Aug. 8, 1961 R. W. GUNDLACH 2,995,464

METHOD AND APPARATUS FOR FIXING XEROGRAPHIC POWDER IMAGES

Filed May 29, 1957 2 Sheets-Sheet 1

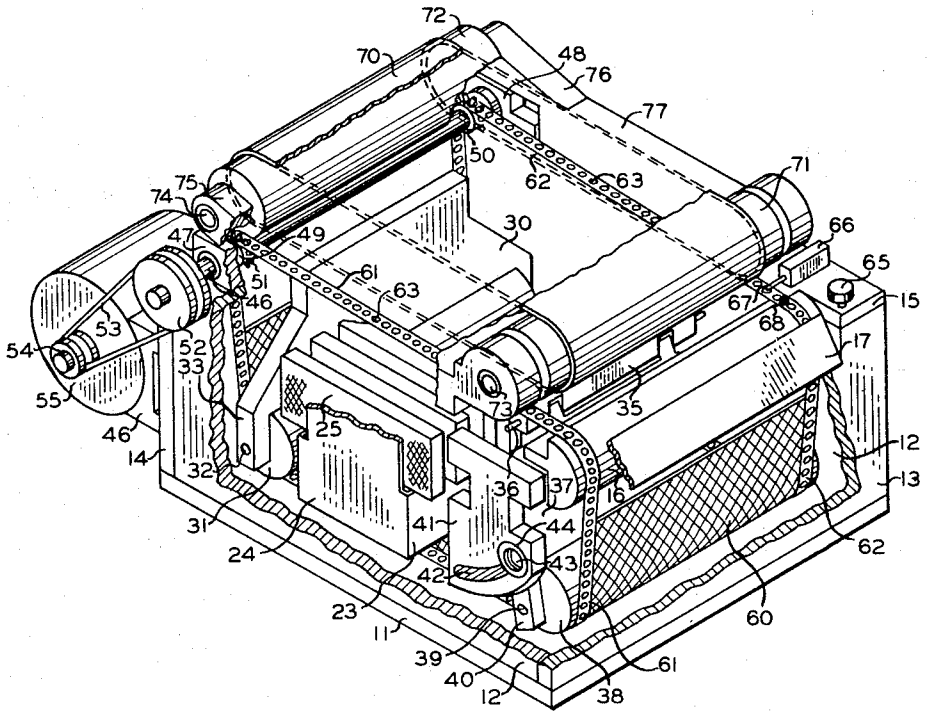

FIG. 1

INVENTOR.
Robert W. Gundlach
BY

Aug. 8, 1961 R. W. GUNDLACH 2,995,464

METHOD AND APPARATUS FOR FIXING XEROGRAPHIC POWDER IMAGES

Filed May 29, 1957 2 Sheets-Sheet 2

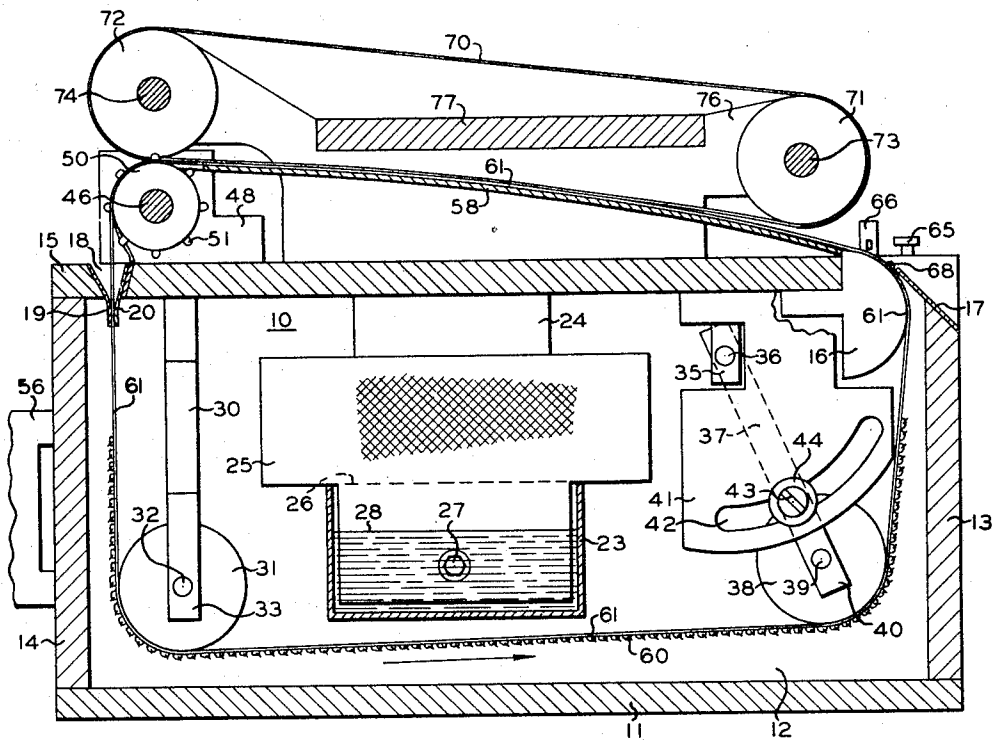

FIG. 2

INVENTOR.
Robert W. Gundlach
BY

United States Patent Office 2,995,464 Patented Aug. 8, 1961

2,995,464

METHOD AND APPARATUS FOR FIXING XEROGRAPHIC POWDER IMAGES

Robert W. Gundlach, Spencerport, N.Y., assignor to Haloid Xerox Inc., a corporation of New York

Filed May 29, 1957, Ser. No. 662,508
11 Claims. (Cl. 117—17.5)

This invention relates to the field of xerography and, particularly, to an improved method and apparatus for fixing xerographic powder images.

More specifically, the invention relates to an improved method for vapor fixing xerographic powder images wherein a controlled quantity of the vapor of a solvent for the resin component of a xerographic developing material is brought into surface contact with a xerographic powder image on a support surface whereby the solvent vapor condenses on the powder particles of the powder image and plasticizes them to fix them to the support surface. In addition, the invention includes apparatus for withdrawing solvent vapor from a source of supply in a predetermined quantity, temporarily maintaining it in a confined space, and applying such confined solvent vapor to the xerographic powder image support surface.

In the process of xerography, for example, as disclosed in Carlson Patent 2,297,691, issued October 6, 1952, a xerographic plate comprising a layer of photoconductive insulating material on a conductive backing is given a uniform electric charge over its surface and is then exposed to the subject matter to be reproduced, usually by conventional projection techniques. This exposure discharges the plate areas in accordance with the light intensity that reaches them, and thereby creates an electrostatic latent image on or in the photoconductive layer. Development of the latent image is effected with an electrostatically