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APPARATUS FOR THERMALLY FIXING ELECTRONICALLY IMPRINTED IMAGES

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Fig. 1

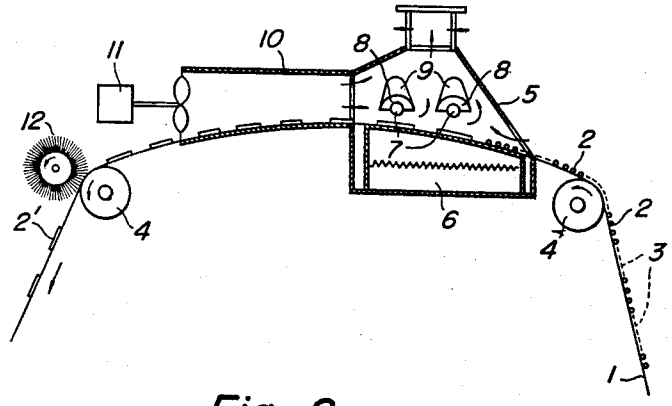
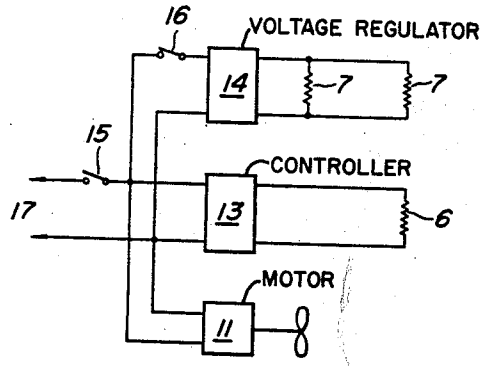


Fig. 2



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APPARATUS FOR THERMALLY FIXING ELECTRONICALLY IMPRINTED IMAGES

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1 Claim. (Cl. 219—388)

This invention relates to apparatus for permanently fixing images formed on a recording sheet with a colored fusible powder by electronic photography, electronic printing or other like means.

Conventionally, latent images electrostatically formed by electronic photography or electronic printing have been converted into fixed or permanent images by the method including the steps of placing a developing material in the form of a colored fusible powder commonly called a "toner" in contact with the electrostatic image surface of the recording sheet, subsequently causing the toner to adhere only to the image areas of the surface under electrostatic attraction thereby converting the images into visible ones, and heating the images thus developed, directly or after they have been transferred onto another recording sheet, to fuse them to the recording sheet.

With conventional apparatus for this purpose, however, the image carrying sheet has been heated by a random mixture of conduction, convection and radiation of heat deriving from a heat source. This naturally has resulted in a nonuniform heating, causing incomplete fusion of images in some areas of the sheet or overheating some areas to such an extent as to be burned. Moreover, both heating and cooling of the sheet have involved a substantial time delay. Therefore, particularly where the recording sheet to be fixed proceeds at high speeds, an extraordinarily large space and a substantial heating power have been required to obtain satisfactory results. In this case, any increase in the travelling speed of the sheet has resulted in total failure to fix the images or incomplete fixing thereof. On the other hand, any decrease in the speed or abrupt stop of the recording sheet has involved the danger of overheating or burning the sheet. This has meant that the travelling speed of the sheet cannot be varied freely.

The present invention provides in improved apparatus for thermally fixing electronically imprinted images which obviates the difficulties met with conventional apparatus and is capable to produce fixed imprinted images which are clear and free from fog. According to the present invention, the heating unit includes at its entrance a preheating device having an exposed surface adapted to be held at a definite temperature appropriate to efficiently preheat the recording sheet and the toner adhering to its upper image carrying surface by heat conduction to a suitable temperature while the sheet and toner is being directed over the exposed surface with the lower surface of the sheet held in close sliding contact therewith. The heating unit also includes at least one incandescent filament lamp of tubular confluration arranged adjacent to and over the path of travel of the recording sheet at right angles or at an appropriate angle of inclination thereto which produces intense heat of radiation with an extremely short heating and cooling time delay and at a rate automatically controlled in proportion to the travelling speed of the sheet so that only the image areas of the tonered sheet preheated selectively take up the radiant heat to be heated to a temperature exceeding the melting point of the toner while passing under the lamp. Provided on the outlet side of the heating unit is a blower for forcing cold ambient air into the heating unit to rapidly cool the surface of the heated recording sheet to complete the fusion of the imprinted images to the sheet while at the same time rapidly expelling the heated air around the source of heat radiation including reflector and radiator means upwardly out of the casing of the heating unit for the purpose of preventing overheat of the recording sheet and fusion thereto of any unwanted toner powder which may cause fogging. The unwanted toner powder thus prevented from fusing to the sheet is subsequently swept off by a rotary brush means.

The foregoing and other objects, features and advantages of the present invention will become apparent from the following description when taken in conjunction with the accompanying drawing which illustrates one embodiment of the invention and in which:

FIG. 1 is a schematic diagram showing the apparatus in cross sectional side elevation; and

FIG. 2 is a diagram of the electric control circuit of the apparatus shown in FIG. 1.

