Dec. 3, 1963 S. TEISER ETAL 3,113,003

APPARATUS FOR MOISTURE CONTACT OF ELECTROPHOTOGRAPHIC SHEET

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Fig. 1

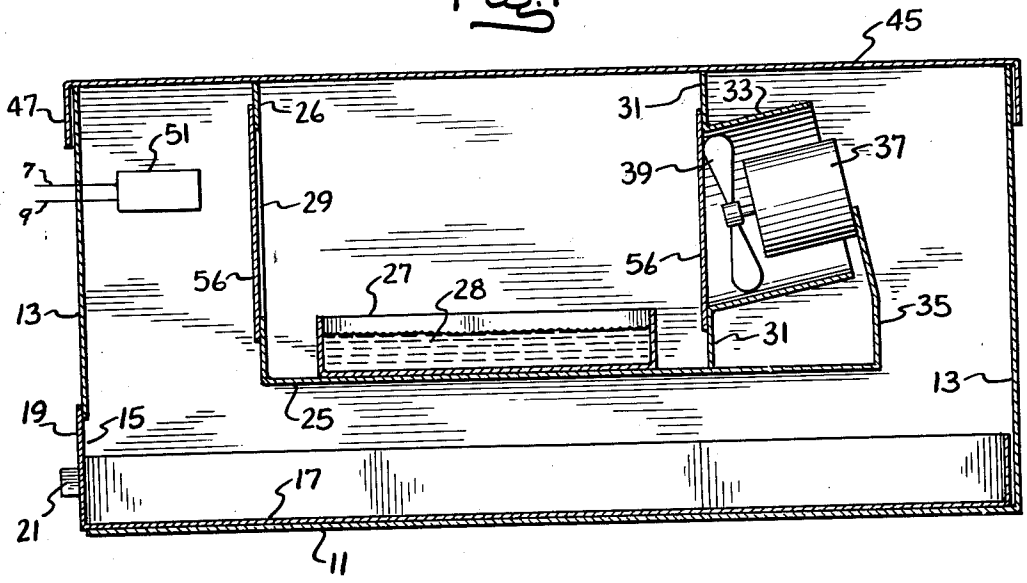
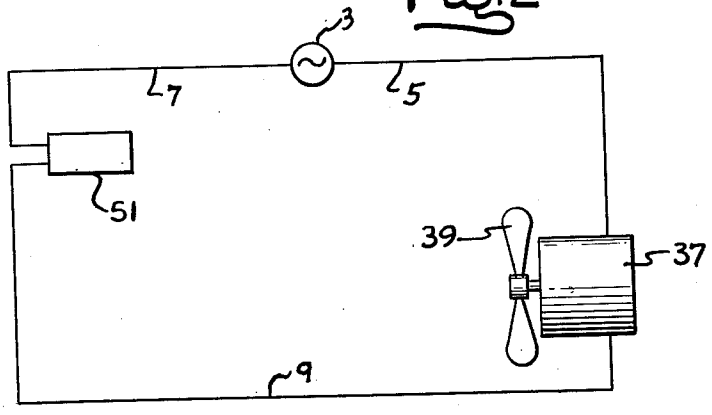


Fig. 2



INVENTORS
SIDNEY TEISER
WALTER R. SASSAMAN
BY
ATTY.

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APPARATUS FOR MOISTURE CONTACT OF ELECTROPHOTOGRAPHIC SHEET

Sidney Teiser and Walter R. Sassaman, Rochester, N.Y., assignors, by mesne assignments, to Magnefax Corporation, Philadelphia, Pa., a corporation of Pennsylvania

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This invention relates to electrostatic reproduction, using a photoconductive layer or coating on a suitable base of sheet material, such as paper, having a substantial dielectric strength or insulating value. The coated sheet material (e.g., paper coated with the photoconductive substance) is already known in the art. The utilization of such material in making a reproduction of an original, either by contact exposure or by projection exposure, is also known in the art.

