate surface contact with the master sheet. Thus there is no opportunity for the infrared radiation to be dissipated or reflected by other sheets prior to being absorbed by the original images, nor is there any opportunity for the heat generated in the master sheet to be dissipated by other sheets prior to being conducted to the transfer composition. In this manner the amount of distortion caused by dissipation and reflection is kept to a minimum.

The invention is best described by reference to the accompanying drawing. As shown by FIG. 1, a master sheet **10** comprising a flexible plastic film foundation **11** having a special release surface 13 is provided on the opposite surface with infrared radiation-absorbing images **12**. The master sheet is superposed with its release surface in contact with the heat-transferable layer **22** of a transfer sheet **20** having a flexible foundation **21**.

In this first step the images **12** are exposed directly to an infrared radiation source to heat the images, the underlying areas of the master foundation and the contacting portions of the transfer layer to cause softening and melting of the portions of the transfer layer in areas corresponding to the location of the original images. These melted portions of the transfer layer adhere to the release surface of the master and transfer thereto in the form of images **23** when the master and transfer sheet are separated.

In the next step, shown by FIG. 2, the dual-imaged master is superposed with a copy paper **30**, so that the images **23** are in contact with the surface of the copy paper and heat is applied to cause the images **23** to again soften and melt and adhere to the surface of the copy sheet. Upon separation of the sheets the images **23** transfer substantially completely to the copy paper as images **24** which are sharp, clear duplicates of original images **12**.

In this second step, heating of the images **23** may be caused by an overall heating of the sheets, such as by passing them between heated rollers or pressing them against a heated platen, or by means of selective heating caused by exposing the sheets to infrared radiation to again heat the original images and the underlying images **23**.

Since one of the important advantages of the present process is the avoidance of the necessity of using a separate duplicating process, such as hectography or planography, the present process lends itself very well to a continuous operation on a single apparatus in which the two transfer operations are carried out and repeated as often as necessary in continuous sequence to produce the desired number of copies.

One such continuous operation is shown by FIG. 4 in which the original sheet **10** is mounted on a transparent drum **50** which may be a cylinder of clear plastic such as polystyrene which does not absorb infrared radiation to any substantial extent. The drum is provided with infrared radiation lamps **51** and **52**. The transfer sheet **20** and copy paper **30** are present as continuous rolls. The transfer sheet is unwound from supply roll **25**, passes over tension roller **26** and against the release surface of the master sheet and over tension roller **27** and is taken up on take-up roll **28**. The copy paper **30** is unwound by supply roll **31**, passes over tension roller **32** and against the imaged release surface of the master sheet and then over tension roller **33** and is taken up on take-up roll **34** for subsequent cutting into sheet lengths.

In operation, the master sheet is attached to the drum **50**, such as by means of a clamp, adhesive tape or the like, so that images **12** are against the drum. As the drum rotates, the master sheet is compressed between the drum and the transfer sheet coating **22** since the transfer sheet is under tension. The transfer sheet and master sheet move with the drum past infrared radiation lamp **51** whereby portions of the transfer layer are melted and adhere to the master sheet in areas corresponding to the location of the original images. As the master sheet and transfer sheet part, the bonded portions of the transfer layer transfer to the master sheet as images **23**.

In the second step, the dual-imaged master is rotated into compression between the drum and the copy paper **30** which is under tension. The compressed sheets are transported past infrared radiation lamp **52** which causes heating of the original images and remelting of images **23** in surface contact with the copy paper. As the master sheet and copy paper are parted, the images remain adhered to and transfer to the copy paper as duplicate images **24**.

Obviously take-up roll **34** may be replaced with a cutting means for cutting the continuous copy web into lengths, each sheet being an exact duplicate of the master sheet, or the continuous copy paper web may be replaced with sheet lengths of copy paper.

The present process may be carried out using precut copy sheets by means of any commercially-available infrared radiation-exposure apparatus, such as a Thermo-Fax machine. This is accomplished by passing the superposed master and transfer sheet through the machine in the order shown by FIG. 1, and then passing the dual-imaged master and a copy paper through the machine in the order shown by FIG. 2. Both of these operations are repeated for each copy which is desired.

