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2,884,704

APPARATUS FOR FIXING ELECTROGRAPHIC PRINTER IMAGES

Filed Sept. 8, 1955

2 Sheets-Sheet 1

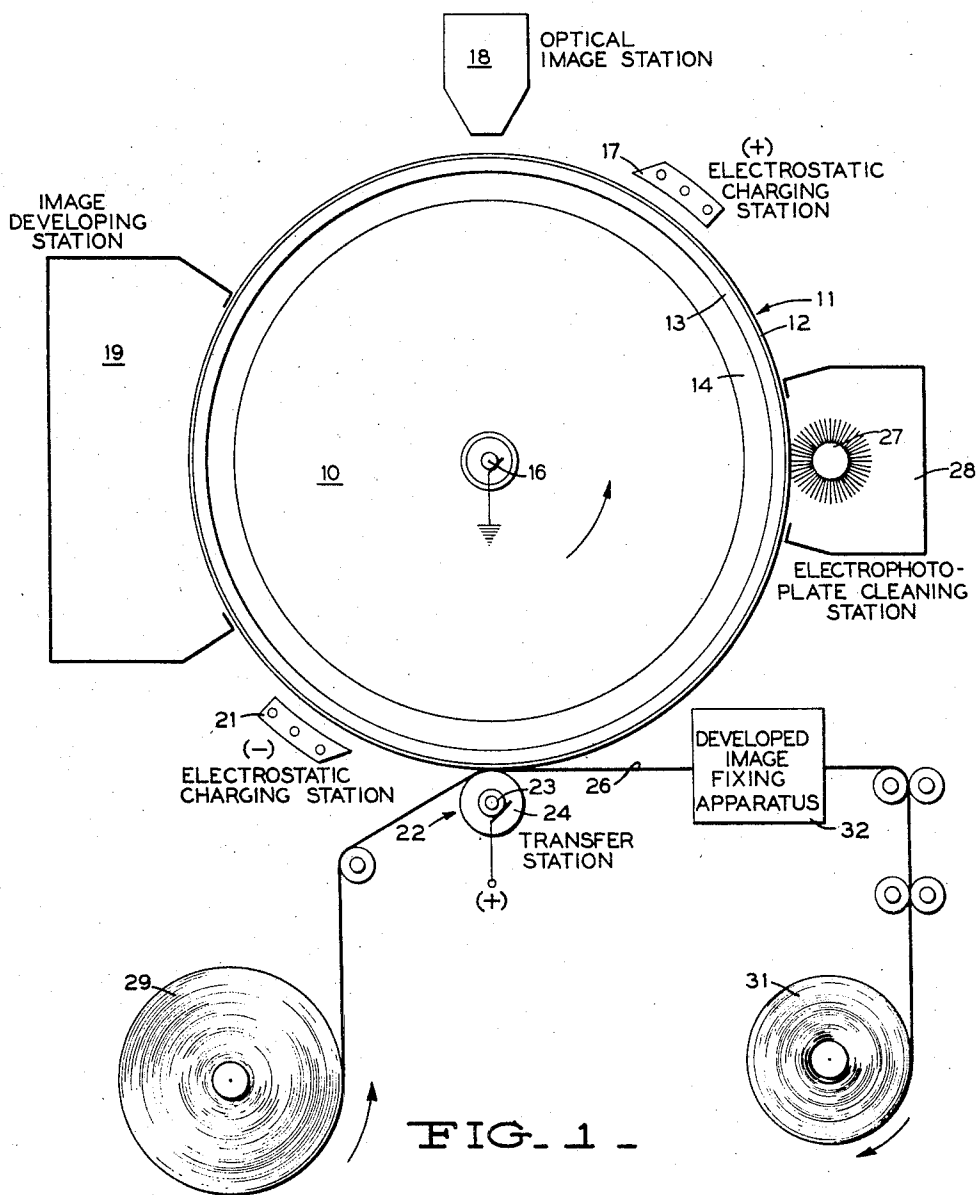


FIG. 1 -

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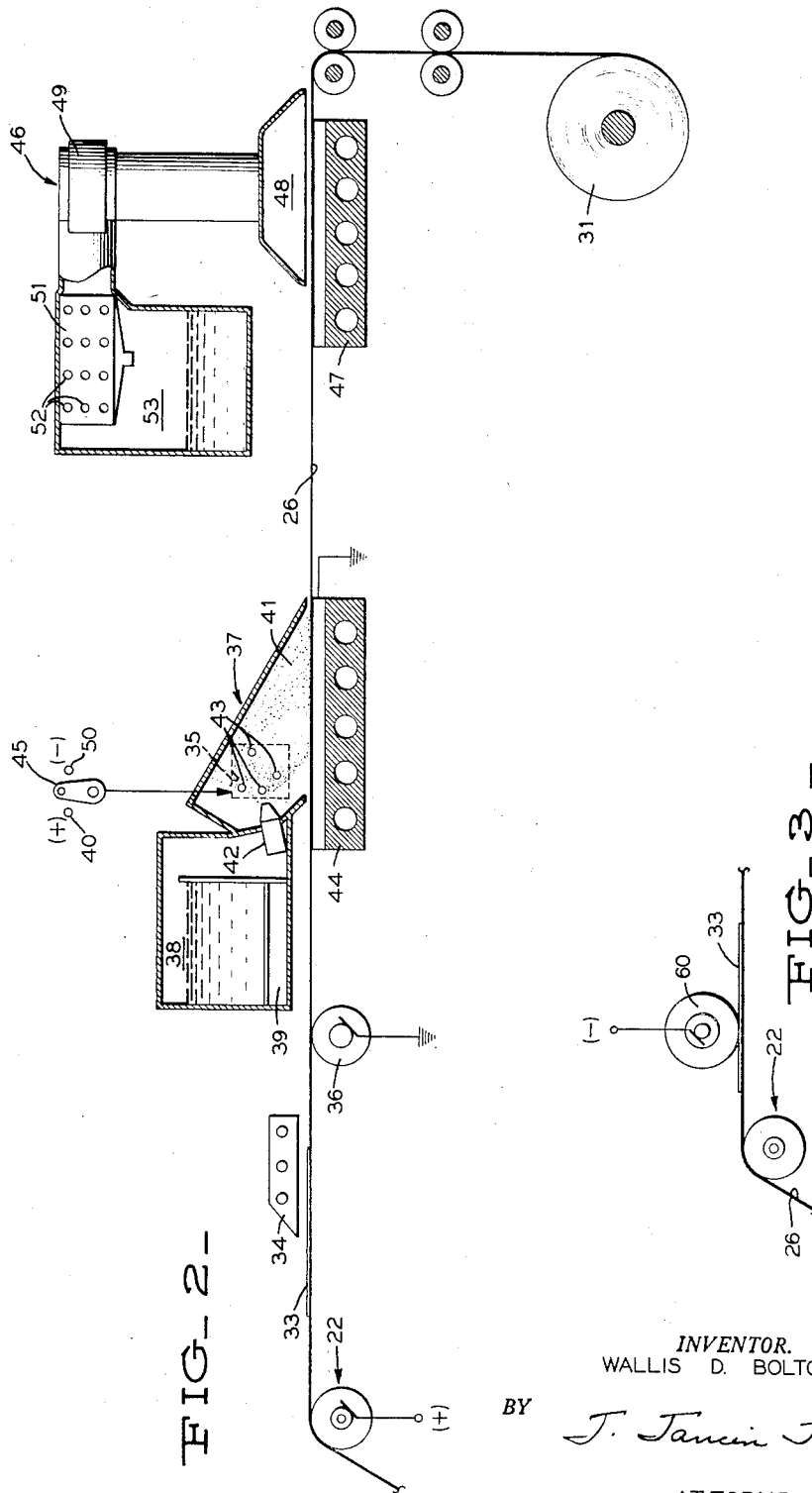


FIG- 2-

FIG- 3-

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APPARATUS FOR FIXING ELECTROGRAPHIC PRINTER IMAGES

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Application September 8, 1955, Serial No. 533,103

4 Claims. (Cl. 34-1)

This invention relates to electrographic printing machines in general, and to the developed image fixing apparatus thereof in particular.