The prior practice has normally included four steps performed by the user or consumer, in making a reproduction of an original. (The term "original" means any suitable article of which a copy is to be made, such as, for example, a drawing, a typewritten or hardwritten letter, or a photograph.) These steps are as follows:

First, the photoconductive coating on the sheet is charged to a relatively high electrostatic potential (anywhere from about one hundred to several thousand volts, depending upon the particular apparatus used) over its entire photoconductive surface, or at least the area which is to be exposed, while in the camera or other suitable dark chamber.

Second, the charged coating is exposed to light in a pattern corresponding to the light and dark areas of the "original" article to be copied, either by familiar "contact" printing technique or, more usually, by "projection" printing technique, well known in the art. During this exposure steps, the electrostatic charge leaks off of the exposed area of the photoconductive coating in a differential manner, proportional to the amount of light falling on each portion of the exposed area, so that a differential amount or pattern of electrostatic charge remains on the photoconductive layer or coating at the conclusion of the exposure.

Third, the differential electrostatic pattern remaining on the photoconductive layer at the conclusion of the exposure step, is developed, or "toned" as it is sometimes called, by variou techniques known per se, usually involving the application to the photoconductive layer of a toner or dye, carried by a suitable carrier or vehicle, such as a mass of iron filings, the iron filings forming a convenient carrier for the toner or dye because they can be applied to the sheet by magnetic means. The toner or dye is retained differentially on the photoconductive material, in accordance with the differential electrostatic charge thereon. Thus the differential electrostatic pattern is made visible.

Fourth, the visible image produced on the photoconductive coating by the toner or dye is fixed or fused or made permanent, either on the original photoconductive surface or on any other surface to which the toner or dye may be transferred, in any of various fixing ways known per se in the art, as for example by application of heat, or by application of chemical vapors or fumes.

When reproductions have been made according to the prior art, carrying out the four steps above mentioned, it is found that surprisingly erratic and unpredictable and unacceptable results have been obtained in many cases, even when each of these four steps has been carefully performed according to the best available technique. For example, it is frequently found that blurred spots or blotches, or even completely blank spots or blotches, occur on various areas in an irregular and unpredictable pattern. Sometimes most of the area of the copy sheet will carry a perfectly satisfactory and legible reproduction, clear and sharp, while other areas of the sheet will have a reproduction which is too faint, or too blurred, or otherwise unsatisfactory. Sometimes the unsatisfactory copy or reproduction is characterized by unwanted "background" in areas that should remain entirely clear or white, such background or "fogging" being sometimes uniform and sometimes in a mottled or uneven pattern.

These unacceptable results are unpredictable, both with respect to their pattern on the sheet (which indicates that it is not due to any defect in the first or charging step, or in the second or exposure step) and with respect to the freshness or age of the sheet. For example, one sheet as taken out of a package of coated sheets received from the manufacturer may give a perfactly satisfactory reproduction, and another sheet taken from the same package at another time may give an unsatisfactory reproduction. Sometimes sheets taken from a fresh package of coated paper just received from the manufacturer will give unsatisfactory reproductions, but sheets taken from the same package after standing for several weeks or months may consistently give good results. Or again, sheets taken from the fresh package may give good results, whereas sheets taken from the same package after standing several weeks or months may give unsatisfactory results. The irregular or non-uniform results have naturally been most distressing to the users of copying processes of the kind mentioned, and also to the manufacturers of the supplies used in such processes. Although much work is believed to have been done on this problem by others working in this field, no satisfactory solution has previously been suggested, so far as the present applicants are aware.

The present applicants have determined that the process as previously practiced, using the four conventional steps above described, lacks a necessary fifth step or operation not heretofore recognized. An object of the present invention, therefore, is to provide the process with an additional step or condition which will overcome the above mentioned difficulties and which will enable the systematic and repetitive production of good reproductions made on coated paper of the conventional kind heretofore known, regardless of whether such paper is fresh from the manufacturer or whether it has been in storage for a considerable time, whether it is taken from a freshly opened package or from a package which has been opened for a long interval.

The studies of the present applicants indicate that the variable and erratic results achieved by the four step process above outlined, may be due at least in large part to variations in the dielectric strength or value of the sheet material which carries the photoconductive layer or coating, at the time the charging step and exposure step are performed. When the photoconductive coating is carried by a metal sheet, as in some of the known processes, the problem apparently does not exist, at least to the same degree. But when the photoconductive coating is applied to a paper sheet, the present applicants believe that it is the heretofore unrecognized variations in the dielectric strength of the paper, at the instant of charging and exposing, which are responsible for at least a substantial part of the trouble.

