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XEROGRAPHIC FUSING AND DRYING APPARATUS

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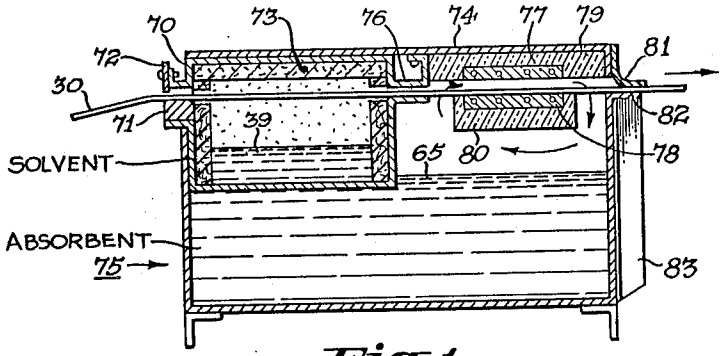


Fig. 1

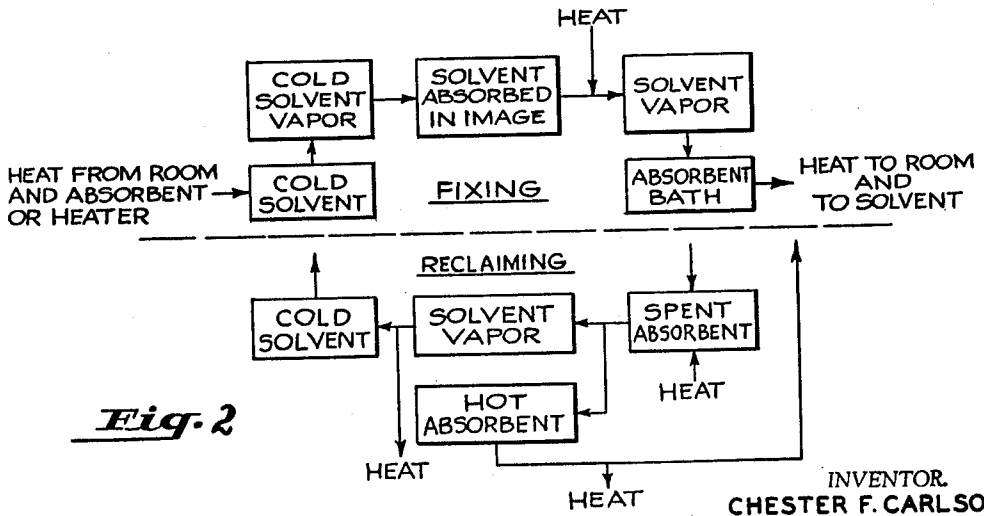


Fig. 2

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XEROGRAPHIC FUSING AND DRYING APPARATUS

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Original application Dec. 3, 1956, Ser. No. 625,929, now Patent No. 3,078,589, dated Feb. 26, 1963. Divided and this application July 2, 1962, Ser. No. 206,871
2 Claims. (Cl. 34—155)

This invention relates to xerographic image fixing apparatus, and particularly, to apparatus for effecting continuous vapor fixing and drying of xerographic powder images.

The present application is a division of my copending application, Serial No. 625,929, filed December 3, 1956, now Patent No. 3,078,589, issued February 26, 1963; wherein certain of the subject matter of the present application is disclosed but not claimed.

In certain electrostatic recording processes, such as the electrophotographic, xerographic and electric printing processes described in my Patents 2,221,776, 2,297,691 and 2,357,809, and the process of graphic recording described in my Patent 2,624,652, an electrostatic image is developed by depositing a powder on a surface to produce a powder image. The powder image is then affixed to the surface upon which it has been deposited or on another surface to which is has been transferred. Heretofore, the usual method of fixing has been by the process of heat fusing, in which case the powder image must be formed of a thermo-adhesive material, such as a fusible resin, which becomes adhesive when heated.

