May 5, 1964 W. G. VAN DORN 3,132,047

XEROGRAPHIC FIXING APPARATUS

Filed June 29, 1961 3 Sheets-Sheet 1

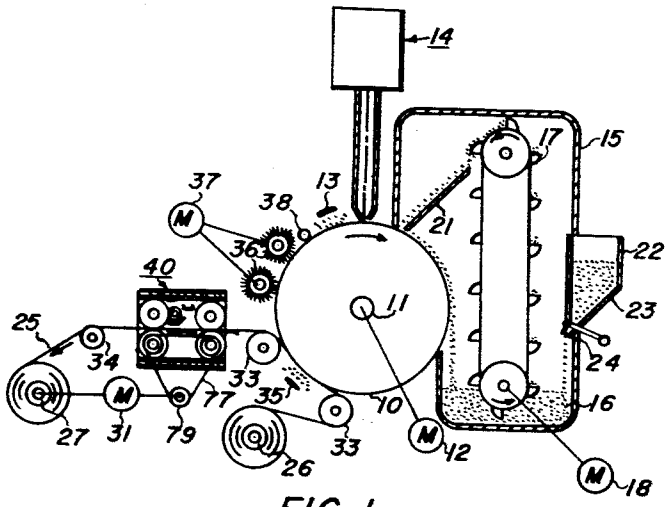

FIG. 1

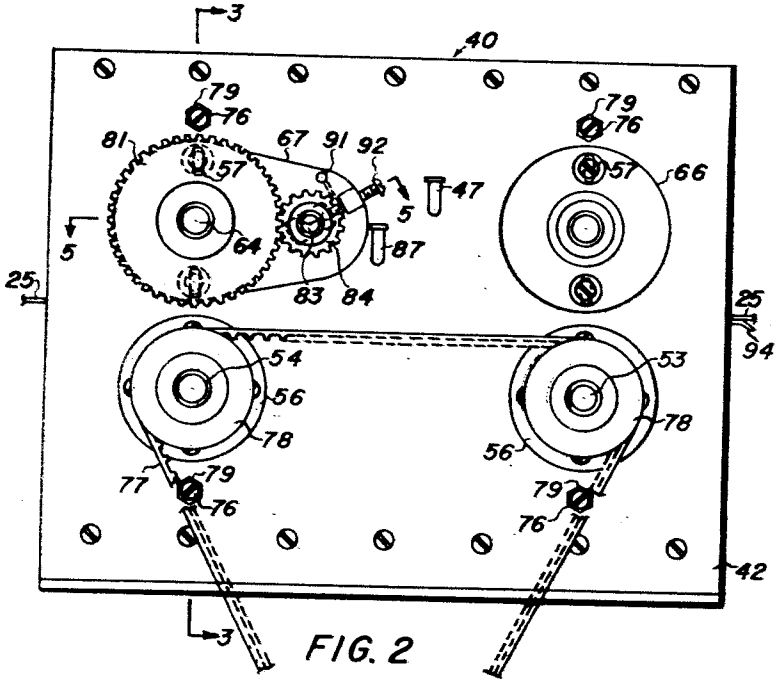

FIG. 2

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May 5, 1964 W. G. VAN DORN 3,132,047