The preferred embodiment of the invention described herein pertains to an electrographic printing machine of the type commonly referred to as a xerographic printer. As is well known to persons familiar with this phase of the graphic arts, xerography is a term applied to a printing process in which a latent electrostatic image that is stored in an insulating member, is rendered visible on the surface of said member by a pigmented, non-conducting electroscopic powder often referred to as electroscopic or xerographic toner. The resulting electroscopic toner image is then transferred after having been developed, and thereafter is affixed to a print receiving material, such as paper for example, so as to afford a permanent printed copy which corresponds to and depicts the aforesaid latent electrostatic image. An apparatus employing such a printing process is shown and described in Carlson Patent No. 2,357,809 which issued on September 12, 1944.

The broad object of this invention is to provide a highly efficient improved apparatus in an electrographic printer for fixing developed images onto a print receiving material.

In keeping with the foregoing, another object of this invention is to provide an improved solvent vapor apparatus which uses a minimum of toner solvent for fixing electroscopic toner images.

And still another object of this invention is to provide an electroscopic toner image fixing apparatus which employs a principle of selective electrostatic attraction of toner particles and solvent vapor particles.

Other objects of the invention will be pointed out in the following description and claims and illustrated in the accompanying drawings, which disclose, by way of examples, the principle of the invention and the best mode, which has been contemplated, of applying that principle.

In the drawings:

Fig. 1 is a somewhat diagrammatic view of a continuous-operation xerographic printer.

Fig. 2 is a somewhat diagrammatic view of an electroscopic toner image-solvent vapor fixing apparatus for use in a xerographic printer.

Fig. 3 depicts another means for charging an unfixed electroscopic toner image.

GENERAL DESCRIPTION

Referring to Fig. 1, a xerographic drum 10 has secured thereto an electrophotoplate 11 which consists of a photoconductive insulating layer 12, such as amorphous selenium for example, on an electrically conductive backing member 13 made of aluminum, for example. The electrophotoplate 11 is flexed around a drum cylinder 14 as shown, and is attached thereto in any one of the numerous conventional ways of attaching a printing plate to a supporting cylinder, such as by suitable clamping devices, for example. It is important,

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however, that in whatever manner this attachment is made, the conductive backing member 13 of electrophotoplate 11 be in good electrical contact with the electrically grounded drum cylinder 14 which, it should be brought out here, is connected electrically to grounded shaft 16.

The xerographic drum 10 is driven in a counterclockwise direction, as is shown in Fig. 1, by an electric motor (not shown) via the drive shaft 16. As successive incremental surface areas of the light sensitive photoconductive insulating layer 12 are moved past an ion-producing charging unit 17 of the type shown and described in Carlson Patent No. 2,588,699 which issued on March 11, 1952, the aforesaid layer 12 is electrically charged positive. After being so charged, the said incremental areas are moved past an optical image producing unit 18 which directs an optical image onto the surface of layer 12. This may be done in any one of a number of ways, such as those which have already been shown and described in the copending U.S. patent applications, Serial Nos. 419,392, 477,556 and 419,702, filed on March 29, 1954, December 24, 1955 and March 30, 1954, respectively. Inasmuch as the optical image forming unit per se is not a part of the present invention, the said unit will not be described herein in detail so as to avoid undue prolixity and unnecessary complexity. It should also be pointed out that the optical image producing unit 18 would not be necessary in a xerographic machine of the type disclosed in Schaffert Patent No. 2,576,047 which issued on November 20, 1951. This latter printer is used to print the same copy over and over again in accordance with the three dimensional design of the printing plate.

