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METHOD FOR FIXING XEROGRAPHIC PRINTS

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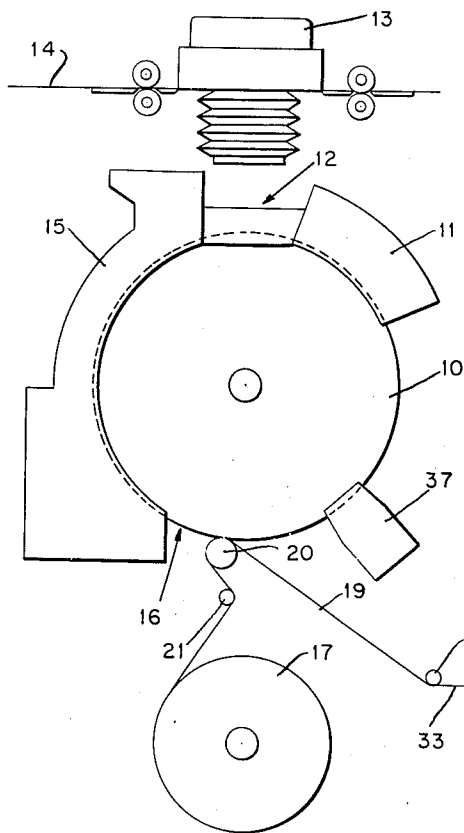


FIG. 1

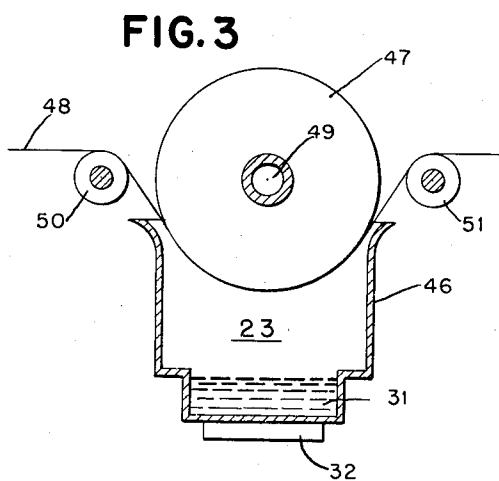


FIG. 3

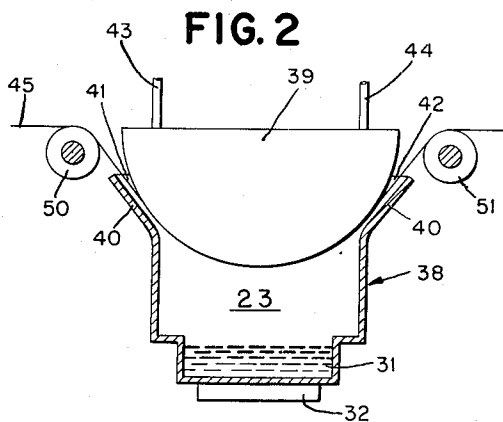


FIG. 2

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METHOD FOR FIXING XEROGRAPHIC PRINTS

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1 Claim. (Cl. 117—21)

The present invention relates to a method and an apparatus for fixing xerographic prints and more particularly for fixing electroscopic powder images formed of electroscopic powder, or as it is sometimes called, xerographic toner, by so-called solvent fixing.

Xerographic reproduction of typewriting, printing, pictures, line drawings, etc., was broadly disclosed in the Carlson Patent No. 2,297,691, and in a more or less automatic form, in Patent No. 2,551,582. The present invention relates to one step only of this general process.

In order to acquaint the reader with the process as a whole, it may be briefly summarized as follows. A plate of some electric conductive material as metal of any suitable character is first coated with a suitable photo-conductor, i. e. a material which possesses the inherent tendency of being electrically conductive only when exposed to light. Among such chemicals or materials which are known to the prior art are anthracene and selenium. There are others which have similar properties. The coated metal plate is first provided with a suitable electrostatic charge, such as a positive charge, by any desired means, including, for example, by friction or by being exposed to electron emissions from suitable heated filaments energized by a high voltage source. The plate, thus charged while being held in the dark, is next exposed in any of the ways that a conventional photographic plate may be exposed. Wherever light strikes the charged plate, the surface coating thereon becomes conductive, so as to permit the electrostatic charge to be conducted to the metal portion of the plate and dissipated. Wherever light does not strike the charged plate, the electrostatic charge remains upon the coating so as to produce on the exposed plate what is termed a latent electrostatic image.