XEROGRAPHIC FIXING APPARATUS

Filed June 29, 1961 3 Sheets-Sheet 2

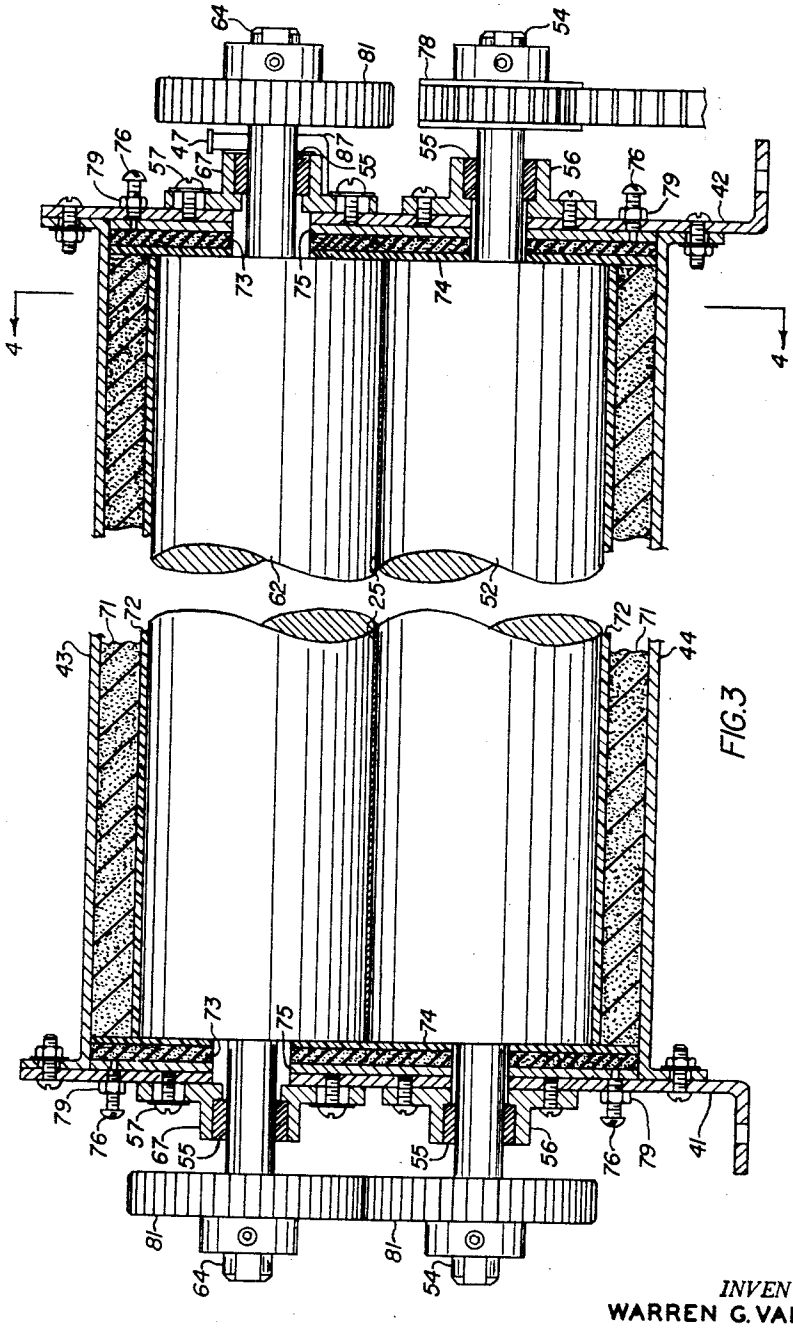

FIG.3

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May 5, 1964 W. G. VAN DORN 3,132,047