The master sheets which are useful for carrying out the present process are thin plastic films which will dissipate a minimum amount of the heat generated in the original images. The master sheet is preferably translucent, except in cases where it is provided with a layer of infrared radiation-reflective material such as a vacuum-deposited metallic layer as taught by copending application, Ser. No. 57,794, filed Sept. 22, 1960, now United States Patent No. 3,230,874. This latter embodiment is important in cases where it is desired to use infrared radiation-absorbing transfer compositions to produce thermographically-reproducible copies and/or magnetically-sensible copies containing magnetic iron oxide pigment.

The most critical feature of the present master sheets is the surface of the master opposite to that carrying the original images. This surface is characterized as a release surface in that it has the ability of substantially completely releasing the images **23** to the copy paper under the effect of heat. While this function depends to some extent upon the nature of the transfer composition and the copy paper surface, it has been found that the release surface must be one which is non-porous and will not absorb the melted transfer composition. In this regard, smooth plastic films perform very well as the master sheet. Likewise an infrared radiation-reflective vacuum-deposited metallic layer on a plastic film master sheet performs very well as a release surface.

Suitable master sheets include thin plastic films such as cellophane, polyethylene terephthalate polyester, tetrafluoroethylene, polyethylene, cellulose acetate, polyvinyl chloride, polyvinyl fluoride and the like. The essential requirement in each case is that the surface of the film must be exceptionally smooth and impervious to the melted transfer composition.

The transfer compositions useful according to this invention are those which have sharp and relatively low melting points. The transfer compositions are based upon wax binder materials, or mixtures of wax and resinous materials, and contain a coloring material such as a pigment or dyestuff which generally is a material which does not absorb infrared radiation to any substantial degree. However, infrared radiation-absorbing colorants such as carbon black and magnetic iron oxide may be used provided that an infrared radiation-reflective element is used in association therewith as disclosed in my aforementioned copending application.

The present transfer compositions are preferably based primarily upon relatively soft waxes such as beeswax, paraffin wax, microcrystalline wax and the like and mixtures thereof with harder waxes such as carnauba wax, and may contain small amounts of liquid or semi-solid resinous additives such as polybutene resins to render the compositions more tacky. Small amounts of oils such as mineral oil may also be present in addition to the coloring matter. The transfer compositions are so formulated as to have sharp melting points, preferably within the range of from about 80° F. to about 180° F., so that they melt sharply and transfer substantially completely when heated.

The following examples illustrate suitable transfer compositions.

Example 1

Ingredients:	Percent by weight
Carnauba wax	40
Paraffin wax	57
Milori blue	3

Example 2

Ingredients:	
Carnauba wax	75
Petroleum wax	23
Milori blue	2

Example 3

Ingredients:	
Beeswax	35
Paraffin wax	43.5
Carnauba wax	20
Milori blue	1.5

The foregoing compositions are applied to thin flexible foundation sheets by conventional hot metal techniques. The foundation may be paper or a plastic film. The latter is preferred in that it permits complete transfer of the imaging composition to the master sheet, although the same result may be obtained through the use of paper foundations carrying a smooth layer of plastic between the paper and the transfer layer. However, the objectives of the present process can also be obtained by means of the partial transfer permitted by an untreated paper foundation.

It is not completely clear why the present heat-meltable compositions will release from the plastic film of the transfer sheet and transfer to the release surface of the master sheet in the first step, and will then separate from the release surface and transfer to the copy paper in the second step. It appears that the present compositions form a stronger bond with the release surface the first time they are melted thereon than they do when they are remelted thereon. Also, the second step transfer is assisted by the porosity of the copy paper which permits the heat-melted images to impregnate the paper surface and strongly bond thereto upon cooling and separation.

The temperatures generated in the present process, both in the initial master-imaging step and the final copy-imaging step, are in excess of a minimum temperature of about 150° F. and generally are within the range of from about 200° F. to 250° F. The temperature in the image areas is controlled, in the case of infrared radiation, by controlling the speed with which the master sheet is transported past the radiation source. The longer the dwell time before the radiation source, the higher will be the generated temperature.