Consequent upon the exposure of the surface of photoconductive insulating layer 12 to the optical image projected thereon from unit 18, a latent electrostatic image is produced in electrophotoplate 11 for the reason that those electrically charged incremental areas of the photoconductive insulating layer 12 onto which light rays are directed, are discharged, whereas those areas not illuminated by the light rays remain positively charged. Hence, after electrophotoplate 11 is exposed to the said optical image projected from unit 18, a latent electrostatic image corresponding to the optical image will remain stored in the electrophotoplate. Continued rotation of the xerographic drum 10 in a counterclockwise direction will then move the latent electrostatic image in electrophotoplate 11 into an image developing chamber 19 which is similar to the one utilized in the printing apparatus of aforementioned Schaffert Patent No. 2,576,047. The image developing chamber is one wherein a xerographic developer material of the type described in Walkup et al. Patent No. 2,638,416 which issued on May 12, 1953, is permitted to cascade over the surface of photoconductive insulating layer 12 and, of course, over the latent electrostatic image already formed thereon. As is brought out in the afore-mentioned Walkup et al. patent, the xerographic developer material consists of xerographic toner of the type described in said Walkup et al. patent and in Copley Patent No. 2,659,670 which issued on November 17, 1953, and a triboelectrically opposite granular carrier therefor to electrically charge the toner. The electroscopic toner which may have different compositions, is a very fine powder, usually made up as a resin base material, and sometimes includes more or less of a material which is in the class of a plasticizer for the resin. It also usually contains a dye or pigment for color imparting purposes. As a result of the triboelectric action between the toner and carrier particles, the toner is charged negative. Hence, the negatively charged toner will adhere to only those afore-mentioned image areas of photoconductive insulating layer 12 which are charged positive.

Therefore, there is a toner image which visibly defines the latent electrostatic image developed on the surface of said electrophotoplate 11. The positively charged carrier in the developer and any surplus xerographic toner that does not adhere to the surface of photoconductive layer 12, will fall into a suitable receiving receptacle within developing chamber 19.

A still further counterclockwise rotation of xerographic drum 10 will cause the toner image on electrophotoplate 11 to move out of chamber 19 and past a negative corona ion-producing unit 21 which is similar to unit 17 and which decreases the magnitude of the electrical charge defining the positive latent electrostatic image, to thereby condition the developed toner image being carried by xerographic drum 10 for removal therefrom by the positively charged image transfer roller 22. In addition thereto, as is brought out in Butterfield Patent No. 2,641,997 which issued on June 16, 1953, the negative corona charge directed from unit 21 onto the surface of electrophotoplate 11, corrects an unfavorable condition known as "selenium fatigue."

A further rotation of the xerographic drum causes the toner image on the surface thereof to move into the toner image transfer, or printing, station. As is shown in Fig. 1, this transfer station includes a transfer roller 22 of the type shown and described in copending U.S. Patent application, Serial No. 419,314, filed by C. J. Fitch on March 29, 1954, and now Patent No. 2,807,233. Since the transfer apparatus per se is not a part of this invention, reference may be had to this copending patent application for a more detailed description than will be given herein. Briefly, however, the positive potential applied to the transfer roller which, in general, comprises an inner metallic conductive portion 23 and an outer portion 24 of very resilient or yielding material having a high electrical resistance of at least 10^6 ohms per cubic centimeter as, for example, a layer of soft conducting rubber, causes the toner particles which define the image to migrate from the surface of the xerographic drum to the surface of the print receiving web 26.

In order to remove any excess or residual xerographic toner particles that might remain on the surface of electrophotoplate 11 prior to electrically charging the incremental photoconductive insulating surface areas thereof again by the ion-producing charging unit 17, a rotating plush cleaning roller 27 is provided. This cleaning roller is positioned within a housing 28 for retaining the toner removed by the action of the roller upon the surface of photoconductive insulating layer 12. A vacuum cleaner unit (not shown) may also be utilized within the housing 28 in order to remove the residual xerographic toner which is accumulated therein.

As stated previously, the positive electrical potential that is applied to transfer roller 22 will cause the developed toner image on the surface of xerographic drum 10 to be transferred from said surface to a print receiving web 26, such as paper for example. As is shown, the said web is advanced at a lineal speed equal to the peripheral speed of xerographic drum 10 from a supply roll 29 to a take-up roll 31, via the transfer station whereat roller 22 is located and a toner image fixing apparatus represented by block 32, which apparatus within block 32 is shown in detail in Fig. 2.