XEROGRAPHIC FIXING APPARATUS

Filed June 29, 1961 3 Sheets-Sheet 3

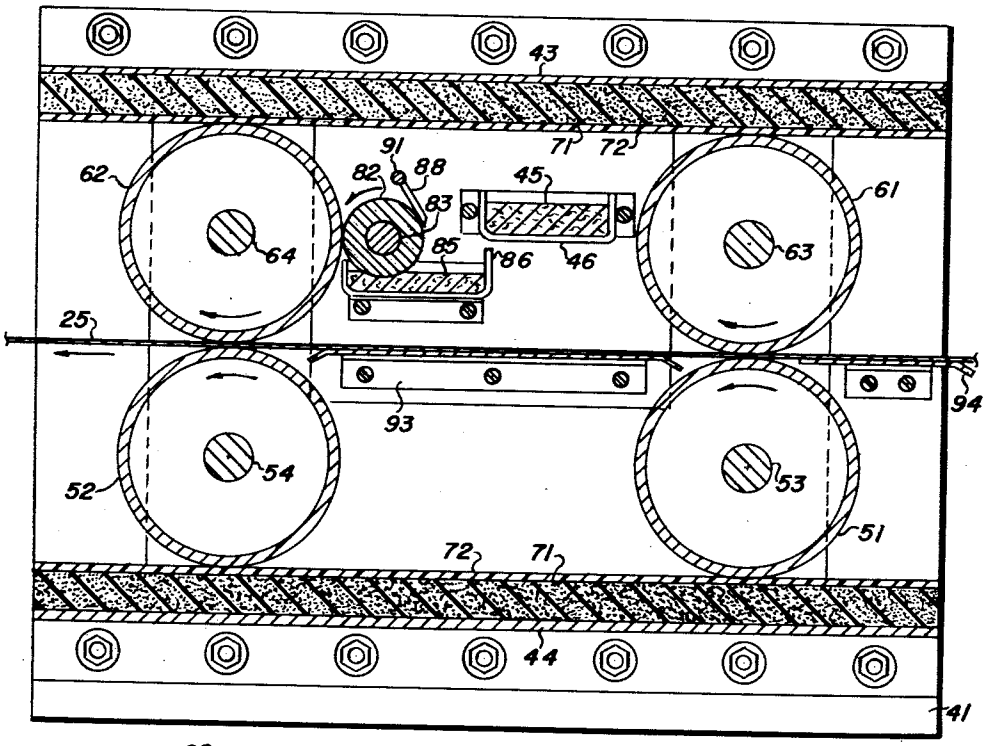

FIG. 4

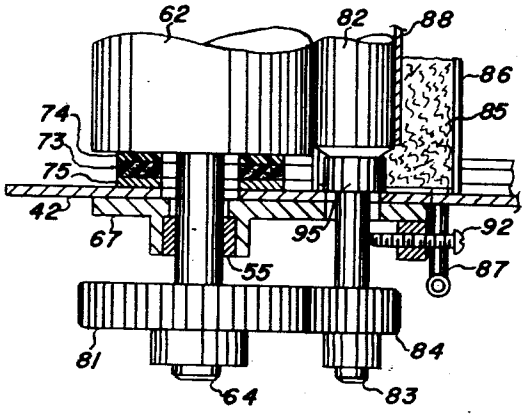

FIG. 5

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United States Patent Office

3,132,047
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3,132,047

XEROGRAPHIC FIXING APPARATUS

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Filed June 29, 1961, Ser. No. 120,613
6 Claims. (Cl. 118—65)

This invention relates to improvements in vapor fusing devices and, particularly, to an improved apparatus for fixing xerographic powder images.

More specifically, the invention relates to an improved solvent vapor fusing device. Although the invention is considered to have general application, it is particularly useful in the field of xerography and has an important application in the fusing of resinous powder images produced by electrophotography or xerography onto sheets of paper and the like to which the powder images have been transferred after they have been formed by deposition of powder on an electrostatic latent image. Therefore, for convenience of illustration, the invention is described with reference to its use as a heat fuser for xerographic powder images. However, it is to be understood that it may be employed with equal facility in other fields.

In the process of xerography, for example, as disclosed in Carlson Patent 2,297,691, issued October 6, 1942, 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 radiation intensity that reaches them, and thereby creates an electrostatic latent image on or in the photoconductive layer. Development of the latent image is affected with an electrostatically charged, finely divided developing material or toner 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 such as paper to which it may be fixed by any suitable means.

One of the methods in common use for developing the electrostatic latent image is described in Walkup Patent 2,618,551, and is known as cascade development, and is in general use for line copy development. In this technique, the powder or toner is mixed with a granular "carrier" material, and this two-component "developer" is poured or cascaded over the plate surface. The function of the carrier material is to improve the flow characteristics of the powder and to produce, on the powder, by triboelectrification, the proper electrical charge so that the powder will be attracted to the image. More exactly, the function of the carrier material is to provide the mechanical control to the powder, or to carry the powder to an image surface and, simultaneously, to provide homogeneity of charge polarity.

