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XEROGRAPHIC FUSING AND DRYING APPARATUS

Original Filed Dec. 3, 1956

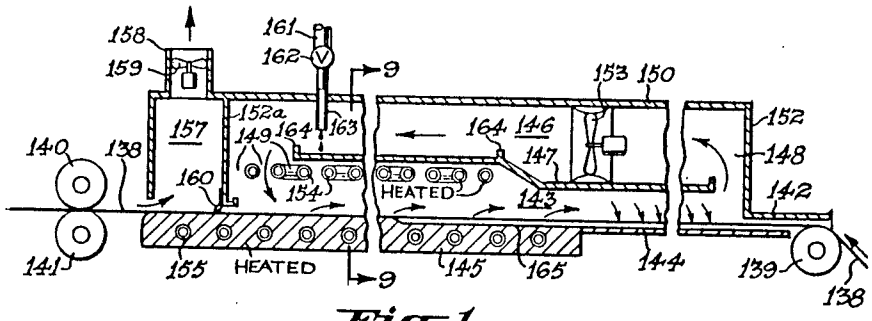


Fig. 1

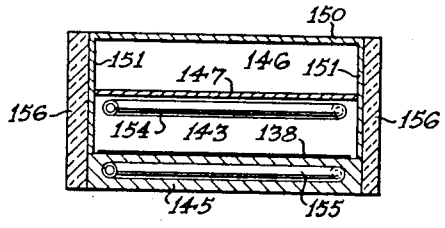


Fig. 2

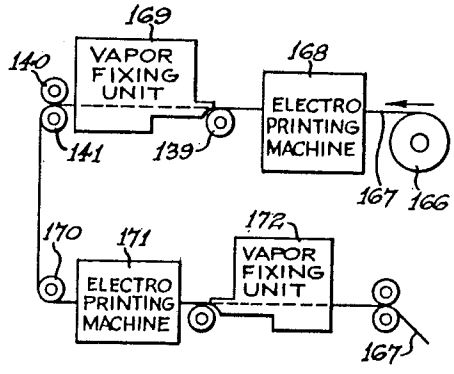


Fig. 3

INVENTOR.
CHESTER F. CARLSON
BY
ATTORNEY

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XEROGRAPHIC FUSING AND DRYING APPARATUS

Chester F. Carlson, Pittsford, N.Y., assignor, by mesne assignments, to Xerox Corporation, Rochester, N.Y., a corporation of New York

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. 206,781

1 Claim. (Cl. 34—155)

The present application is a division of my co-pending 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.

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

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 advanges 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 when taken in conjunction with the drawing wherein:

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

FIGURE 2 is a sectional view taken along the line 2—2 of FIGURE 1; and

FIGURE 3 is a diagram of the process steps that may be employed with the apparatus of FIGURE 1.

FIGURES 1 and 2 show a high production unit such as may be used to fix the output of a xeroprinting machine of the type shown on page 122 of Fortune Magazine (New York) for June 1949, or R. M. Schaffert Patent 2,576,047, for example. Web 138 of paper, cloth, sheet plastic or the like carrying a powder image or coating on its upper surface is led into the fixer over idler roller **139**, and passes horizontally through the unit drawn by power-driven delivery rolls 140, 141 at the output end. As it passes over roll 139 the web enters a narrow slot or passage 142 which leads into the fixing chamber 143. Chamber 143 comprises a horizontal passage having a bottom wall 144 at the end where the web enters, and a bottom plate 145 joined to the inner end of wall 144 and extending to the output end of the unit, so that wall 144 and plate 145 form a continuous floor to the chamber 143. Wall 144 and the adjoining portion 165 of plate 145 are spaced slightly from the web but the rest of plate 145 is directly in contact with the web, and has a highly polished surface.

Above fixing chamber 143 is a return flow passage 146 separated by a horizontal partition 147 from the fixing chamber 143 but communicating with it at the ends by openings 148 and 149. The top of passage 146 is enclosed by the top wall 150 of the unit and the sides and ends of chamber 143 and passage 146 are closed by vertical side walls 151 and end walls 152.

An air blower 153 is located in passage 146 to withdraw air from fixing chamber 143 through opening 148 at the end at which the paper enters the fixing chamber and to return the air to chamber 143 through the opening 149 at the web output end of the fixing chamber.

A series of heating elements 154, such as steam pipes or electric radiant heaters, are mounted beneath partition 147 in chamber 143 near the web output end, the elements being mounted across the chamber to afford uniform heating of all portions of the web width. Some of the elements 154 are also distributed across opening 149. Further heating elements 155 such as steam pipes or electric resistance elements, are provided inside bottom plate 145. Side walls 151 are covered with insulation layers 156 (FIGURE 9) to prevent condensation thereon. The entire unit may be covered with insulation, if desired.