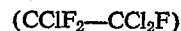
Developed image fixing apparatus

Developed electroscopic toner images may be fixed to a print receiving material, such as paper web 26 for example, by heat fixing as is shown and described in Carlson Patent No. 2,357,809, by pressure fixing as is shown and described in afore-mentioned copending Hix et al. patent application Serial No. 419,392, and by toner solvent vapor fixing as is shown and described in copending U.S. patent application Serial No. 401,285, filed by R. W. Greaves on December 30, 1953, and now Patent No. 2,726,166. Each of these methods of fixing toner images onto the print receiving material produces

a permanent imprint on the said print receiving material of the matter reproduced by the xerographic printing process as afore-described. Depending on the type of fixing used, and in the case of solvent fixing, depending on the type and rate of solvent action characteristic of a solvent and the period of time that solvent action is permitted to occur, a toner image may be fixed to practically any degree of resistance to smudging and erasure. As may be expected, the range of fixing goes from a toner image of no adhesion of the toner particles to the surface of the print receiving material to a toner image which actually penetrates the said material so deeply that the said image is visible on the reverse side thereof. The degree of fixing desired in general is one at which no smearing occurs and it requires a prolonged erasure with print receiving material wear to weaken the fixed toner image. Needless to say, this is an extremely safe degree of fixing inasmuch as an alteration of the fixed toner image would not go unnoticed.

The third afore-mentioned method of fixing the developed toner image, i.e., solvent vapor fixing, and the one to which the present invention particularly pertains, is to expose the unfixed toner image which is supported by the print receiving web to the vapor of a material which is a solvent for at least one constituent of the electroscopic toner, if not for all constituents thereof. This serves to dissolve enough of the electroscopic toner so that a solution or suspension thereof penetrates into the fibers of the print receiving web so as to fix the image indelibly into the said web. It might be mentioned here that this method of fixing has the advantage over heat and pressure fixing in that it neither changes the dimensions of the print receiving material nor materially affects the moisture content thereof, to thereby avoid warping and curling of the said print receiving material.

In order to secure the desired fixing results by way of vapor fixing, e.g., by way of the vapor of trichloromonofluoro-methane (CCl_3F) for example, it is necessary that some small portion of the vapor be condensed on or in the immediate vicinity of the toner to be fixed. That is, the vapor per se of the toner solvent does not appear to be effective to secure the desired toner fixing results. In order to produce this result, it is necessary that heat be extracted from the print receiving material at about the time it is exposed to the solvent vapor, or immediately in advance of this time, so that the temperature of the print receiving material and the toner image when exposed to the solvent vapor will be somewhat less than the boiling point of the solvent used at the ambient pressure. It would be well to point out here that it is not always necessary, and in fact at times it is not desirable, to liquify some electroscopic toner solvents, such as trifluorotrichloroethane



for example, to obtain the best toner image fixing results, due to the particular characteristics of the said solvents. Thus, of course, it would be unnecessary to have a cooling chamber to drop the temperature of the print receiving material to a value less than the boiling point of the solvent used at the ambient pressure.

From the foregoing, it should be clear that whatever quantity of solvent vapor is used on the exposed surface of the print receiving material as distinguished from the amount of solvent vapor used directly with the toner image, the first said quantity is wasted because it is not effective for toner fixing. That is, only enough vapor solvent need be used so that there be a sufficient amount of the same condensed on or in the immediate vicinity of the electroscopic toner to be fixed. Accordingly, none need be used on the exposed surface of the print receiving material. The method and apparatus by which this highly efficient and most desirable way of toner image-solvent vapor fixing is accomplished by the present invention, will now be described in detail.

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Referring to Fig. 2, a print receiving web 26 of poor conducting paper, for example, as in fact is most paper used for such continuous-operation printing, having an unfixed toner image 33 thereon, is advanced from the realm of transfer roller 22 (see also Fig. 1) past a negative corona ion-producing unit 34 which is also similar to unit 17. Said unit 34 may be controlled to cause a negative electrical charge of 30 to 90 volts to be placed on the unfixed toner image 33 as well as on the exposed surface of paper web 26. In view of the fact that the electroscopic toner material is an extremely good insulator whereas the print receiving paper web is a poor conductor but has relatively low resistivity in comparison to the toner material, the negative charge imparted to the exposed surface of web 26 will be lost very rapidly. Especially is this true when the paper web is grounded electrically via roller 36 which is provided to aid in the discharging of the said web. Hence, as the toner image 33 approaches the toner image-solvent fixing station 37, only the non-conductive toner image 33 will remain charged negatively. It should be brought out here that the toner image 33 along with the exposed surface portions of paper web 26, can be charged negatively by the use of charging roller 60 (Fig. 3) which is similar to transfer roller 22.

