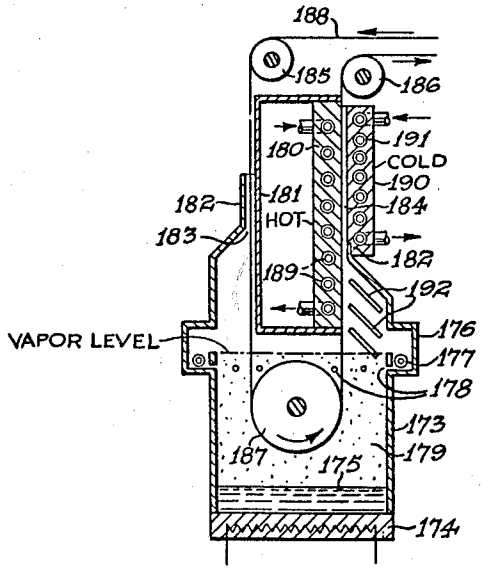
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XEROGRAPHIC FUSING AND DRYING APPARATUS

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XEROGRAPHIC FUSING AND DRYING APPARATUS

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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 it 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, thereby 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.

A specific embodiment of the invention is disclosed in the accompanying drawing which constitutes a form of fixing and drying apparatus intended primarily for use with heavy vapors and moderate web speeds. The unit comprises a vapor tank **173** having a closed bottom and sides and heated at the bottom by a hot plate **174** or other form of heating element. A layer of liquid solvent **175** is placed in the bottom, a solvent being selected which will yield a vapor substantially above the density of air and preferably several times the density of air. A vapor level control channel **176** is provided around the upper portion of the side walls. This comprises a recess running horizontally around the tank with its walls forming a trough. A pipe **177** carrying cold water or other cooling fluid is laid in the trough and openings **178** are provided to allow condensed vapor to run into the tank. When heated by element **174** the solvent forms a heavy vapor layer **179** up to the level of the channel **176**, as shown. The upper parts of the side walls of the tank are sloped inward to form a throat portion **182** in which is mounted a hot plate **180** whose back is enclosed by a heat shield **181**. The back of the heat shield and the face of the hot plate are spaced from the walls of the throat **182** to leave narrow slots **183** and **184**, respectively, through which a web of paper or other material can pass into and out of the tank. Web guide rollers **185** and **186** are mounted above slots **183** and **184**, respectively, and a larger roller or drum **187** is located inside the vapor zone of the tank so that a web **188** can be fed through the tank by passing it over roller **185**, down through slot **183**, around drum **187**, up through slot **184**, and over roller **186**.

Hot plate **180** is heated by embedded heating elements **189** which may be steam pipes or electric resistance elements. A cold plate **190** is mounted on the top edge of the tank throat **182** on the side facing the hot plate and is parallel with the face of the hot plate, so that the space between them comprises an upward extension of slot **184**. Cold plate **190** is provided with cooling pipes **191** through which cold water or a refrigerant is circulated. Hot plate **180** extends down into the tank below the throat and a series of baffles **192** are mounted in the tank adjacent to the hot plate surface and sloping away from it.

In operation the web **188** carrying a powder image is drawn through the tank in the path described. The powder image is located on its upper or outside face as the web passes over roller **185**. As the web enters the tank the shield **181** protects it from heating by the hot plate so that the web is relatively cold as it enters the vapor zone. Solvent condenses on the web and powder image as it passes through the vapor and passes underneath drum **187**, thus making the image adhere to the web. As the web advances up into contact with the lower portion of the hot plate and out of the vapor zone it becomes heated and most of the solvent is re-evaporated in the region of baffles **192** which deflect the vapor away from the web and allow it to settle back to the vapor zone along the wall of the tank. When the web reaches slot **184** and passes between the hot plate and cold plate **190** it is sub-

jected to a condition in which the heat drives off any remaining solvent and the resulting vapor is immediately condensed on the cold plate so that the vapor concentration in the slot is kept at a minimum. The condensed solvent on the cold plate drains back down the wall to the bottom of the tank. This affords a very effective fixing operation with substantially no loss of solvent.

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, Penna.) 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.

For high speed operation it is desirable to regulate the heating of the solvent to raise it to a temperature at which it has a substantial vapor pressure but to keep the temperature below the boiling point. With perchlorethylene, for example, which has a boiling point of 121 degrees C., excellent fixing of Amberol images can be accomplished in a vapor chamber at 80 to 100 degrees C.

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 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 is intended to cover the invention broadly within the spirit and scope of the appended claims.

What is claimed is:

1. Image fixing and drying apparatus for fusing 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 enclosed vapor chamber having a wall containing an inlet slot and an outlet slot to permit passage of a web of sheet material into and out of said chamber,

guide means defining a path of travel for said web of sheet material within said vapor chamber,

said vapor chamber including

a reservoir of liquid solvent below the path of travel of the web of sheet material,

first heating means positioned to vaporize said liquid solvent,

second heating means positioned adjacent said outlet slot parallel to the path of travel of the web of sheet material to vaporize solvent on the web of sheet material,

cooling means adjacent said outlet slot and on the opposite side of the path of travel of the web of sheet material from said second heating means to condense solvent vapors produced by said second heating means,

and solvent vapor guide means beneath said cooling means to direct condensed solvent from said cooling means to said liquid reservoir.

2. Image fixing and drying apparatus for fusing 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 enclosed vapor chamber having a wall containing an inlet slot and an outlet slot to permit passage of a web of sheet material into and out of said chamber,

guide means defining a path of travel for said web of sheet material into and out of said vapor chamber,

said vapor chamber including

a reservoir of liquid solvent below the path of travel of the web of sheet material,

first heating means positioned to vaporize solvent

from said reservoir to form a vapor fixing zone encompassing a portion of the path of travel of web material,

first cooling means positioned above said reservoir of liquid solvent and below said inlet and outlet slots to condense solvent vapor and thereby form an upper limit for said vapor fixing zone,

second heating means positioned adjacent said outlet slot parallel to the path of travel of the web of sheet material to vaporize solvent on the web of sheet material,

second cooling means adjacent said outlet slot and on the opposite side of the path of travel of the web of sheet material from said second heating means to condense solvent vapors produced by said second heating means,

and solvent vapor guide means beneath said cooling means to direct condensed solvent from said second cooling means to said liquid reservoir.

No references cited.