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 or toner formed of any of a variety of pigmented thermoplastic resins that have been specifically developed for the purpose. A number of such developer materials are manufactured and marketed by Xerox Corporation, 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 compounded to

permit them to be fixed to the surface of a transfer material either by heat fixing or vapor fixing techniques, in accordance with the particular application in which they are employed, that is, the individual particles of resin (toner) soften and coalesce when heated or plasticized by solvent, so that they become sticky or tackified and readily adhere to the surface of the transfer material.

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 heated or plasticized by a solvent 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.

Such developing material is 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 support surface on which xerographic powder images are formed 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 speed of movement of the support surface. Should the speed of movement of the surface support be increased or the oven temperature decreased, the powder images are not properly fixed and are subject to smearing. In the event the speed of the support surface 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. This imposes limitations on the choice of resins which make it difficult to meet other desirable characteristics in the powder composition.

Because of the above-described limitations inherent in heat fixing, the process of solvent vapor fusing is preferred to fix or fuse resinous powder images. In this process, as described for example in Carlson Patent 2,624,652, the powder images are fixed by subjecting the powder to an atmosphere of solvent vapor. Vapor fusing offers the advantages of a broadened choice of powder materials, lower power requirements as compared to heat fixing, and elimination of heat damage to the support surface.

However, it is recognized that solvents, in general, have odors and therefore vapor fusers must be constructed in such a manner to eliminate or control the amount of solvent vapor escaping into the atmosphere since loss of solvent vapor from a fuser will not only be uneconomical, but it can also be objectionable to the operator because of its odor.

In manually operated vapor fusers for periodically fixing powder images on single cut sheets of support material, this problem can readily be overcome by the use of a structure of the type disclosed in Carlson Patent 2,922,230.

In automatic xerographic machines embodying vapor fixing apparatus, the problem of preventing vapor loss and keeping the consumption of solvent to a minimum is much more critical, and it is apparent that a vapor fuser

of the type disclosed in Carlson Patent 2,922,230, would not be practical in an automatic xerographic machine.

It is, therefore, the principal object of this invention to improve vapor fusing apparatus for fusing xerographic powder images, the vapor fusing apparatus being adapted for use in automatic xerographic reproducing apparatus.

Another object of this invention is to improve vapor fusing apparatus to minimize solvent loss.

A further object of this invention is to improve vapor fusing apparatus to effect a seal against vapor loss while preventing toner offset onto the seal.

These and other objects of the invention are attained in the preferred embodiment of the invention by means of a vapor chamber having entrance and exit openings sealed by sets of rollers adapted to cooperate with each other to permit the ingress and egress of support material.

For a better understanding of the invention as well as other objects and further features thereof, reference is had to the following detailed description of the invention to be read in connection with the accompanying drawings, wherein:

FIG. 1 illustrates schematically a preferred embodiment of a xerographic apparatus adapted for automatic operation, and incorporating a vapor fuser constructed in accordance with the invention;

FIG. 2 is a right hand end view of the vapor fuser;

FIG. 3 is a sectional view taken along line **3**—**3** of FIG. 2;

FIG. 4 is a sectional view taken along line **4**—**4** of FIG. 3; and,

FIG. 5 is a sectional view taken along line **5**—**5** of FIG. 2.

Although it forms no part of the subject invention, there is shown schematically in FIG. 1 a continuous xerographic apparatus for the purpose of illustrating a suitable environment for a heat fuser having mounted therein heating elements of the subject invention.

As shown in FIG. 1, the xerographic apparatus comprises a xerographic plate including a photoconductive layer or light-receiving surface on a conductive backing and formed in the shape of a drum, generally designated by numeral **10**, which is mounted on a shaft **11** journaled in a frame (not shown) to rotate in the direction indicated by the arrow to cause the drum surface sequentially to pass a plurality of xerographic processing stations. Drum **10** is rotated at a constant rate through the drive action of synchronous motor **12**.