This image is then developed by bringing into contact therewith an electroscopic powder or xerographic toner, as it is sometimes called. This powder which may have different compositions, is a very fine powder, usually made up as a resin base material, and sometimes including more or less of material which is in the class of a plasticizer for the resin. It also usually contains some one or more color-imparting materials such, for example, as dyes or pigments. The present invention is not particularly concerned with the composition of the electroscopic powder or xerographic toner per se; but any commercially available material of this kind, and there are several, may be used in accordance with this invention.

The xerographic toner may be negatively charged in respect to the image charge on the plate and is attracted to those portions only of the plate. The balance of the powder flows by gravity or is shaken off the plate. This produces what is sometimes termed an electroscopic powder image or as it is sometimes called a developed plate, which, as will be understood from the foregoing, is not fixed, but which may be mechanically removed, for example, by wiping a finger across it.

The electroscopic powder image is then transferred onto paper which may be either single sheets or a continuous

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web or any other desired form, this transfer being effected in part mechanically by bringing the paper physically against the plates carrying the powder image and in part electrically by having a substantial potential exerted across between the metal portion of the plate and the opposite side of the paper which is held against the image-carrying surface of the plate. Upon separation of the paper from the plate, there is an adequate amount of the powder adhering to the paper so that the image may clearly be seen. On the other hand, this powder still is but loosely adhering to the paper and may be easily wiped off it.

The next necessary step and the one to which the present invention particularly pertains, is to fix the powder onto or into the paper so as to make a permanent print on the paper of the matter reproduced as aforesaid. This may be done in any of several ways. For example, it has been proposed to put the paper carrying the powder image through a pair of calender rolls and physically to press the powder into the paper. This is effective for some purposes, although it may require the use of such high pressure that the physical dimensions of the paper are somewhat altered. Where this alteration is not material, this method of fixing may be found adequate.

A second method of fixing which is known is by exposing the paper carrying the powder image to heat of a sufficient intensity to fuse at least one element of the powder, so as to cause this element to carry enough of the powder into the paper as a molten material to fix the image on the paper. For this purpose, the powder image is exposed to some heat source, usually only for a few seconds, so as to fuse a part or all of the powder. Again, while this scheme is quite adequate in many instances, the heat required may in some cases dry out so much of the moisture normally present in the paper as to cause it to curl or warp.

A third method of fixing the powder image and the one to which the present invention particularly pertains, is to expose the unfixed powder image to the vapor of a material which is a solvent for at least one constituent of the powder, if not for all constituents thereof. This serves to dissolve enough of the powder so that the solution thereof penetrates into the fibers of the paper and fixes the image indelibly in the paper. This plan has the advantage that it neither changes the dimensions of the paper, nor materially affects the moisture content thereof. This prevents warping or curling.

If the process is to be carried on in plants having numbers of people around and particularly where the operating personnel are not highly skilled, it is practically necessary that the solvent used be one which is non-combustible, so as to avoid fire hazards, and also have very low toxicity so as to assure the safety of the personnel nearby. This obviously precludes the use of most of the common organic solvent. It was found, however, that some of the compounds of carbon with chlorine and/or fluorine, such as have been used from time to time in refrigeration, are quite satisfactory for the present purposes. This will appear in greater detail hereinafter.

An essential element of the present invention, however, was the discovery that the vapor per se of the solvent does not appear to be effective to secure the desired results, but that to get such desired results, it seems necessary that some small portion at least of the vapor be condensed on or in the immediate vicinity of the powder to be fixed. In order to effect this result, and particularly as many of the solvent materials contemplated for use in accordance with the present invention have a boiling point in the order of magnitude of expected room temperatures at a place where the process might be carried on, it is practically necessary in accordance with the present invention that heat be abstracted from the paper at about the time it is exposed to the

solvent vapor or immediately in advance of this time, so that the temperature of the paper when exposed to the solvent vapor will be somewhat less than the boiling point of the solvent used at the ambient pressure. The present invention, therefore, provides positive cooling means or heat abstracting means for use either immediately in advance of the place where the paper is exposed to solvent vapor or simultaneously with such exposure.

One of the outstanding advantages of the present invention is its adaptability to automatic machine operation. In such an operation, it is necessary that the vapor be supplied in the vapor chamber at a relatively rapid rate and, further, that there be adequate temperature difference to effect condensing of a sufficient amount of the vapor so as to fix the xerographic toner onto the paper, also at a rate commensurate with that desired for the machine operation. Both of these objects are attained by apparatus embodying the present invention.