A box-like housing 157 is provided at the web output end of the unit, having a common wall 152*a* with the end of chamber 143 and passage 146, and has an exhaust pipe 158 connected thereto provided with exhaust blower 159.

Common wall 152*a* is provided with a flexible flap 160 of thin sheet metal, leather, plastic or rubber which rests

lightly on top of web **138** where it leaves the fixing chamber, and thereby acts as an air seal.

A liquid solvent feed pipe **161** provided with needle valve **162** supplies liquid solvent to drip tube **163** located in passage **146** above that portion of partition **147** which is over heating elements **154** and consquently is at an elevated temperature. The edges of the heated area of partition **147** are formed into a ridge **164** enclosing the area to retain any excess liquid which may accumulate, although the solvent which drips from tube **163** will ordinarily evaporate before it can spread to the edge of the area.

In operation of the unit of FIGURES 8 and 9 the web **138** is started through the unit so that it is grasped by delivery rollers **140**, **141** which will then continuously draw the web through the fixing chamber. Elements **154** and **155** are supplied with a heating medium and blower **153** is operated to circulate the air in the unit in a closed path through passage **146**, opening **149**, fixing chamber **143**, and opening **148** back into passage **146**.

The air thus enters chamber **143** at the end where it is first heated by elements **154** located across opening **149** and then passes under partition **147** where it is further heated by the elements **154** located under the partition. In the heated zone the air also comes into contact with web **138** and passes over it in counter-flow relation throughout the heated zone and then into an unheated zone near the end of chamber **143** at which web **138** enters. Valve **162** is adjusted to provide a drip feed of liquid solvent having relatively low vapor pressure at room temperature and high vapor pressure at the temperature reached by the air in the heated zone.

The web, on entering the fixing chamber is at substantially room temperature and hence solvent vapor from the solvent-laden air coming from the heated zone rapidly condenses on the web and any powder image it carries on its surface. The powder is dissolved or rendered adhesive by the condensed solvent and becomes bonded to the web. Condensation of vapor raises the temperature of the web so that the rate of condensation slows down as the web advances through the unheated zone. As the web approaches the heated zone a point of equilibrium is reached so that condensation ceases and then the condensed solvent begins to evaporate under the combined influence of the heated air stream and the heat radiated from elements **154** and from plate **145**. The air stream, having been partly denuded of solvent vapor as it passed over the relatively cold web, and returned through passage **146** to the heated zone readily dries out the now heated web of the solvent it has previously condensed so that the web leaves the fixing chamber in a substantially solvent-free state. Most of the solvent never leaves the fixing chamber since it is condensed on the web at the cold end of the chamber, again evaporated as the web moves to the heated zone and returned to the cold end by the air stream. Drip tube **163** introduces additional solvent into the air stream only to compensate for that small amount which remains in the web and is carried out of the chamber and any which may be carried out by moving air. Since the chamber is substantially sealed against air leakage there is negligible loss from this cause. Housing **157** and exhaust pipe **158** are primarily for safe removal of small amounts of solvent from the web as it leaves the unit in case of unusual conditions. Since the powder image has been fixed before it leaves the fixing chamber the sliding flap **160** can do no damage to it and prevents the web from carrying an air layer out of the unit. Practically no vapor reaches the back of the web and the operation is so rapid that the condensed solvent will not normally penetrate through the web. The recessed portion **165** of plate **145** further insures that no contact will be made with the web until the solvent has been largely driven off in the case of thin webs where solvent penetration might occasionally take place. This insures that there will be no smudging of any image which might be on the back of the web.

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. In the unit shown in the drawing, 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, diothyl 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, trichoroethylene.
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 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 claim.

What is claimed is:

Apparatus for fixing and drying a xerographic powder image to the surface of a web of sheet material by means of solvent vapor for a soluble component of the powder comprising said powder image, said apparatus including

a substantially closed chamber having end walls containing substantially aligned inlet and outlet openings to permit passage of web material,

said chamber having a heating zone adjacent the outlet opening and a condensing zone adjacent the inlet opening whereby the web material is conveyed first through the condensing zone after the web material has passed said inlet opening and then through the heating zone,

a partition in said chamber for defining a return flow passage within said chamber, said return flow passage being in communication with said heating zone and said condensing zone,

means for supplying a quantity of solvent vapor within the return flow passage,

vapor circulating means positioned in said return flow passage and being adapted to continuously move vaporous air from said passage first through said heating zone and then through said condensing zone and back into said passage,

and heating means associated with said heating zone for heating the web material as the same passes through said heating zone and evaporating solvent from the web material,

said vapor circulating means being adapted to move air laden with solvent vapor evaporated within said heating zone into said condensing zone where some of the solvent vapor is condensed upon the web material.

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NORMAN YUDKOFF, *Primary Examiner.*

GEORGE D. MITCHELL, *Examiner.*