The station 37 (Fig. 2) includes a chamber 38 for storing the electroscopic toner solvent which can be trichloro-monofluoro-methane (CCl_3F), for example. This chlorine-fluorine-carbon compound has a boiling point at atmospheric pressure of about 74.7° F., and is eminently suitable for fixing electroscopic toner images. Within the chamber 38 is also a solvent vapor which is preferably generated by boiling the aforesaid solvent. The heating may be conventionally effected by providing a suitable heating element 39 in heat transferring relationship with the bottom of the chamber 38. The solvent vapor generated in chamber 38 by boiling the liquid solvent therein, is permitted to escape from within said chamber to a second, but unenclosed, chamber 41 via a spray producing nozzle 42 of conventional design. Included as a part of said nozzle 42 is a means (not shown) for varying the size of the nozzle orifice so as to control the amount of solvent vapor passing therethrough. In the immediate vicinity of the orifice in nozzle 42, are one or more positively charged wires 43 for electrifying or charging the toner solvent vapor particles. These wires 43 may be replaced by a grid-like structure which is also positively charged for electrifying said vapor particles.

A still another method of generating charged vapor particles includes "induction charging"; i.e., a method which depends upon the generation of vapor particles or liquid droplets by a compressed air spray gun and placing a charge upon the particles electrostatically by means of induction. This may be accomplished, for example, by spraying the vapor particles through an electrified metal ring. To obtain positively charged particles, the spray gun may be charged to 15,000 volts positive, for example, whereas the metal ring may be connected to ground potential.

As a result of the toner image-solvent vapor being sprayed by nozzle 42 around and past wires 43, the cloud of vapor particles in unenclosed chamber 41 has a positive electrical charge imparted thereto.

As the negatively charged unfixed toner image 33 is moved into and through chamber 41, the cooling of paper web 26 takes place simultaneously with the exposure of the negatively charged toner image to the positively charged cloud of solvent vapor particles. The cooling body 44 is preferably formed of good heat conducting metal, such as copper for example, and is provided with intake and outlet conduits for the supply and removal of a coolant fluid, such as cooled brine for example. By connecting body 44 to ground potential as shown, the roller 36 may be eliminated. Thus, the

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cooling and discharging functions will occur simultaneously. What is believed to occur when web 26 is moved over cooling body 44, is that web 26 is cooled by conduction from the body 44 to a temperature somewhat less than the boiling point of the toner solvent material in chamber 38. When, therefore, the web carrying the unfixed toner image 33 passes into and then through the unenclosed chamber 41, the positively charged solvent vapor particles are attracted to, and then condensed on, the negatively charged toner image which is cooled to an extent such that the toner solvent is liquified sufficiently in amount to effect the solution of some one or more constituents of the electroscopic toner. The solution so formed is believed to run into the paper web and between the fibers thereof to create a permanent image that is indelibly carried by the web. Thus, when the paper web is moved beyond fixing station 37, the toner image 33 thereon will be permanently affixed thereto.

It has been proved by actual doing that the fixing of electroscopic toner images can be prevented, or suppressed as the case may be, by charging the solvent vapor particles negatively. This may be done by connecting wires 43 (Fig. 2) to a negative voltage source. In the case of "induction charging," the metal ring should be connected to a positive voltage source and the spray gun grounded. Thus, if the wires 43 as represented collectively by broken line block 35, are each connected to positive voltage source 40 via manually operable switch 45, the highly improved method of electroscopic toner image fixing will take place. If the said wires are connected to negative voltage source 50, fixing thereof will not occur.

In order to improve the operation and efficiency of the toner image fixing apparatus even more, a solvent recovery station 46 is located adjacent fixing station 37 so that immediately after the toner image 33 is fixed, the said fixed image will be advanced through the solvent recovery station 46 on its way to being wound on take-up roll 31. The advantages of recovering as much solvent as possible are many, among which are the following:

- (1) A reduction of operation expense through lower solvent consumption.
- (2) Minimizing possible atmospheric contamination of machine parts which may be chemically attacked by the toner solvent evaporating after fixing from the toner image and the web surface.
- (3) Protecting the health and safety of operating personnel.