These differences apparently introduce another variable factor into the leakage of the electrostatic charge from the photoconductive layer or coating, as the leakage should be dependent only on the amount of light falling on each unit area of the photoconductive layer during the exposure step, independently of other factors. These differences in dielectric value are apparently the result of differences in moisture content or water vapor content of the paper or other non-metallic sheet material which carries the

photoconductive coating, such differences occuring between one sheet and another sheet, or between one area and a different area of the same sheet.

Manufacturers have in the past tried to improve the uniformity of results by attempting to control the moisture content of the sheet material at the time of coating the paper, or at the time of packaging the paper. But so far as now known to the present applicants, no attention has previously been paid to the moisture vapor content or the humidity conditioning of the coated paper sheet at the instant of charging and exposure thereof, which usually occurs long after the manufacture and packaging of the sheet.

It is therefore, another object of the present invention to provide a reproduction process comprising five steps as distinguished from the four usual steps above mentioned, the added step being the step of conditioning the coated paper sheet to a satisfactory moisture content which will give uniformly good results, immediately prior to the charging and exposure steps.

Still another object is the provision of a sheet conditioning process of such simple form that it can be carried out efficiently in conjunction with any of the various known charging and exposing processes and mechanisms, immediately prior to the conventional charging and exposing steps.

A further object is the provision of simple and inexpensive apparatus for carrying out the new conditioning step above mentioned, which now becomes the first step of a new five-step process, followed by the four steps heretofore conventionally used.

These and other desirable objects may be attained in the manner disclosed as an illustrative embodiment of the invention in the following description and in the accompanying drawings forming a part hereof, in which FIG. 1 is a diagrammatic or schematic vertical section taken centrally through sheet conditioning apparatus in accordance with one embodiment of the present invention and FIG. 2 is a schematic electrical circuit illustrating the means for a control circuit for the fan illustrated in FIG. 1.

The method of the present invention comprises the step, performed immediately prior to the conventional charging and exposing steps previously mentioned, of conditioning the sheet to give it a moisture content in the range from about 4% to about 8% of water vapor, by weight, the midpoint of about 6% of water vapor apparently giving best results.

According to another aspect of the invention, this step is best performed by placing the sheet of coated paper (that is, coated with the desired photoconductive layer) temporarily in a chamber having an atmosphere of controlled humidity, preferably in the range of about 55% to 65% relative humidity at ordinary room temperature. This paper conditioning chamber either may be built into the exposing or copying camera, as an integral part thereof, or may be a separate chamber placed alongside of or otherwise in nearby convenient relation to the copying camera.

In use, the sheet of paper is removed from the manufacturer's package (or from any other convenient box, container, or shelf in or on which it may have been stored after removal from the manufacturer's original package) and is placed in the conditioning chamber, having the relative humidity above mentioned. After remaining in this conditioning chamber for a short interval (say for example from one minute to five minutes) the sheet of paper is then removed from the conditioning chamber and placed in the camera or copying machine, and is then electrostatically charged and exposed, and subsequently developed and fixed according to the usual technique, the charging and developing steps taking place within a very brief interval after the removal of the sheet from the conditioning chamber. Preferably the charging and exposing take place within just a few seconds after removal from the conditioning chamber, or within a minute or two at the most, so that the conditioned sheet will not have had a substantial change in its moisture vapor content and will still be at or close to the optimum condition, at the time of the charging and exposing steps. Of course if the surrounding atmosphere in the room is close to the optimum condition of relative humidity, a longer delay between conditioning and charging will not matter appreciably; but if the atmosphere in the room happens to be unusually dry or unusually humid, then it is important to have the charging and exposing steps follow quickly after the conditioning of the paper, within the above mentioned interval of a few seconds to a minute or two.