For the purpose of the present disclosure, the several xerographic processing stations in the path of movement of the drum surface may be described functionally, as follows:

A charging station, at which a uniform electrostatic charge is deposited on the photoconductive layer of the xerographic drum;

An exposure station, at which a light or radiation pattern of copy to be reproduced is projected onto the drum surface to dissipate the drum charge in the exposed areas thereof and thereby form a latent electrostatic image of the copy to be reproduced;

A developing station, at which a xerographic developing material including toner particles having an electrostatic charge opposite to that of the electrostatic latent image are cascaded over the drum surface, whereby the toner particles adhere to the electrostatic latent image to form a xerographic powder image in the configuration of the copy to be reproduced;

A transfer station, at which the xerographic powder image is transferred from the drum surface to a transfer material or support surface; and,

A drum cleaning and discharge station, at which the drum surface is brushed to remove residual toner particles remaining thereon after image transfer, and at which the drum surface is exposed to a relatively bright light source to effect substantially complete discharge of any residual electrostatic charge thereon.

In general, the charging apparatus **13**, which may be of the type disclosed in Walkup Patent 2,777,957, includes a corona discharge array of one or more corona discharge electrodes that extend transversely across the drum surface and are energized from a high potential source and are substantially enclosed within a shielding member.

Next subsequent thereto in the path of motion of the xerographic drum is an exposure station. This exposure station may be one of a number of types of mechanisms or members such as desirably an optical projection system **14** or the like designed to project a line copy image onto the photoconductive surface of the xerographic drum from an original as is well known in the art.

Adjacent to the exposure station is a developing station in which there is positioned a developer housing **15** including a lower or sump portion for accumulating developing material **16**. A bucket type conveyor **17** having a suitable driving means, such as motor **18**, is used to carry the developing material to the upper part of the developer housing where it is cascaded down over a hopper chute **21** onto the xerographic drum.

As the developing material is cascaded over the xerographic drum, toner particles are pulled away from the carrier component of the developing material and deposited on the drum to form powder images, while the partially denuded carrier particles pass off the drum into the developer housing sump. As toner powder images are formed, additional toner particles must be supplied to the developing material in proportion to the amount of toner deposited on the drum. For this pumpose there is provided a container **22** for toner **23** to be added to the developing material as needed, the toner being added at a rate determined by control gate **24**.

After development, the image thus formed is transferred to support surface web **25**, which may be paper or any other suitable material. Web **25** is transported from supply spool **26** to take-up spool **27** by a suitable paper handling apparatus. The paper handling mechanism includes a synchronous motor **31** driving take-up spool **27**, while guide rolls **33** serve to direct web **25** into contact against a powder image on the surface of drum **10**. Electrostatic transfer unit **35**, which may be of type similar to unit **13**, generates an electrostatic charge to electrostatically attract the powder image from the surface of drum **10** to web **25**.

Thereafter, image-bearing web **25** is transported through vapor fuser **40** of the type disclosed in detail hereinafter, whereby the developed and transferred xerographic powder image on the web **25** is permanently fixed thereto. From the vapor fuser **40**, the web is transported over guide roll **34** onto take-up spool **27**.

The next and final station in the device is a drum cleaning and discharge station where any powder remaining on the xerographic drum after transfer is removed by rotating brushes and the xerographic drum is flooded with light to cause dissipation of any residual electrical charge remaining on the xerographic drum. The residual powder image on the surface of the drum **10** after transfer is removed by brushes **36** driven by motor **37** after which residual electrostatic charge is dissipated by illumination from lamp **38**.

Referring now to FIGS. 2 through 5, inclusive, there is shown a preferred embodiment of a vapor fusing device **40** constructed in accordance with the invention.

In the embodiment shown, the vapor fusing device includes a flanged left-hand end plate **41** and right-hand end plate **42** connected together in spaced parallel relation to each other by a top cover plate **43** and a bottom cover plate **44** suitably secured thereto to form a vapor chamber open at opposite ends to form entrance and exit openings.