The said recovery station 46 includes a heating body 47 having conduits therein for passing a heated fluid therethrough. The heating body is preferably made of metal, such as copper for example, for effecting good heat conduction from the body 47 to the paper web 26. Thus, whatever liquid solvent may still be within the fibers of paper web 26 after the fixing process, is caused to vaporize once again due to the heating thereof by body 47. The vapor is captured within an unenclosed, baffle-like chamber 48 which is connected by suitable air conducting means to a blower 49. This blower which is continuously operating, sucks air in from chamber 48 and forces it out through an opening 51 whereat a plurality of cooling coils 52 are located. Hence, whatever solvent vapor is present in chamber 48 due to the expulsion of said vapor from paper web 26 by the heating thereof, is carried by the air currents created by blower 49 past the cooling coils 52, and is condensed almost immediately into toner solvent liquid droplets by the cooling coils 52. Those solvent droplets which form, drop into the reservoir 53. The liquid solvent in reservoir 53 is then subsequently reused for toner fixing purposes in station 37.

While there have been shown and described and pointed out the fundamental novel features of the invention as applied to a preferred embodiment, it will be understood

that various omissions and 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. It is the intention, therefore, to be limited only as indicated by the scope of the following claims.

What is claimed is:

1. In an electrographic printer of the class described, the combination of apparatus for fixing an electroscopic toner image onto a poorly conductive record sheet comprising ion-producing means for electrically charging said electroscopic toner image and said record sheet negative, heat producing means for boiling liquid toner solvent trichloro-monofluoro-methane so as to form a cloud of toner solvent vapor particles thereof, means for charging said cloud of vapor particles positive, a toner image fixing station including an electrically conductive cooling body for abstracting heat from said toner image and said record sheet so as to lower the temperature thereof below the boiling point of said solvent, means for electrically connecting said cooling body to ground potential, means for directing said positively charged cloud of solvent vapor particles to said fixing station, and means for moving said record sheet from said ion-producing means to said fixing station whereat said record sheet is supported by said electrically grounded cooling body to thereby electrically discharge said record sheet, whereupon positively charged vapor particles from said cloud thereof are attracted to and condensed on said cooled negatively charged toner image.

2. A printer according to claim 1 additionally comprising a solvent recovery station having a heating body for supporting and heating said paper sheet and said toner solvent captured therein when said toner image is fixed thereto, to a temperature above the boiling point of said solvent; an unenclosed baffle-like chamber over said supported paper sheet for collecting the vapor of said toner solvent captured in said paper sheet when said toner image is fixed; cooling means for condensing said solvent vapor; air transport means for directing to said cooling means said vapor boiled out of said paper sheet; and a reservoir for collecting said condensed vapor in the form of a liquid solvent.

3. In an electrographic printer of the class described, the combination of an apparatus for permanently affixing an electroscopic toner image onto a paper sheet com-

prising means for electrically charging said electroscopic toner image and said paper sheet negative, means for forming a cloud of toner solvent vapor particles, means for charging vapor particles within said cloud positive, a toner image fixing station including an electrically conductive cooling body for abstracting heat from said toner image and said paper sheet to reduce the temperature thereof below the boiling point of said solvent to condense the vapor particles, means for discharging the negative charge applied to said paper sheet, means for directing the positively charged solvent vapor particles within said cloud to said fixing station, and means for moving said paper sheet from said negative charging means past said discharging means and to said fixing station where said paper sheet is supported by said cooling body so that positively charged vapor particles within said cloud are attracted to and condensed on said toner image.

4. In an electrographic printer of the class described, the combination of an apparatus for permanently affixing an electroscopic toner image onto a paper sheet comprising means for electrically charging said electroscopic toner image and said paper sheet negative, means for forming a cloud of toner solvent vapor particles, means for charging vapor particles within said cloud positive, a toner image fixing station including an electrically conductive cooling body for abstracting heat from said toner image and said paper sheet to reduce the temperature of said image below the boiling point of said solvent to condense the vapor particles, means for electrically connecting said cooling body to ground potential, means for directing the positively charged solvent vapor particles within said cloud to said fixing station, and means for moving said paper sheet from said negative charging means to said fixing station where said paper is supported by said cooling body so that said negative charge is conducted from said paper sheet and said positively charged vapor particles within said cloud are attracted to and condensed on said toner image.

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