Referring to the drawing and particularly to FIG. 1, reference numeral **1** designates a recording sheet carrying on its surface toner images **2** formed by electronic printing and developing processes and proceeding in the direction indicated by the arrow. The sheet **1** also carries unwanted fogging toner powder **3** and proceeds over guide rollers **4**, **4'** and through a heating unit having a casing **5**, which is lined over the inside wall surface with a thermal insulation material such as asbestos. Reference numeral **6** designates a preheater device for preheating the recording sheet **1** which has an exposed surface which is adapted to be held at a definite temperature and over which the recording sheet is advanced. The exposed surface is made of copper, aluminum or other material of high thermal conductivity and being plated with hard chromium is smooth and highly wear-resistant. The surface is also convexed upward with an appropriate curvature to enable the sheet to proceed in close sliding contact with the surface.

One or more sources of heat radiation **7** are arranged in the casing **5** each of which include an incandescent filament lamp, such as an iodine lamp, of tubular configuration arranged at right angles or at an appropriate angle of inclination to the path of travel of the sheet so as to cover the entire width thereof. The lamps are capable of producing intense heat of radiation with an extremely short heating and cooling time delay. The sources of heat radiation **7** each include a reflector plate **8** having an appropriately curved surface for reflecting the radiant heat from the lamp with efficiency to the recording sheet passing through the heating unit. The reflector plate **8** is preferably formed of polished aluminum sheet and has radiator blades **9** extending upwardly from its outside. An air duct **10** is connected to the outlet side of the heater casing **5** for directing the flow of air caused by a fan unit **11** to the surface of the recording sheet **1** and into the heater casing. The bottom wall of the air duct **10** has a smoothly finished wear-resistant surface of an appropriate curvature to serve as a support for the recording sheet. Reference numeral **12** designates a rotary brush of cylindrical configuration arranged opposite to the adjacent guide roller for rotation in the direction of the arrow and formed, for example, of hog bristle radially fixed to a mandrel.

Referring next to FIG. 2, which illustrates the control circuit of the present apparatus, reference numeral **13** designates a controller for setting the temperature of the preheater device at an appropriate value; **14** a voltage regulator for automatically controlling the supply voltage to the sources of heat radiation **7** in proportion to the travelling speed of the recording sheet **1**; and **15** a main switch for connecting and disconnecting the source of

power supply 17. A protective relay 16 is provided for interrupting the power supply to the sources of heat radiation 7.

In one experiment conducted by the inventors, the exposed surface of the preheating device 6 had a length of sliding contact with recording sheet 1 of 20 cm. and was held at a temperature of 90° C. As the recording sheet 1 was used an electrostatic sheet of web form comprised of a bleached kraft paper approximately 20 cm. wide and approximately 60 microns thick carrying on one surface a polystylene coating of approximately 10 microns thickness. On the coated surface of the sheet, images of letter form were electrostatically imprinted and developed by a toner in the form of a colored resin powder mixed with carbon black and having a particle size ranging from one to five microns and a melting point of approximately 130° C. The recording sheet 1 was advanced at a speed of 50 cm. per second. Under these conditions, the total input to the sources of heat radiation 7 of one kilowatt was found appropriate selectively to heat only the toner images to obtain completely fused clearly defined letter images without fogging. Also, it has been found that quite the same satisfactory result obtains by virtue of the automatic control of the input to the radiation sources without any danger of burning the recording sheet or forming incompletely fixed images even when the travelling speed of the recording sheet is reduced or the sheet is abruptly brought to rest.

The reason why the unwanted toner powder is not fused to the sheet areas outside the images but only the toner on the imprinted images is selectively fused thereto is not clear. It will be recognized, however, that since the recording sheet is highly reflective and transparent to heat radiation the heat absorption of the sheet material is very limited and the sheet itself is hardly heated by radiation to any elevated temperature. On the other hand, the toner on the sheet areas outside the images is physically lightly placed on the sheet surface so that during preheating it can hardly receive any substantial heat from the sheet through conduction. In addition, the particles of the toner on such sheet areas are distinct and isolated from each other having a very substantial radiation surface for volume of each particle. This means that the amount of radiant heat received by the toner on such areas is much smaller than that of heat dissipation therefrom and thus the temperature rise of the toner is only limited. In contrast, the toner on the image areas is compacted and closely bonded to the

sheet surface under the electrostatic force and thus is fully preheated through conduction. In addition, the amount of heat radiation absorbed by such toner particles is presumably far larger than that of heat dissipation therefrom as contrasted to the case of isolated toner particles.

At any event, the discovery of the fact that it is possible to fix only the tonered imprinted images onto the recording sheet and to remove any toner previously laid on the sheet outside the image areas if the sheet is properly preheated and the rate of heat radiation is properly set is very important in the art of electronic printing in that the fogging contamination previously held extremely difficult to avoid can now be eliminated completely.

As apparent from the foregoing, the apparatus of the present invention is capable of fixing electronic record images during their travel at a widely variable speed with a minimum of heat energy requirement and that with safety and rapidly to produce clearly defined fixed images completely free from fogging contamination. Also, it will be appreciated that the present apparatus is simple in structure, efficient and dependable.

What is claimed is:

An apparatus for thermally fixing electronically imprinted images on a recording sheet comprising a heating unit having an exposed surface adapted to be held at a definite temperature, means for directing said recording sheet over said exposed surface in close sliding contact therewith, at least one source of heat radiation of tubular configuration effective to cause said recording sheet being directed over said exposed surface to heat and cool with an extremely small time delay, means for controlling the rate of heat radiation of said source in accordance with the speed at which said recording sheet is directed over said exposed surface so that only the imprinted image on said recording sheet is selectively fused thereto, and rotary brush means for removing any unfixed fogging contamination from said recording sheet.

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