However, it is preferred to use a more intense radiation source or a hot plate in the final copy-imaging step to insure complete transfer of the master images to the copy sheet. The temperature generated in the final step is preferably from 10° to 30° F. in excess of the temperature generated in the initial step.

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 continuous thermographic duplicating system for the production of numerous copies of original infrared radiation-absorbing images which comprises the steps of:
   (a) applying such images to one surface of a plastic film master sheet, the opposite surface of which is smooth and substantially impervious to molten wax;
   (b) contacting the said opposite surface with a layer of heat-meltable wax imaging composition which has a sharp melting point within the range of from about 80° F. to about 180° F.;
   (c) applying infrared radiation to the images to cause them to become heated and to generate an imagewise heat pattern which is conducted through the opposite surface of the master sheet to melt portions of the heat-meltable imaging composition in contact therewith;
   (d) permitting the melted composition to solidify and separating the master sheet and layer of imaging composition so that the solidified portions of the layer remain bonded to the opposite surface of the master sheet and transfer thereto as duplicate images in areas corresponding to the location of the original images on the other surface;
   (e) contacting the duplicate images with the surface of a copy paper and applying sufficient heat to melt the duplicate images and cause them to adhere to the surface of the copy paper;
   (f) separating the master sheet and the copy paper whereby the duplicate images remain adhered to the copy paper and transfer substantially completely from the master sheet; and
   (g) repeating steps (b) through (f) using the same master sheet with a succession of copy papers to produce as many duplicate copies of the original images as desired.

2. The system of claim 1 in which the layer of heat-meltable imaging composition is present as a continuous layer on a flexible foundation.

3. The system of claim 1 in which the imaging composition comprises a mixture of carnauba wax and a soft wax from the group consisting of beeswax, paraffin wax and microcrystalline wax.

4. The system of claim 1 in which the heating in step (e) is effected by means of infrared radiation.

5. The system of claim 1 in which the succession of copy papers is present in the form of a continuous paper web which is subsequently cut into sheet lengths corresponding to the subject matter of the master sheet.

6. A continuous thermographic duplicating system for the production of numerous infrared radiation-absorbing copies of original infrared radiation-absorbing images which comprises the steps of:
   (a) applying such images to one surface of an infrared radiation-reflective plastic film master sheet, the opposite surface of which is smooth and substantially impervious to molten wax;
   (b) contacting the said opposite surface with a layer of infrared radiation-absorbing heat-meltable wax imaging composition which has a sharp melting point within the range of from about 80° F. to about 180° F.;
   (c) applying infrared radiation to the images to cause them to become heated and to generate an imagewise heat pattern which is conducted through the opposite surface of the master sheet to melt portions of the heat-meltable imaging composition in contact therewith, the infrared radiation striking the unimaged areas of the master sheet being reflected back by the master sheet and prevented from reaching the layer of imaging composition;
   (d) permitting the melted composition to solidify and separating the master sheet and layer of imaging composition so that the solidified portions of the layer remain bonded to the opposite surface of the master sheet and transfer thereto as infrared radiation-absorbing duplicate images in areas corresponding to the location of the original images on the other surface;
   (e) contacting the duplicate images with the surface of a copy paper and applying sufficient heat to melt the duplicate images and cause them to adhere to the surface of the copy paper;
   (f) separating the master sheet and the copy paper whereby the infrared radiation-absorbing duplicate images remain adhered to the copy paper and transfer substantially completely from the master sheet; and
   (g) repeating steps (b) through (f) using the same master sheet with a succession of copy papers to produce as many infrared radiation-absorbing duplicate copies of the original images as desired.

7. The system of claim 6 in which the infrared radiation-reflective master sheet has thereon a thin vacuum-applied metallic layer.

8. The system of claim 6 in which the heating in step (e) is effected by means of infrared radiation which is absorbed by the duplicate images.

9. The system of claim 6 in which the succession of copy papers is present in the form of a continuous paper web which is subsequently cut into sheet lengths corresponding to the subject matter of the master sheet.

References Cited

UNITED STATES PATENTS

3,148,617 9/1964 Roshkind ---------- 101—149.4

EARL M. BERGERT, *Primary Examiner.*

M. L. KATZ, *Assistant Examiner.*

U.S. Cl. X.R.

117—36.1; 250—65.1