While heat fusing has been put to practical use, certain difficulties have been encountered. Where the image is to be fused to paper, plastic or other organic base, as is usually the case, the powder must be made of material which becomes adhesive at a temperature below that which will cause damage, browning or distortion to the organic base. This imposes limitations on the choice of resins which make it difficult to meet other desirable characteristics in the powder composition. Moreover, it has been difficult to reach an entirely satisfactory design of heat fuser with regard to short warm-up time, low electric current requirements, adequate heat insulation and uniform heat distribution.

Fixing of powder images by condensing a liquid solvent onto the image surface from a heated solvent vapor, as described, for example in my above-mentioned Patent 2,624,652, has been successfully used and offers the advantages of a broadened choice of powder materials, lower power requirements, and elimination of heat damage to the base sheet. A device for fixing xerographic powder images by exposure to an atmosphere of solvent vapor is disclosed in my Patent No. 2,922,230, issued January 26, 1960. The latter device is currently in commercial use but is limited primarily to applications in which successive sheets are manually processed.

The present invention contemplates, as its principal object improvements in apparatus for effecting continuous vapor fixing of xerographic powder images whereby powder images may be permanently fixed in high production installations with a minimum expenditure of electric power and solvent. In addition, the several structures of the invention are such to eliminate the need for a "warm-up" period to condition the apparatus for normal operation. Furthermore, the apparatus of the invention eliminates the possibility of scorching the support surface on which xerographic powder images are formed, as may be done in heat fusing devices, and provides a preferred apparatus for fusing powder images on plastic film. These and other objects of the invention are attained by

apparatus in which a continuous web of material, supporting continuous or successive xerographic powder images, is introduced into an atmosphere of solvent vapor which is at substantially the same temperature as the powder image, or lower. The vapor atmosphere is held at a vapor concentration sufficient to produce absorption of solvent vapor by the powder image particles and consequent fusing of the image. In addition, recycling and/or absorption devices are included to retain the vapor solvent within the system, hereby minimizing loss of solvent and minimizing the possibility of introducing toxic or inflammable fumes from the solvent into the surrounding atmosphere. Other features of the invention will be apparent in the description of the invention when taken in conjunction with the drawing wherein:

FIGURE 1 is a sectional view of a continuous vapor fixing and drying device for use with an electrostatic powder printing or xerographic copying machine; and

FIGURE 2 is a diagram of the process steps that may be employed with the apparatus of FIGURE 1.

In the drawing there is illustrated a vapor fixing and drying device for fusing a continuous web of copy issuing from an electrostatic powder printing machine or a continuous electrostatic copying machine. Paper or plastic web **30** carrying unfixed powder images enters in a horizontal plane from a powder printing or copying machine located on the left, as viewed in the drawing, and enters a fusing tank **70** through a horizontal slot defined by guide bar **71** and adjustable plate **72**. The tank **70** provides a saturated vapor space lined with a porous wicking of fiberboard, fabric or blotting paper **73** which is kept saturated by a liquid solvent **39** inside the tank. The wicking **73**, by lining the fusing chamber **70**, dips into the solvent **39** and, as shown in FIGURE 1, extends above the level of the slot defined by the guide bar **71** to thereby draw solvent to the upper part of this chamber and generate solvent vapor above the path of web travel through the chamber. As the web **30** enters the vapor space within the chamber **70**, the powder image absorbs solvent vapor and becomes adhesive. Solvent tank **70** is mounted inside the cover **74** of rectangular absorbent tank **75** and as the web **30** leaves the solvent tank it passes through a long shallow slot **76** into the air space above absorbent liquid. An absorbent liquid is used in the tank **75** which itself has low vapor pressure and which will readily absorb or dissolve large quantities of the solvent vapor used in the inner fusing or solvent tank **70** before the solvent vapor pressure rises to a very high value. Thus, when trichloroethylene is used as a fusing solvent, the absorbent may be a high boiling petroleum fraction, such as paraffin oil, new or used lubricating oils, and even oils containing a high percentage of dissolved waxes or tars, or crude petroleum with the volatile fractions removed. Suitable absorbent liquids for the volatile esters and alcohols include the higher boiling esters, alcohols, aliphatic oils and some hydrocarbons. Here the web passes between a pair of closely spaced horizontal electric hot plates or strip heaters **77** and **78** surrounded by layers of insulation **79** and **80** on all sides except the shallow space between them through which the paper web passes. The web and the fused images it carries are heated slightly by these plates to drive off the solvent more rapidly. The travel of the web sets up a circulation of air in the absorption chamber, as indicated by the arrows, which carries the slightly warm solvent vapor driven off from the web down over the surface of the absorbent liquid which rapidly takes up the solvent. The web leaves the absorption tank through an air seal comprising a soft rubber flap **81** which slides on the top surface of the web as the web rides over the horizontal guide flange **82** on leaving the tank. Some of the heat imparted to absorbent bath **65** is returned to liquid solvent **39** through the bottom of fus-