From the foregoing, the objects of the present invention are apparent, i. e. to provide a method and suitable apparatus for the fixing of xerographic powder images by solvent vapor exposure, without introducing any change in the dimensions of the paper being used or any substantial change in the moisture content thereof. Other more detailed objects of the present invention will become apparent from the following detailed description of certain preferred embodiments thereof and from the illustrations in the accompanying drawings, in which:

Figure 1 is a diagrammatic view of a continuous xerographic printing apparatus including solvent vapor fixing means in accordance with the present invention, the cooling of the paper occurring in advance of the exposure of the unfixed powder image to the solvent vapor;

Fig. 2 is a detailed view, similar to a portion of Fig. 1, showing simultaneous cooling of the paper and exposure of the powder image to solvent vapor, the cooling means being stationary; and

Fig. 3 is a detailed view, similar to Fig. 2, showing a further modification of the invention in which the cooling means comprises a rotatable drum forming one boundary of the chamber containing the solvent vapor.

Referring now to the accompanying drawings and particularly to Fig. 1 thereof, there is illustrated diagrammatically a substantially continuously operable apparatus for making xerographic prints. This apparatus includes a drum 10 which is arranged to rotate at a predetermined speed and in a counter-clockwise direction, as seen in the figure. The drum 10 may be continuously coated or may carry on its periphery a plurality of plates corresponding to the plate previously described, i. e. each having a metal base covered with a coating of a suitable photo-sensitive material as aforesaid. The coated plates are moved by the rotation of the drum beneath a hood structure 11 in which is located one or more suitable wires or filaments capable of emitting a corona discharge, so as to charge the surface of the coating on the plates with a suitable static charge. Inasmuch as this subject matter is now well known in the art and is only illustrated diagrammatically and generally described to familiarize the reader with the whole process, it is not shown, nor will it be described, in greater detail. As the plates move from beneath the hood 11, in which they are charged in a zone which is otherwise dark, to the area generally indicated at 12, they are moved to the place where they are exposed in a manner similar to the exposing of a photographic plate. In the present instance, the exposure may be by light transmitted from a source within a housing 13 through a transparency 14, which is the master to be copied or reproduced. Alternatively, the exposure may be to light reflected from the master or in any of the ways in which photographic plates are conventionally exposed. All this is generally described in the Carlson Patent No. 2,297,691 above referred to (see Figs. 1, 2, 2a and 2b thereof and the associated description).

Subsequent to the exposing of the plate, which forms a latent electrostatic image as aforesaid, the plates are carried again beneath a light-protecting hood 15 in which a developing powder is cascaded across the plates in a manner which is now well known in the art and which is not therefore illustrated or further described in detail. The powder may conventionally be carried by minute glass beads serving as a carrier therefor. This is also well known in the art.

As the plates emerge from beneath the hood 15, at about the zone indicated at 16, the electroscopic powder or xerographic toner image is complete thereon. The next step is to transfer this image onto paper. In the present instance, the paper is shown as a continuous web which is supplied as a supply roll 17. The apparatus is also provided with a suitable take-up roll 18 which may be driven in a conventional manner (not shown) to cause the paper to move from the supply roll through the predetermined path therefor, later to be described, and to the take-up roll. The predetermined path for the paper 19 is defined by a plurality of guide means, such as roll means, as shown. In instances where the rollers may contact the surface of the paper 19 bearing the electroscopic image, the roll means comprises a pair of rollers which are narrow in an axial direction and which engage the edge portions only of the strip of paper.

The transferring of the powder image from the plates onto the paper 19 is effected by passing the paper around a roller 20 which presses it lightly against the plates on the periphery of the drum 10. Between the roller 20, which may be of a conductive rubber composition, and the drum 10, there is preferably impressed a static electrical charge of substantial voltage, for example, 1,000 volts. This static charge in conjunction with the physical contact between the paper and the powder causes a sufficient amount of the powder to be transferred onto the paper 19, so that the paper may be said to bear an electroscopic powder image following its passage around the roller 20. The paper is guided by a guide roll 21, which may engage the entire width of the paper as the powder image is not yet placed thereon, and a roll means 22, which engage only the marginal edge portions of the paper so as not to affect or contact the powder image.

After the plates have passed in contact with the paper adjacent to roll 20, they are moved under a cleaner unit generally indicated at 37, which cleans off any remaining powder from the plates, so that they may immediately be recharged and used again.

During its course from the place where the powder image is transferred thereto as aforesaid to the take-up roll, the paper is passed through a chamber 23 defined by a box-like structure and having suitable roll means 24, 25, 26 and 27 mounted therein for guiding the paper as shown. The paper passes into and out of the structure forming the chamber 23 through narrow slots illustrated at 28 and 29. The paper then passes around an additional idler roller 30 which may now engage the entire width of the paper as the powder image has at this stage of the travel of the paper been fixed thereto, so that no further damage thereto will ensue.