charged, finely divided material, such as an electroscopic powder, which is brought into surface contact with the photoconductive layer and is held thereon electrostatically in a pattern corresponding to the electrostatic latent image. Thereafter, the developed xerographic powder image is usually transferred to a support surface to which it may be fixed by any suitable means.

In the Carlson patent it is noted that a variety of types of finely divided electroscopic powders may be employed for developing electrostatic latent images. However, as the art of xerography has progressed, it has been found preferable to develop line copy images with a powder formed of any of a variety of pigmented thermoplastic resins that have been specifically developed for the purpose. A number of such developing materials are manufactured and marketed by The Haloid Company of Rochester, New York, and are specifically compounded for producing dense images of high resolution and to have characteristics to permit convenient storage and handling.

Such developing materials are specifically designed to permit them to be fixed to support surfaces either by conventional heat fixing or vapor fixing techniques, in accordance with the particular application in which they are employed. However, in order to provide the characteristics mentioned above, such materials are inherently limited in latitude in the operating conditions under which they may be used. For example, in automatic xerographic machines embodying heat fixing apparatus, the xerographic powder image support surface web is passed through an oven-like structure that is maintained at a constant temperature that is determined by the fusing temperature of the resin component of the xerographic developing material and the web speed of the support surface. Should the web speed be increased or the oven temperature decreased, the powder images are not properly fixed and are subject to smearing. In the event web speed is decreased or oven temperature increased, the support surface itself is subjected to increased heat that is liable to deform, discolor, or even char it, depending upon the type of material of which the support surface is composed.