ing tank 70 to thereby maintain the solvent temperature at a value which will maintain the required evaporation rate. Cooling fins 83 on tank 75 remove the extra heat imparted from the strip heaters. Most of the heat generated by the heaters is carried out by the paper web.

FIGURE 2 is a diagram of a process cycle which may be used with FIGURE 1, and a typical reclaiming cycle in which the solvent and absorbent are reclaimed by distillation of the spent absorbent bath. Where it is uneconomic to reclaim the materials the distillation steps can be eliminated and the spent absorbent liquid is thrown away. The heat introduced in the generation of the cold vapor is preferably obtained from the surroundings, or by transfer back from the absorbent tank, or from a thermostatically controlled heater and is sufficient only for vaporization of the solvent to produce a vapor at room temperature. The temperature of the absorbent bath is raised slightly during operation and the heat passes out through the tank walls into the room, aided, if necessary, by added cooling surfaces on the tank in order that the bath temperature shall be held as low as possible.

Besides making possible the use of powders which are not fusible by heat, the solvent fixing means described also affords economies in heat utilization which are particularly valuable in large production units. For example, the only heat drain on the system, except for losses through the walls, is that required to heat the web from room temperature to substantially the solvent boiling point, which may be in the order of 100° C. If a heat fusion method were used it would be necessary with most suitable powders to raise the temperature of the web above 150° or 200° C. In addition to the extra B.t.u. output required the heat must be supplied at a higher temperature, making economical heat sources, such as steam pipes, unavailable.

Very little solvent is required in order to fix a resinous powder image and the web of paper or other material remains relatively dry. The solvent also lowers the melting or softening point of the powder composition so that it is sometimes possible to limit the solvent condensation to a very small amount and rely upon the final heating step to further the softening of the powder to its adhesive point before complete evaporation of the solvent occurs. It is thus possible to obtain fixing under conditions in which either the temperature or the solvent alone would be inadequate.

It is apparent that a wide variety of powder images can be fixed by use of the present invention, it being only necessary to use a solvent which dissolves or renders adhesive the particular material of which the powder is composed. On the other hand it is also possible to provide a web which is rendered adhesive by the solvent, in which case the powder need not be solvent-fusible. In some cases, as where the web is of plastic film, such as ethyl cellulose or nitrocellulose, its surface can be rendered adhesive by a solvent such as butyl lactate, to permit the film to adhere to or embed the powder image. In other cases, the web may have a coating of an adhesive film which is made to adhere to the powder image. For instance, paper with an ethyl cellulose or a polyethylene coating can be made to adhere to and fix a carbon or lampblack image.