It is found in practice that even when the coated sheet has been kept in an atmosphere differing very materially from the optimum conditions, nevertheless the sheet will be quickly conditioned to the desired range, if it remains in the conditioning chamber as above described for an interval even as short as four or five minutes. When the sheet is already not far from optimum condition, the interval in the conditioning chamber may be even shorter, for example, one minute. As already indicated, the conditioning chamber, if not actually built into the camera or exposing apparatus, is nevertheless placed relatively close to it, so that in normal manual handling at normal routine speed, only a few seconds will elapse between taking the sheet out of the conditioning chamber and placing it in charging and exposing position in the camera. The camera or exposing apparatus may take many forms, the details of which are unimportant for purposes of the present invention. For example, the exposing apparatus may be in the form disclosed in our application Serial No. 724,946, filed March 31, 1958.

In the above description, it has been mentioned that "a sheet" of coated paper or the like is taken from the manufacturer's package or other place of previous storage, and placed within the conditioning chamber, to condition it ready for use in the charging and exposing apparatus. However, it must be understood that it is not necessary to place a single sheet at a time in the conditioning chamber. A considerable number of sheets, say 50 or 100 for example, may be placed in the conditioning chamber at a time, and then may be withdrawn one by one as needed for charging and exposing, to make reproductions.

The conditioning chamber itself may take many forms. One simple form thereof is illustrated diagrammatically or schematically. It comprises a stationary sheet metal box rectangular in plan, having a bottom wall **11** and side walls **13** rising from all four sides, there being an opening **15** in the lower part of the front wall, through which a drawer or tray **17** may be slid horizontally forwardly and rearwardly. When the drawer is closed, the front wall **19** of the drawer tightly closes the opening **15** so that the box is substantially sealed. A handle **21** on the front wall of the drawer enables it to be pulled forwardly to open it.

Extending across the interior of the box, a little above the top edge of the tray **17**, there is a horizontal shelf **25** on which a small container **27** of water **28** is placed. At the front edge of the shelf **25** a vertical partition **26** rises to the top edge of the box, and contains a large aperture **29**. At the rear of the shelf **25** there is another approximately vertical partition **31**, extending from the shelf to the top edge of the box, and carrying a cylindrical flange **33** which extends rearwardly approximately along the horizontal center line of the apparatus, but at a slight tilt or inclination as seen in the drawings. Mounted in this tubular flange **33**, and held by a rigid bracket **35** which rises from the shelf **25**, is a small electric motor **37**, on the shaft of which are fan blades **39**. The axis of the motor is parallel to the axis of the cylindrical flange **33**, being tilted downwardly so that when the motor is run-

ning, the fan blades 39 will cause air to be drawn forwardly from the rear part of the box or casing, through the space between the motor and the surrounding flange 33, and will direct the flow of air obliquely downwardly onto the water 28 within the container 27.

The current of air thus impinges upon the top surface of the water, picks up moisture from the water, and continues to flow forwardly, through the aperture 29 in the partition 26. Thence the moist air flows downwardly and rearwardly past and around the front edge of the horizontal partition, passing rearwardly over the tray 17 and the sheet or sheets of material to be conditioned therein, and thence flows upwardly again at the rear of the apparatus, and again forwardly past the motor 37.

The apparatus is tightly closed at the top by a cover 45 having depending side flanges 47 which grip snugly the vertical side walls 13 of the box. However, the cover may be removed to obtain access to the interior, to replenish the supply of water 28 in the container 27.

A suitable relative humidity indicator or gage, including a hygrometer or humidity sensing element including associated circuitry operable to operate an integral switch indicated schematically at 51, is connected either to an external relative humidity dial, or, if electronic in type, to a suitable circuit for either indicating relative humidity or automatically controlling the operation of the fan motor as shown, for example, in FIG. 2. When the relative humidity, as sensed by the element 51, rises to approximately the top of the desired range, the fan motor is turned off either by hand, or automatically by the circuit connected to the sensing element such as the circuit shown in FIG. 2, and when the relative humidity within the chamber drops to a point near the bottom of the desired range, the fan motor is turned on. FIG. 2 illustrates but one of many control circuits that can be utilized to turn the fan 37 on and off. A source of electrical energy is schematically illustrated at 3 and is connected to the fan 37 by line 5 and to the humidity sensing element including associated circuitry operable to energize an integral switch all identified as 51 by the line 7. The unit 51 is connected to the other side of fan 37 by line 9. When the integral switch in unit 51 is open the fan 37 is off and when the integral switch in unit 51 is closed the fan 37 is on. Thus, by turning the fan on and off as required, the relative humidity within the chamber is kept within the above indicated limits. When the fan is shut off, it is desirable to place a plate or shutter 56 across the opening 29 and across one end of the tubular flange 33 (either by hand, or automatically by operation of a solenoid, for example) to impede unwanted circulation of air so that the humidity within the lower part of the chamber does not continue to increase (due to the presence of the water 28 in the upper part of the chamber) while the fan is not operating.