Vapor fusing is achieved by forwarding the web **25**, bearing the toner image to be fused, thorugh an atmosphere of solvent vapors maintained within the vapor

chamber. To generate a saturated vapor atmosphere within the vapor chamber there is provided a solvent wick **45**, formed of felt, cloth or blotting paper, supported within a reservoir **46** secured at opposite ends to left-hand end plate **41** and right-hand end plate **42**. Solvent is fed to the reservoir through a suitable commercial constant level device, not shown, and a solvent entrance elbow **47** extending through right-hand end plate **42** and connected to the reservoir whereby solvent saturation of the wick is maintained.

Powder images can be fused in the device as soon as a saturated vapor atmosphere has been generated. Once the wick **45** has become wet with solvent over its entire area the necessary vapor atmosphere is quickly produced. Although the solvent and solvent vapor are preferably at the same tempertaure as the copy sheet and powder image, namely at room temperature, fusing of the image takes place, provided the powder is soluble in the solvent. The powder absorbs solvent from the vapor until it becomes adhesive. As soon as the copy is removed from the vapor chamber the solvent begins to evaporate from the image and the image solidifies and becomes permanently bonded or fixed upon the base material in a few seconds. If it is desired to generate more rapidly a saturated atmosphere of solvent vapors, a conventional heater element may be mounted within the vapor chamber. This however would create a greater pressure within the chamber, resulting in greater loss of solvent vapors from the chamber.

Whether the solvent is maintained at room temperature or heated to more rapidly generate vapors, there is provided a vapor seal at both the entrance and exit opening of the vapor chamber in accordance with the invention in the preferred embodiment. To effectively seal the ends of the vapor chamber there is provided two sets of rolls at opposite ends of the chamber. The sets of rolls permit the ingress and egress of the support material, such as web **25** while forming a movable seal for the vapor chamber.

As shown, both the bottom entrance roll **51** and bottom exit roll **52** are mounted on shafts **53** and **54**, respectively, which extend through the end plates and are journaled in suitable bearings **55** mounted on flanged bearing brackets **56** secured to the end plates. In a similar manner, the upper entrance roll **61** and the upper exit roll **62** are mounted on shafts **63** and **64**, respectively, extending through the end plates and journaled in bearings **55** mounted in flanged bearing brackets **66** and **67**, respectively adjustably secured by screws **57** to the end plates, whereby the upper rolls are adapted to move with respect to the bottom rolls and cooperate with their respective bottom rolls or with a sheet of support material sandwiched therebetween to effectively seal a part of the entrance and exit openings of the vapor chamber.

To further seal the openings of the vapor chamber to prevent loss of vapor, both the top and bottom cover plates have attached to their inner surfaces a pad of foam rubber **71** and, to the inner surface of the foam rubber, a sheet **72** of material having an abhesive characteristic, such as a sheet preferably made of polytetrohaloethylene synthetic resin or other high melting-point synthetic resins, which is biased by the foam rubber into surface contact with the peripheral surface of the rolls.

The sheet **72** is preferably made of a chemically inert non-porous and non-absorbent relatively hard and generally form-retaining wax-like synthetic resin which is slightly elastic under low stress and which is capable of cold-flowing under greater stress, and which is capable of sliding over a surface in the manner of self-lubricating relationship therewith. Among such polytetrahaloethylene synthetic resins are polytetrafluoroethylene which is sold commercially by the E. I. duPont de Nemours Company under the trademark name "Teflon," and polytrifluorochloroethylene, which is sold commercially by the M. W. Kellogg Co., under the name of "Kel-F."

The edges or ends of the rolls and, therefore, the sides of the vapor chamber, are sealed in a similar manner by sheets **74** also made of a material having abhesive characteristics biased into contact with the ends of the rolls by means of a foam rubber pad **73** secured to floating end plates **75** adjustably positioned within the chamber by means of screws **76** threaded through nuts **79** secured as by welding to the end plates, the reduced portion of the screw extending into suitable apertures formed in the floating end plates **75**.

To prevent smearing and toner offset of the toner images, the entrance and exit rolls are driven in synchronization to the speed of movement of web **25** by a suitable drive means such as motor **31**. Shafts **53** and **54** are shown connected operatively to motor **31** by belt **77**, which runs on pulleys **78** fixedly mounted on the right-hand ends of shafts **53** and **54**, as seen in FIGS. 2 and 3, and to a pulley **79** driven by the motor **31**. The motor is connected to a source of electric power and is controlled by switching means (not shown).