Soluble powder images may be formed of a wide variety of materials, such as finely divided resin, Vinsol, ethyl cellulose, asphalt, sodium carboxymethylcellulose, Amberol F–71, polystyrene, or zein. (Vinsol is a petroleum hydrocarbon-insoluble resin derived from pine wood, and produced by Hercules Powder Company, Wilmington, Delaware. Amberol F–71 is a resin-modified phenol-formaldehyde resin manufactured by Rohm and Haas Company, Philadelphia, Pa.) The powders may be dyed or pigmented.

While low boiling solvents such as ethyl alcohol, water and naphtha may in some cases be used with cold webs, it is usually preferable to use a solvent of medium

or high boiling point, such as butanol (butyl alcohol), butyl lactate, butyl acetate, amyl acetate, octyl alcohol, butyl Cellosolve, Carbitol, diethyl Carbitol, butyl Carbitol, Carbitol acetate, butyl Carbitol acetate, trichloroethylene and perchlorethylene.

Examples of solvents useful with specific powders are:

For Vinsol—ethyl alcohol, butyl alcohol, butyl Cellosolve.

For ethyl cellulose or polystyrene—butyl acetate, trichloroethylene.

For asphalt—perchlorethylene.

For sodium carboxymethylcellulose—water.

For zein—90% ethyl alcohol.

For Amberol F–71—trichloroethylene, perchlorethylene.

In any event it is apparent that the partial pressure of the solvent in the chamber is greater than the vapor pressure of the solvent from a tacky solution of the soluble resin at the temperature of the entering web of sheet material so that solvent will condense on and tackify the resin powder or coating.

It may be noted that a single form of the invention has been described as applicable for fixing or fusing xerographic powder images on continuous web material such as paper, plastic film, or the like. However, it is to be understood that the invention is not limited in its application to use with continuous web material. Obviously, the continuous web material illustrated may be replaced by an endless belt formed of metallic foil or other substance having high heat-conducting characteristics, whereby it may be employed as a conveyor belt for supporting and transporting successive sheets of support material having xerographic powder images thereon through the vapor fusing apparatus.

While the present invention, as to its objects and advantages, has been described herein as carried out in a specific embodiment, thereof, it is not desired to be limited thereby, but it is intended to cover the invention broadly within the spirit and scope of the appended claims.

What is claimed is:

1. Image affixing apparatus for fixing xerographic powder images to the surface of a web of sheet material by means of solvent vapor for a soluble component of the powder comprising said powder images,

said apparatus including

a substantially closed fusing vapor chamber having end walls provided with substantially aligned horizontal inlet and outlet slots on opposite ends of said chamber to permit straight-line travel of a web through said chamber,

a liquid solvent reservoir spaced at the bottom of said chamber below the level of said slots,

wick-like material disposed in said chamber outside the path of said web and dipping into said liquid solvent reservoir and also extending above the level of said slots to draw liquid solvent to the upper part of said chamber and generate solvent vapor above the path of web travel through said chamber,

a drying chamber mounted to receive a web issuing from the outlet slot of said vapor chamber and containing a reservoir for absorbent material for solvent vapor,

and a heating element mounted in said drying chamber to apply heat to said web during passage of said web through said chamber,

said drying chamber being provided with an outlet slot on the end of said chamber opposite to the entering position of said web, whereby said web may pass in sequence through said vapor chamber and said drying chamber.

2. Xerographic image affixing apparatus for fixing xerographic powder images to the surface of a web of sheet material by means of solvent vapor for a soluble component of the powder comprising said powder images,

said apparatus comprising walls defining a pair of adjacent chambers,

one of said chambers being a fusing vapor chamber and the other of said chambers being a drying chamber,

means to guide a web of sheet material in a path parallel to its own surface through said chambers with said web passing through said drying chamber after leaving said vapor chamber,

said vapor chamber having a reservoir for liquid solvent and wicking material disposed partly within said reservoir and partly above said reservoir and above at least part of the path of said web through said vapor chamber,

a heater element mounted in said drying chamber to apply heat to said web during passage of said web through said chamber,

and said drying chamber having a reservoir for an absorbent for said solvent vapor.

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