Similarly, in automatic xerographic machines embodying vapor fixing apparatus, the xerographic powder image support surface is usually passed through a vapor chamber containing a saturated atmosphere of developing material solvent. In such machines it is also essential that the web speed of the support surface be carefully correlated to the solvent vapor concentration in the vapor chamber to minimize the possibility of under-fixing or over-fixing the powder images, or of excessively wetting the support surface with condensed solvent. In addition, since substantially all solvents suitable for fixing xerographic powder images are either inflammable or noxious, the vapor drag-out caused by the support surface web moving through the vapor chamber tends to produce undesirable ambient conditions.

The principal object of the present invention is to improve the method of vapor fixing xerographic powder images whereby metered amounts of solvent vapor are applied to the surface on which the powder images are supported to attain optimum vapor fusing conditions. A further object of the invention is to improve the method of vapor fixing of xerographic powder images to prevent under-fixing or over-fixing of the powder image, and to minimize vapor drag-out. A further object of the invention is to improve vapor fixing apparatus for xerographic powder images to effect precise quantitative control of the solvent vapor applied to a powder image. A further object of the invention is to minimize solvent loss in vapor fixing devices. A further object of the invention is to increase the effective speed of vapor fixing apparatus.

These and other objects of the invention are attained in accordance with the method of the invention by immersing a layer of foraminous material in an atmosphere of vapor of a solvent for the resin component of the xerographic developing material employed, allowing the layer to reach vapor equilibrium at the ambient temperature, removing the layer from the vapor chamber and bringing it into surface contact with a xerographic powder image formed on a support surface, maintaining the foraminous layer and the support surface in surface contact for a time period to permit the solvent vapor to condense on the powder image particles whereby the powder particles are plasticized or tackified sufficiently to flow into interstices of the support surface and adhere thereto, then separating the support surface from the foraminous layer, and permitting the solvent to evaporate from the support surface.

The invention also includes apparatus for carrying out the foregoing method that includes a vapor chamber wherein an atmosphere of solvent vapor is generated and contained, a web of foraminous material for entrapping and containing metered amounts of solvent vapor, and actuating means for advancing the web through the vapor chamber for a time period to permit the web to reach vapor equilibrium therein and to advance the web to a position wherein a support surface having a xerographic powder image thereon may be placed in surface contact therewith. Preferably, the apparatus also includes a pressure pad or web whereby the support surface having the powder image may be maintained in surface contact with the vapor impregnated foraminous web.

The term "tackified" and the several variant forms thereof used throughout this specification are employed to define the condition of the powder particles of the

xerographic powder image when treated in a manner such that the individual particles soften and coalesce and in which state they become sticky and readily adhere to other surfaces. Although this condition necessarily requires a flowing together of the particles to effect a thorough fusion thereof, it is to be understood that the extent of such flowing is not sufficient to extend beyond the boundary of the pattern in which the particles are formed.

A preferred form of the invention is shown in the accompanying drawings, in which:

FIG. 1 is an isometric view, partly in section, of the xerographic powder image fixing apparatus of the invention; and

FIG. 2 is a sectional view of the apparatus of FIG. 1.

In the form of apparatus shown in the drawings, a vapor chamber **10** is formed by a base plate **11** having side walls **12**, and a front wall **13** and a rear wall **14** integrally connected thereto. To complete the chamber a removable top plate **15** is supported on side walls **12** and rear wall **14**, and is employed to support the vapor generating apparatus and the foraminous web supporting apparatus, described below. A laterally extending semi-cylindrical member **16** is secured to the forward edge of top plate **15**, and, together with a resilient strip of silicone impregnated fiberglass **17** secured on front wall **13**, forms a substantially vapor-tight seal at the forward end of the chamber. At the rearward end of top plate **15** a tapered slot **18** is cut therethrough and is provided with silicone impregnated fiberglass strips **19** and **20** on its opposed faces which form a vapor seal for the entire length of the slot. By this construction base plate **11**, side walls **12**, front and rear walls **13** and **14**, and top plate **15**, together with the vapor seals form a substantially vapor-tight chamber.