Within the chamber 23 is a solvent vapor which is preferably generated by boiling a suitable solvent contained in a sump portion 31 by supplying heat to the liquid in this portion. This heating may be conventionally effected by providing a suitable heating element 32 in heat transferring relationship with the bottom of the sump portion 31.

The solvent vapor used in accordance with the present invention may be any material which is preferably non-combustible and relatively non-toxic as aforesaid, and which must be a solvent for at least one constituent of the electroscopic powder or xerographic toner of which the powder image is composed. As stated hereinabove, it has been found in accordance with the present invention that vapor per se is not effective rapidly and on a com-

mercial machine basis to dissolve one or more elements or constituents of the powder; but rather that such solution occurs apparently upon the condensation of small amounts of the liquid vapor immediately at the place where the powder is located. As such, therefore, it is preferred that the paper at the time of exposure to the solvent shall have a temperature somewhat less than the boiling temperature of the solvent material used at the ambient pressure, i. e., at the pressure existing within the chamber 23.

It has been found that some of the chlorine-fluorine-carbon compounds, such as trichloro-monofluoromethane (CCl_3F), having a boiling point at atmospheric pressure of about 74.7°F ., is eminently suitable for this purpose. It has also been found that other similar compounds are operative and may in some instances be desired. Among these other operative compounds are trichloro-trifluoro ethane ($\text{CCl}_2\text{F}\cdot\text{CClF}_2$) and methylene chloride (CH_2Cl_2), although the latter is somewhat toxic. Other solvents for one or more of the constituents of the electroscopic powder used may also be operative, it being preferred, however, that they shall comply with the requirements herein set up, that is, that the combustibility and toxicity be minimized and that they shall have a boiling point not too high in respect to room temperature, while being condensable at a temperature at which it is reasonably possible to maintain the paper on entering or during its passage through the solvent vapor zone.

In the embodiment of the invention shown in Fig. 1, the paper is cooled by heat abstraction means prior to its entry into the chamber 23, i. e., the solvent vapor zone aforesaid. For this purpose, the under surface of the paper 19 as it passes through a horizontal portion 33 of its predetermined path is exposed to a plate 34 which is cooled as hereinafter more particularly set forth. The cooling in the embodiments of the invention shown on all figures of the drawings is effected by heat conduction from the paper to a plate, preferably of metal, with which the paper is in contact for a time during which cooling is desired. It is contemplated, however, that any type of cooling means effective to cool the paper during its exposure to the solvent vapor or immediately in advance of this time will be effective to carry out the method of the present invention and to constitute the apparatus embodiments thereof. Heat may be transferred, of course, either by convection or radiation as well as by conduction, as shown in the drawings, and such other methods are contemplated as alternatives or equivalents of the conduction means and method particularly herein illustrated and described.

In order to cool the plate 34, a cooling fluid may be passed through suitable conduits, as illustrated at 35, in heat transfer relation with the plate 34. Again and alternatively, any desired method of temperature control for the plate 34 may be used. As shown, a cooling fluid, for example, refrigerated brine, may be circulated through suitable conduits as at 35. Other means for abstracting heat and which would be considered equivalent to the arrangement herein described from the point of view of those familiar with refrigeration techniques should be considered as equivalents thereto from the point of view of the present application. There is illustrated diagrammatically at 36 a means by which the cooling fluid may be itself cooled and may be caused to circulate through the conduits 35 in heat transferring relation to the plate 34.

What is believed to occur is that the paper 19 is cooled by conduction from the plate 34 during its passage across and in contact with that plate and to a temperature somewhat less than the boiling point of the solvent material in the sump 31 in the bottom portion of the chamber 23. When, therefore, the paper carrying the unfixed powder image passes into and through the chamber 23, the solvent vapor is condensed to a small but necessary extent immediately at the powder forming the image. This condensed vapor which is so

small in amount that droplets thereof cannot even be seen by the naked eye, is yet in a liquid state and is sufficient in amount to effect the solution of some one or more constituents of the powder, so that the solution so formed may run into the paper itself, between the fibers thereof and create a permanent image indelibly carried by the paper. Thus, when the paper is wound on the take-up roll 18, the powder image will be a permanent part thereof as has been proven by actual tests.