One or several sheets of paper are placed in the drawer and the drawer is normally kept closed. When a sheet is needed from time to time for making a reproduction, the drawer is opened, the sheet is taken out of the drawer, the drawer is immediately closed again, and the sheet is immediately placed in the copying or exposing apparatus, in position to be charged and exposed and subsequently developed according to the usual known techniques.

When the sheet is conditioned immediately prior to making the reproduction, in accordance with the above disclosed method, the above mentioned difficulties of erratic reproduction are overcome, and it is found in practice that the unwanted background, or the irregular or splotchy results which are apparent when using untreated or unconditioned paper, are absent. Extremely satisfactory reproductions can be obtained consistently, one after another, when the paper is conditioned immediately prior to the charging and exposing steps, in accordance with the present invention, whereas paper from the same batch or package, put directly into the copying apparatus without previous insertion in the conditioning chamber, frequently gives the above described imperfect and erratic reproductions.

It is seen from the foregoing disclosure that the above mentioned objects of the invention are well fulfilled. It is to be understood that the foregoing disclosure is given by way of illustrative example only, rather than by way of limitation, and that without departing from the invention, the details may be varied within the scope of the appended claims.

What is claimed is:

1. In an electrophotographic sheet conditioner apparatus wherein electrophotographic sheets are maintained in a predetermined water vapor content condition the combination of: means for defining a substantially closed chamber, an open top drawer positioned within said chamber for removably holding electrophotographic sheets within said chamber in position to be conditioned, said drawer being movable substantially horizontally to an open position for insertion and removal of said electrophotographic sheets, a partition arranged substantially horizontally in said chamber and spaced above said drawer, a water container supported on said partition for containing a quantity of water having a substantial top area freely open to the atmosphere within said closed chamber, a fan mounted in position to create a current of air directed obliquely at said substantial top area for causing water lying thereon to be absorbed by said current of air, said fan further creating a circulation of said current of air in one direction above said partition and over said top area of said quantity of water and thence to flow in the opposite direction below said partition and over the top of said drawer, and means responsive to the humidity within said chamber for energizing said fan when the relative humidity falls below a predetermined value and for de-energizing said fan when the relative humidity rises above another predetermined value.

2. In an electrophotographic sheet conditioner apparatus wherein electrophotographic sheets are maintained in a predetermined water vapor content condition the combination of: means for defining a substantially closed chamber, an open top drawer removably positioned within said chamber for removably holding electrophotographic sheets within said chamber in position to be conditioned, said drawer being movable substantially horizontally to an open position for insertion and removal of said electrophotographic sheets, a partition arranged substantially horizontally in said chamber and spaced above said drawer, a water container supported on said partition containing a quantity of water, said container having a relatively large open top so that water therein will have a relatively large surface area freely exposed to atmosphere within said chamber, fan means mounted within a tube and directed at said relatively large surface area for causing water lying thereon to be absorbed by a stream of air created by said fan means, said tube being inclined in a direction to direct said stream of air created by said fan means in an oblique direction against the relatively large surface area within said container, said fan means further creating a circulation of said stream of air in one direction above said partition and over said mentioned top area of said quantity of water and thence to flow in an opposite direction below said partition and over the top of said drawer, an electric motor for driving said fan means, and means responsive to the humidity within said chamber for energizing said fan means when the relative humidity falls below a predetermined value and for de-energizing said fan means when the relative humidity rises above another predetermined value.

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