For generating an atmosphere of solvent vapor within vapor chamber **10** there is an apparatus similar to that disclosed in copending application, S.N. 479,454, filed in the name of Robert W. Gundlach et al., on January 3, 1955, that includes an open, fluid-tight trough member **23** that extends substantially across the width of vapor chamber **10** and is suspended at each end by side plates **24** that are connected to the underside of top plate **15**. Contained within trough member **23** are a plurality of alternately arranged wick members **25** and **26**, preferably formed of heavy felt material, that are threaded on a rod **27** to form an integral wick assembly. Wick members **25** are each preferably cut in the form of a block T that fits closely within the outline of trough member **23** whereby the cross members of each T are supported on the upper edges of the trough and the bottoms are held slightly above the bottom of the trough to permit unimpeded flow of liquid solvent therein. Wick members **26** are of rectangular configuration and are arranged as spacers between members **25** thereby to provide a substantial area of exposed wick surface. The resin solvent **28** that is employed as a plasticizing or tackifying agent is poured into trough member **23** at convenient intervals, when top plate **15** is removed, in order to maintain an adequate supply of the liquid in the trough.

By this arrangement solvent liquid **28** is dispersed through a large volume of wick material having an extensive exposed surface area, whereby the liquid is readily volatilized in the atmosphere of the vapor chamber to form a substantially saturated atmosphere of solvent vapor therein. Any of a variety of resin solvents may be used for this purpose. However, it is preferred that the solvent be of a type that forms a vapor that is heavier than air, such as trichloroethylene or Freon, so that the vapor is most highly concentrated in the region in the bottom of the vapor chamber.

For supporting a web of foraminous material relative to the vapor chamber and advancing it therethrough, the apparatus includes a suitable arrangement of guide and drive rollers. For this purpose, a bracket **30** is supported from the underside of top plate **15** near the rearward end of the vapor chamber and, in turn, serves to support a nylon roll **31** that is mounted for rotational movement on studs **32** that are journalled in downward extensions **33** on bracket **30**. At the forward end of the vapor chamber there is provided a downwardly extending bracket **35** that is supported from the underside of top plate **15** and is provided with pins **36** for pivotally supporting a downwardly extending, roll supporting member **37**. A laterally extending nylon roll **38** is supported for rotational movement on studs **39** that are journalled in downwardly extending arms **40** on member **35**. In order to vary the position of roll **38**, for adjusting the tension of the foraminous web, described below, there is provided a downwardly extending plate **41** that is secured to the underside of top plate **15** and is provided with an arcuate milled slot **42**. A screw **43**, seated on a washer **44**, extends through slot **42** into a tapped hole in roll supporting member **37**, and may be adjusted to position roll **38**, as desired.

For advancing the foraminous web, the apparatus includes a driven shaft **46** that is rotatably mounted in suitable bearings formed in bearing blocks **47** and **48** that are secured to the upper face of top plate **15**. Fixed on shaft **46** are two wheels **49** and **50** that are provided with spaced, outwardly extending pins **51** for advancing the foraminous web, as described below. Shaft **46** extends outwardly beyond the edge of the vapor chamber and is provided with a pulley **52** fixed thereto that is driven by a belt **53** that extends over a pulley **54** fixed on the drive shaft of a motor **55** that is secured on a bracket **56** fixed on rear wall **14** of the vapor chamber.

For supporting the foraminous web exteriorly of the vapor chamber there is provided a formed sheet metal plate **58** (see FIG. 2) that is secured to the face of the forward edge of slot **18** in top plate **15** and extends upwardly and over shaft **46** and between wheels **49** and **50**, in an arc that approximates the periphery of the wheels, and then is bent downwardly so that its forward edge abuts the upper edge of cylindrical member **16**. By this arrangement a smooth, flat surface is provided for supporting the foraminous web over the top of the vapor chamber.

For withdrawing solvent vapor from the vapor chamber, the apparatus includes a foraminous web **60**, preferably formed of a single thickness of cheesecloth, that is supported between two Phosphor bronze endless belts **61** and **62** that extend around wheels **49** and **50**, rolls **31** and **38** and cylindrical member **16**. Each of the belts **61** and **62** is provided with a plurality of perforations **63**, having a spacing equal to the pitch of pins **51** in wheels **49** and **50**, whereby the rotation of shaft **46** is effective to drive the belts and thereby provide a means for drawing the web into and out of the vapor chamber. Web **60** is of such length that it is fully contained within the vapor chamber when the apparatus is in the condition shown in the drawings.