The upper entrance and exit rolls are driven in synchronization with the bottom rolls by means of gears **81** fixed to the left outboard ends of the shafts as seen in FIG. 3.

As the powder image is tackified by solvent, part of the image carried by the support material will stick, in the embodiment shown, to the surface of the upper exit roll, so that as the next sheet contacts the uper exit roll, the tackified image partly removed from the first sheet will partly transfer to the next sheet and at the same time part of the tackified image from the next sheet would adhere to the upper exit roll. This process is commonly referred to in the printing art as "set off" or "offset," the latter term being preferred.

To further prevent their offset on the upper exit roll, which in the embodiment shown will contact toner on the upper surface of web **25**, a roll type aplicator is used to supply a thin film of offset preventing liquid such as silicone oil to the upper exit roll. Although various means may be used to apply the silicone oil to the upper exit roll, in the preferred embodiment of the invention, there is used an applicator roll **82** mounted on axle **83** which extends through slot formed at an angle to the horizontal plane in the end plates, and is journaled in the slot formed in the flanged bearing bracket **67**, whereby the applicator roll is adapted to rotate in peripheral contact with the surface of the upper exit roll. To prevent excessive movement of the applicator roll, it is held in substantial contact with the upper exit roll by means of adjusting screws **92** threaded in turned out portions of the flanged bearing brackets **67** to contact the axle **83**. The axle **83** is maintained in axial alignment by collars **95** secured to the axle. The applicator roll **82** is driven in timed relation to the upper exit roll by gear **84** secured to one end of the applicator roll axle **83**, the gear **84** engaging a second gear **81** on the right-hand end of shaft **64** of the upper exit roll.

When the applicator roll is rotated it will pick up oil from a saturated felt pad **85** positioned in the open oil reservoir **86** secured to and extending between the end plates. Silicone oil is fed to the reservoir through a suitable commercial constant level device, not shown, and the oil entrance elbow **87** connected to the reservoir whereby oil saturation of the felt pad is maintained. Oil picked up by the applicator roll from the felt pad is then thinned to the desired thickness by a doctor blade **88** before it is deposited on the upper exit roll. The doctor blade is suitably supported and adjustably positioned with respect to the applicator roll by means of pivot rod **91** inserted in suitable apertures formed in the end plates.

To guide the support material as it is transported from the entrance rolls to the exit rolls there is provided a paper guide **93** secured at opposite ends to plates **41** and **42**. In a similar manner an entrance guide **94** is provided in front, in terms of paper travel, of the entrance rolls.

Although the entrance and exit rolls contacting the powder image on the support material may be made of various materials, in the preferred embodiment the image contacting entrance roll, the upper entrance roll **61**, as shown, is coated with a layer of Teflon. The image contacting exit roll, upper exit roll **62**, as shown, may be bare metal, such as a brass roll, having a smooth satin finish so the silicone oil will spread over the peripheral surface of the roll in a thin, continuous layer. The peripheral surface of this roll may also be coated with Teflon, slightly roughened by polishing with a crocus cloth abrasive wetted with silicone oil to permit a more uniform wetting of this roll with silicone oil by the applicator roll to prevent toner offset.

Both the Teflon and silicone oil have such physical characteristics so that they are substantially abhesive to dry or tackified xerographic developing materials. "Abhesive" is a relatively new term that was coined by Dow Corning Corporation, primarily in connection with their silicones to define a surface that has "release" characteristics such that it is highly repellant to sticky or tacky substances. The word is adopted in this sense herein and is so used through the disclosure.

While there have been shown and described the fundamental novel features of the invention as applied to a preferred embodiment, it will be understood that various omissions, substitutions and changes in the form and details of the device illustrated and in its operation may be made by those skilled in the art, without departing from the spirit of the invention. Thus, for example, there may be provided only one opening at the end of the vapor chamber closed by a set of three rolls, the center roll cooperating with the top or first roll to form a closable entrance for the support material and with the bottom or third roll to form a closable exit for the support material. It is therefore the intention to be limited only as indicated by the scope of the following claims.