As an example of an actual test employing an apparatus substantially as diagrammatically illustrated in Fig. 1 and hereinabove described, the following may be given. The ambient conditions on the day of the test were that there was a dry bulb temperature in the room of 85°F . and a wet bulb temperature of 75°F ., with a relative humidity of 63.5%. The paper being used was white tabulating card stock. The electroscopic powder or toner used was known as "BXT-75," which is a commercial product made for this purpose by The Haloid Company of Rochester, New York. The solvent used was trichloro-monofluoro-methane having a density of 92.32 pounds per cubic foot and a boiling point (at atmospheric pressure) of 74.7°F . The cooling fluid circulated through the conduits 35 had a temperature of -15°C . The linear speed of the paper was 600 inches per minute. The cooling time, i. e., the time of the paper in contact with the plate 34 was 1.3 seconds. The fixing time, i. e., the time for the paper to move through the chamber 23 was 1.84 seconds. The surface area of the solvent in the bath thereof within the sump 31 was 20.34 sq. inches. The slot openings, i. e., the width of the slots 28 and 29 was 0.0625 inch. Satisfactory results were obtained under these circumstances.

The cooling of the paper as aforesaid, need not take place prior to exposing the powder image to the solvent vapor, but may take place simultaneously therewith. In Fig. 2 is shown an embodiment of the invention in which such simultaneous cooling and exposing of the powder image to the solvent vapor is carried on. As shown in this figure, the chamber 23 for the solvent vapor is formed in a different fashion as illustrated at 38, so that the upper portion or boundary of the solvent chamber 23 in this instance is formed by a stationary semi-cylindrical body 39, which may have its plane ends in contact with side wall portions of the chamber-forming member 38 and which has its semi-cylindrical surface spaced from upwardly inclined portions 40 of the chamber-forming member 38 to provide inlet and outlet slots 41 and 42, respectively. The body 39 is preferably formed hollow and of good heat conducting metal, such as copper, and is provided with intake and outlet conduits 43 and 44 for the supply and removal of a coolant fluid, such as cooled brine or a refrigerant, in a conventional manner. It will be seen in this form of the invention that the rear surface of a paper web 45 passes in wiping contact with the cylindrical surface of the body 39, while the lower surface of the web 45 carries the powder image to be fixed by exposure to the solvent vapor simultaneously with the cooling of the paper.

In Fig. 3 of the drawings is shown a further modified form of the invention, wherein a body 46 provides a solvent chamber 23 having a sump 31 and an electric heater as described for the form of Fig. 1. Cooperating with the body 46 is a cylindrical hollow member 47 equivalent to the body 39, except that it is mounted for rotation about its axis, so that the paper web, shown in this instance at 48, does not have any relative movement in respect to the cylindrical surface of the member 47, but rather is moved as this member rotates. The coolant in this instance may be supplied to and removed from the interior of the member 47 through axial openings, one of which is indicated at 49. With these exceptions the operation of the device of Fig. 3 is substantially the same as that of

Fig. 2. As will now be obvious, the surface of the paper carrying the powder image is downwardly directed as seen in both Figs. 2 and 3, while the opposite surface is cooled by contact with the stationary semi-cylindrical body 39 of Fig. 2 or with the rotatable cylindrical member 47 of Fig. 3, as the case may be. In both Figs. 2 and 3 the paper web is guided into and out of the solvent vapor chamber 23 by roll means 50 and 51 which engage the marginal portions only of the paper web 45 or 48.

While there is herein described but a few of the possible embodiments of the invention and while the principles by which equivalencies may be determined have been pointed out, many equivalents other than those particularly referred to herein will occur to those skilled in the art from the foregoing description. I do not wish to be limited, therefore, except by the scope of the appended claim, which is to be constructed validly as broadly as the state of the prior art permits.

I claim:

The process of continuously fixing xerographic prints on paper having an unfixed electroscopic powder image thereon without at the same time undesirable affecting the physical characteristics of the paper, comprising the steps of continuously moving the paper carrying the electroscopic powder image in a predetermined path including a

portion extending into and through a substantially closed zone, supplying in said closed zone for contact with the paper aforesaid the vapor of trichloro-monofluoro-methane (CCl_3F), which is a solvent for at least one constituent of the electroscopic powder of which said image is formed, positively abstracting heat from said paper in a portion of its path of travel adjacent to said zone by contacting the surface of said paper opposite that carrying the powder image with a heat conducting surface, so as to cool said paper by conduction to a temperature less than the boiling point of said trichloro-monofluoro-methane at the ambient pressure within said zone and thereby to condense some of said vapor onto said paper and said image thereon while in said zone, the contact of said paper with the heat conducting surface occurring during movement of said paper through at least a portion of said path up to and including that portion within said zone, positively cooling said heat conducting surface by passing a cooling fluid in heat-transferring relation therewith, and positively cooling said cooling fluid by the use of refrigerating apparatus.

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