By the arrangement thus far described, it is apparent that web **60** may be drawn into and out of vapor chamber **10** and pass over the surface of support plate **58** during each cyclical excursion of belts **61** and **62**. While web **60** is outside the vapor chamber, the vapor that is entrapped within the web openings is withdrawn from the chamber and is free to evaporate to the atmosphere. As web **60** is returned to the vapor chamber, the openings therein quickly re-establish vapor equilibrium with the solvent vapor atmosphere in the chamber, so that when the web is again withdrawn a quantity of solvent vapor equivalent to that contained within the web openings is entrapped in the openings and is withdrawn from the chamber.

For controlling the operation of the fixing apparatus, a starting button **65** (see FIG. 1) may be arranged on top plate **15** at the forward end of the apparatus to permit the operator to initiate the operation of motor

55, as desired. In order to ensure that web 60 remains within the vapor chamber when the apparatus is not in use, a microswitch 66 may be arranged on top plate 15 adjacent to the path of movement of belt 62 in a position to have its actuating lever 67 operated by a knob or button 68 fixed on the belt to open the switch to stop motor 55 when web 60 is completely contained within the vapor chamber.

When a sheet of support material having a xerographic powder image thereon is to be fixed, the operator depresses starting button 65 to initiate the operation of motor 55, whereby web 60 is moved outwardly from the vapor chamber and over support plate 58. As web 60 advances, the operator places the sheet of support material, with powder image side down, on the surface of the web is it emerges from the vapor chamber. As the web material advances over plate 58, the vapor entrapped in the web material condenses on the powder particles of the xerographic powder image on the support material and is effective to tackify these particles and cause them to flow into the interstices of the support material. By the time the support material and adjacent web material reach the rearward end of the fixing apparatus, the powder particles therebetween are tackified to an extent sufficient to form a permanent bond with the support material. At the rearward end of the apparatus the support surface is removed from the web material and is exposed to the air to permit the resin solvent to evaporate therefrom, thereby leaving the pigmented resin of the xerographic powder image permanently bonded to the support surface.

It may be noted that when a support surface with a xerographic powder image thereon is positioned on web 60, the powder particles of the powder image adhere to the support surface merely as the result of electrostatic attraction, in accordance with conventional xerographic practice. As such, it may be expected that these particles will tend to become detached from their support surface and to edhere to the surface of the web material or be smeared thereby during the fixing operation. However, it has been found as the result of extensive experimentation that the powder particles remain electrostatically adhered to the support surface and do not tend to adhere to the web material. Furthermore, as the powder particles tackify, they combine exclusively with the support surface and do not combine with the material of the web. As a result, the surface of the web material remains clean and the complete xerographic powder image is affixed to the support surface. It is believed that this end result is caused by the fact that the support surface, although resting on the web material, only makes contact therewith at isolated points throughout its surface even though it appears to lie flat on the web.

Although the fixing apparatus thus far described may be employed for fixing xerographic powder images in many applications, it is preferred to provide a pressure pad or web to ensure that the support surface is maintained at an optimum relation with respect to the web material, regardless of the type of support surface that may be employed, so that air does not migrate back and forth through the foraminous web. For this purpose, a flexible belt or web 70, preferably of plastic material, is supported between rollers 71 and 72 that are fixed on shafts 73 and 74, respectively, which, in turn, are journalled for rotation in bearing brackets 75 and 76, respectively, that are secured on top plate 15. Brackets 75 and 76 are connected by a plate 77, whereby the pressure belt assembly may be removed from the machine as a unit, if desired. By this arrangement pressure belt 70 conforms to the curve established by support plate 58 and applies a substantially uniform pressure thereover. With the pressure belt assembly in place, support surfaces with xerographic powder images thereon may be fed, as above, onto web 60 as it passes under roll 71. Thereafter, the pressure belt will advance with the support surface, because of the frictional contact between the support surface and the pressure belt, and will maintain the support surface in optimum relationship to the web material throughout its passage through the apparatus.