What is claimed is:

1. Apparatus for fixing a powder image to the surface of a support material, said apparatus including walls defining a vapor chamber having an ingress opening and an egress opening therein, seal means positioned to partly seal said ingress opening and said egress opening, each of said seal means including a first roll and a second roll journaled for rotation in said vapor chamber, said second roll being mounted parallel to said first roll and movable radially with respect to said first roll; drive means for rotating said first roll and said second roll in cooperative relation to feed a support material therebetween, vapor generating means connected to said vapor chamber for generating an atmosphere of solvent vapor within said vapor chamber, and means to apply an offset preventing liquid to said second roll of said seal means partly closing said egress opening.

2. Apparatus for fixing a powder image to the surface of a support material, said apparatus including a top wall, side walls, a bottom wall and movable end walls defining a vapor chamber having an ingress opening and an egress opening therein, each of said movable end walls including a pair of rolls journaled for rotation, said rolls being mounted parallel to each other, one of said rolls being movable radially with respect to said other one of said rolls, drive means for rotating said rolls in cooperative relation to each other to feed a support material therebetween, vapor generating means connected to said vapor chamber for generating an atmosphere of solvent vapor within said vapor chamber, and means to apply an offset preventing liquid to the one of said rolls contacting a powder image on a support material forwarded between said rolls at said egress opening.

3. Apparatus for fixing a powder image to the surface of a support material, said apparatus including a top wall, side walls, a bottom wall and movable end walls defining a vapor chamber, said movable end walls adapted to provide an ingress opening and an egress opening to the interior of said vapor chamber, each of said movable end walls including a first roll and a second roll journaled for rotation, said second roll being mounted parallel to said first roll and movable radially with respect to said first roll from a first position in contact with each other to a second position in spaced relation to each other for passage of a support material therebetween; drive means for rotating said first roll and said second roll in cooperative relation to feed a support material therebetween, vapor generating means connected to said vapor chamber for generating an atmosphere of solvent vapor within said vapor chamber, and means to apply an offset preventing liquid to said second roll partly closing said egress opening whereby as said second roll contacts a tackified powder image on a support material the image will not adhere to said second roll.

4. Apparatus for fixing a powder image to the surface of a support material, said apparatus including a top wall, side walls, a bottom wall and movable end walls defining a vapor chamber having an ingress opening and an egress opening therein, each of said movable end walls including a pair of rolls journaled for rotation, said rolls being mounted parallel to each other, one of said rolls being movable radially with respect to said other one of said rolls, seal means positioned in contact with said pair of rolls of said movable end walls and said top wall, said side walls and said bottom wall; drive means for rotating said first roll and said second roll in cooperative relation to feed a support material therebetween; vapor generating means connected to said vapor chamber for generating an atmosphere of solvent vapor within said vapor chamber, and means to apply an offset preventing liquid to one of said rolls contacting a powder image on a support material forwarded between said rolls at said egress opening.

5. The apparatus described in claim 4 wherein the portion of said seal means contacting said movable end walls, and the peripheral surface of one of each of said rolls contacting the powder image on a support material is a material formed of a chemically inert non-porous and non-absorbent relatively hard and generally form-retaining wax-like synthetic resin which is slightly elastic under low stress and which is capable of cold flow under greater stress, and which is capable of sliding over a surface in the manner of self-lubricating relationship therewith.

6. In an apparatus for fixing a powder image to the surface of a support material, including wall means forming a vapor chamber having at least one opening therein for egress of a support material and means to generate an atmosphere of solvent vapor within the vapor chamber, the improvement comprising a movable seal adapted to partly close said opening, said movable seal including at least a first roll and a second roll adapted by rotation in cooperative relation to each other to forward a support material from said vapor chamber and means to apply an offset preventing liquid to said second roll.

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