Although the apparatus of the invention is intended primarily for single sheet operations under the control of an operator, it is apparent that it may readily be adapted for use with automatic xerographic processing machines within the scope of the present invention. Furthermore, although web 60 is disclosed as being contained within the vapor chamber to minimize vapor loss during standby conditions, it is obvious that it could be made in the form of an endless belt if intended to be employed with a processing apparatus in which the xerographic powder images are supported on a continuous web or on closely spaced successive sheets.

In the particular embodiment of the invention described thus far it is proposed that solvent vapor be metered from the vapor chamber by means of a web of foraminous material such, for example, as cheesecloth. Specifically, it has been found that a single thickness of cheesecloth arranged as shown in the drawings may be advanced at a rate such that it remains within the vapor chamber for a period of several seconds and is then effective to withdraw sufficient solvent vapor to fix a xerographic powder image placed in contact therewith in a period of approximately two to four seconds. Obviously, web materials and web speeds may be varied, at will, in accordance with the requirements of any given application. Although the specific phenomenon that is responsible for the results attained is not precisely known, it is thought that the solvent vapor is withdrawn from the vapor chamber by a combination of mechanical scooping of the vapor and a certain amount of absorption of vapor within the interstices of the web material. This concept is borne out by the fact that loosely woven absorbent or porous material such as linen toweling is particularly effective for use as a web material; wheres a porous but more closely woven material such as flannel or blotting paper does not function quite as well, in that they require a longer holding period in the vapor chamber in order to absorb sufficient vapor to effect proper fixing. On the other hand, webs formed of silk screen or metal screen materials are relatively ineffective for the use intended, primarily, it is believed, because they are incapable of absorbing sufficient solvent vapor.

From the foregoing, it seems apparent that the web material should preferably be of a type to effect a certain amount of mechanical scooping of solvent vapor and, concomitantly, a certain amount of absorpition of solvent vapor. In the appended claims a material of this type is defined as a layer of porous material, a web of foraminous material, or a layer of material having a plurality of openings therein. For the purposes of the present specification such definitions are deemed equivalent and are considered most adequately to define the particular type of material most suited for use in the invention and are intended to include all comparable types of material.

Obviously, a number of different types of instrumentalities and techniques may be employed in carrying out the method of the invention and widely differing applications of the invention may be made without departing from the scope thereof. Furthermore, many changes could be made in the above-described construction and a number of apparently different embodiments of the apparatus could be made within the scope of the invention. Therefore, it is intended that all matter contained in the above description shall be considered as illustrative, and that the invention be limited only as defined in the appended claims.

What is claimed is:

1. The method of fixing a resin powder image onto a backing sheet to which said powder image is loosely adhering, said method comprising the steps of placing said sheet and a layer of porous material in surface contact, said porous material containing the vapor of a solvent for

said resin, to thereby allow solvent vapor to penetrate into and soften said powder image to the point of adhesiveness whereby the softened powder image particles migrate into surface interstices of the backing sheet, and then separating said sheet and said porous layer to allow the solvent in said image to evaporate and leave a fixed resin image on said sheet.

2. The method of fixing a resin powder image onto a backing sheet to which said powder image is loosely adhering, said method comprising the steps of entrapping vapor of a solvent for said resin in the openings of a foraminous material, placing said sheet and said foraminous material with solvent vapor entrapped therein in surface contact thereby to allow solvent vapor to penetrate into and soften said powder image to the point of adhesiveness whereby the softened powder image particles migrate into surface interstices of the backing sheet, and then separating said sheet and said porous layer to allow the solvent in said image to evaporate and leave a fixed resin image on said sheet.

3. The method of fixing a resin powder image onto a backing sheet to which said powder image is loosely adhering, said method comprising the steps of generating an atmosphere of vapor of a solvent for said resin in a closed chamber, passing a web of foraminous material through a chamber of said vapor atmosphere to entrap solvent vapor in the openings of said material, and placing said sheet and material in surface contact exteriorly of said chamber, thereby to allow solvent vapor to penetrate into and soften said powder image to the point of adhesiveness, and then separating said sheet and said porous layer to allow the solvent in said image to evaporate and leave a fixed resin image on said sheet.

4. The method of fixing a resin powder image onto a backing sheet to which said powder image is loosely adhering, said method comprising the steps of generating an atmosphere of vapor of a solvent for said resin in a closed chamber, passing a web of foraminous material through a chamber of said vapor atmosphere to entrap solvent vapor in the openings of said material, and placing said sheet and material in surface contact exteriorly of said chamber, maintaining said sheet and said material in intimate surface contact for a predetermined time period thereby to allow solvent vapor to penetrate into and soften said powder image to the point of adhesiveness, and then separating said sheet and said porous layer to allow the solvent in said image to evaporate and leave a fixed resin image on said sheet.

5. An apparatus for fixing resin base powder images on support surfaces including a layer of material having a plurality of openings therein, said openings being adapted to entrap solvent vapor means including a vapor chamber for entrapping vapor of a resin solvent in the openings of said layer, and means for effecting surface contact of said layer and a powder image supporting surface exteriorly of the vapor chamber.

6. An apparatus for fixing resin base powder images on support surfaces including a layer of material having a plurality of openings therein, said openings being adapted to entrap solvent vapor means including a vapor chamber for entrapping vapor of a resin solvent in the openings of said layer, and means for pressing a powder image supporting surface into surface contact with said layer exteriorly of the vapor chamber.

7. An apparatus for fixing resin base powder images on support surfaces including a substantially vapor-tight chamber, means for forming an atmosphere of vapor of a resin solvent within said chamber, a web of material having a plurality of openings therein, said openings being adapted to entrap solvent vapor and means for advancing said web through said chamber and exteriorly thereto whereby to entrap solvent vapor in the web openings and to transport such solvent vapor exteriorly of the vapor chamber.

8. An apparatus for fixing resin base powder images on support surfaces including a substantially vapor-tight chamber, means for forming an atmosphere of vapor of a resin solvent within said chamber, a web of material having a plurality of openings therein adapted to entrap solvent vapor, means for supporting said web exteriorly of said chamber, and means for advancing said web through said chamber and then in surface contact with said supporting means whereby to entrap solvent vapor in the web openings and to transport such entrapped solvent vapor on the supporting means.

9. An apparatus for fixing resin base powder images on support surfaces including a substantially vapor-tight chamber, means for forming an atmosphere of vapor of a resin solvent within said chamber, a web of material having a plurality of openings therein adapted to entrap solvent vapor, means for supporting said web exteriorly of said chamber, means for advancing said web through said chamber and then in surface contact with said supporting means, and means for maintaining a powder image supporting surface in surface contact with said web during at least a portion of its travel exterior to the chamber.

10. An apparatus for fixing resin base powder images on support surfaces including a substantially vapor-tight chamber, means for forming at atmosphere of vapor of a resin solvent within said chamber, a web of material having a plurality of openings therein adapted to entrap solvent vapor, means for advancing said web through said chamber and then exteriorly thereto, and means for maintaining a powder image supporting surface in surface contact with said web during at least a portion of its travel exterior to the chamber.

11. An apparatus for fixing resin base powder images on support surfaces including a substantially vapor-tight chamber, means for forming an atmosphere of vapor of a resin solvent within said chamber, a web of material having a plurality of openings therein adapted to entrap solvent vapor, an endless belt apparatus for advancing said web through said chamber and then exteriorly thereto, means for maintaining a powder image supporting surface in surface contact with said web during at least a portion of its travel exterior to the chamber, and means for controlling the operation of the endless belt apparatus to retain the web within the chamber except when a powder image support surface is to be placed in contact therewith.

References Cited in the file of this patent

UNITED STATES PATENTS

1,339,529	Verhoogen	May 11, 1920
1,712,600	Westphal	May 14, 1929
1,776,141	Bibb et al.	Sept. 16, 1930
1,846,474	Darling	Feb. 23, 1932
2,097,885	Koppe	Nov. 2, 1937
2,130,665	Bradner	Sept. 20, 1938
2,702,254	Dowd	Feb. 15, 1955
2,776,907	Carlson	Jan. 8, 1957