

June 10, 1969

J. A. ADAMEK ET AL

3,449,548

FUSING DEVICE

Filed Dec. 30, 1966

Sheet 1 of 3

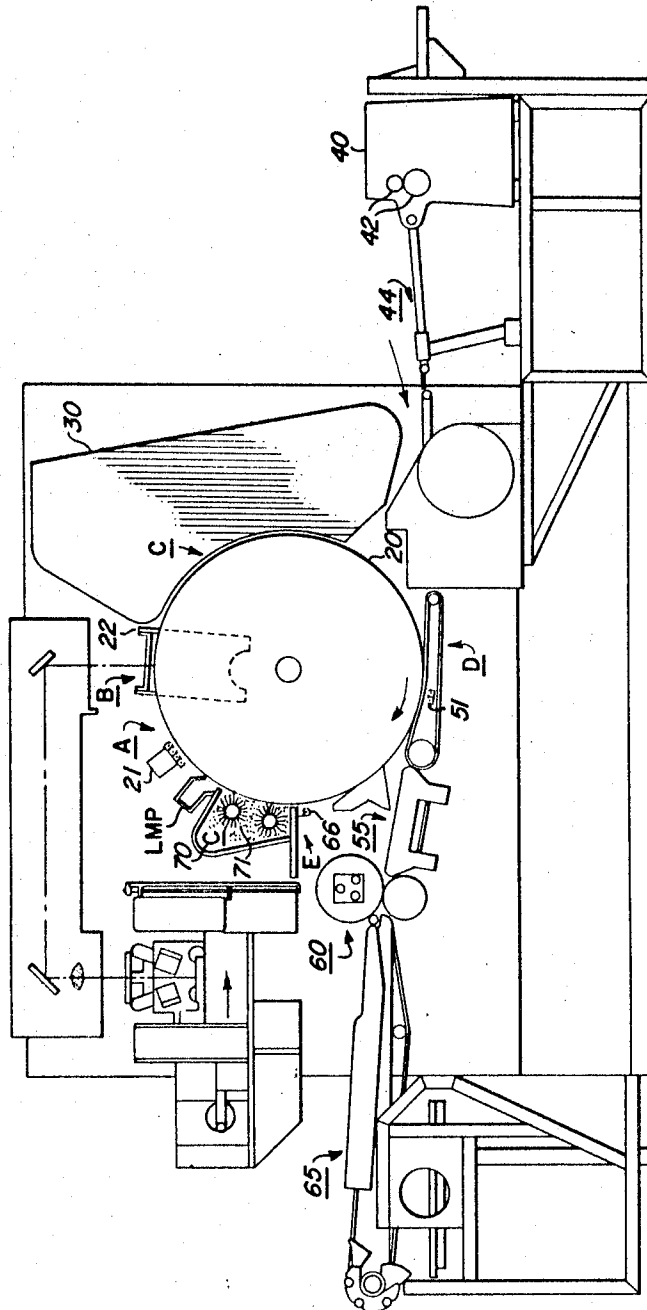


FIG. 1

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Sheet 3 of 3

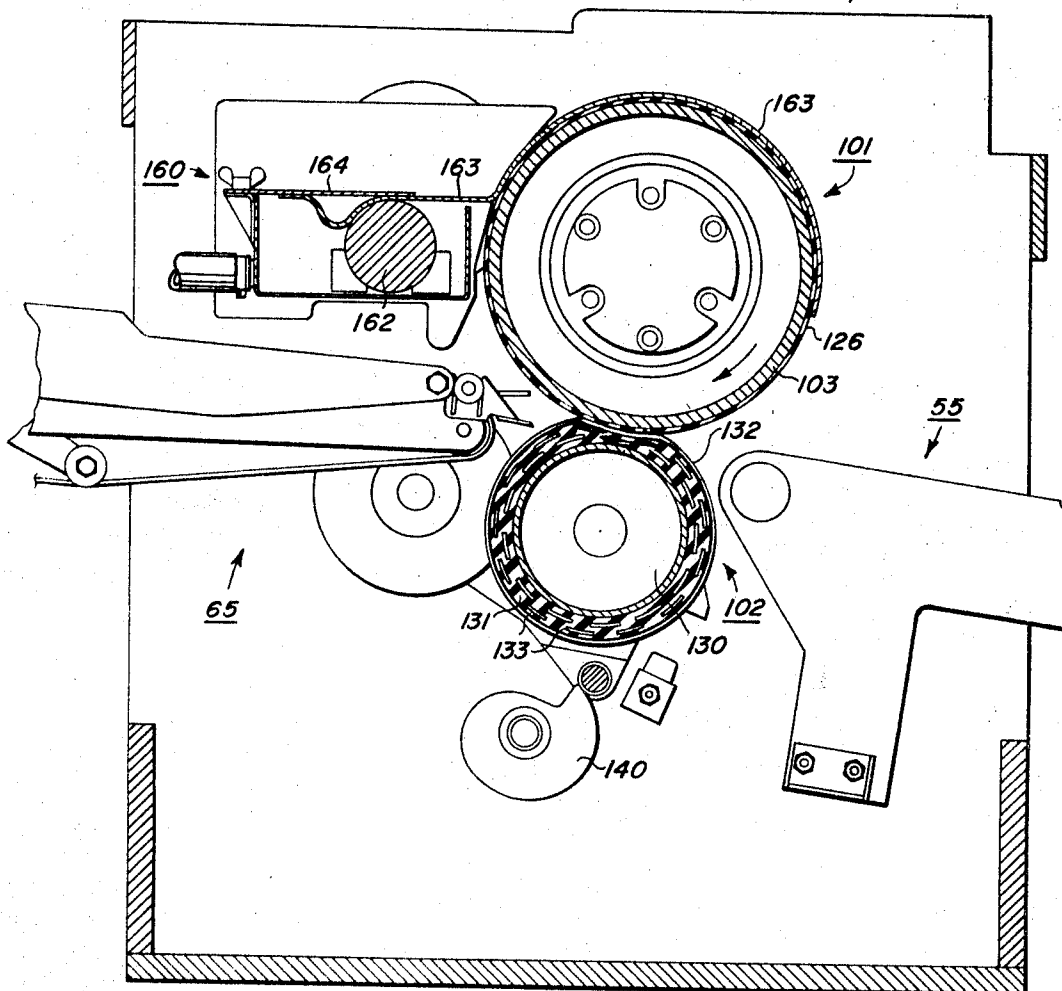


FIG. 3

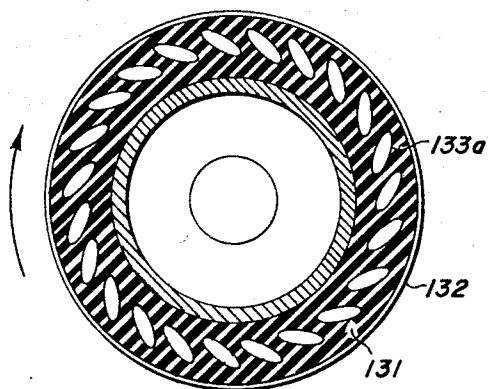


FIG. 4

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1

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FUSING DEVICE

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3 Claims

ABSTRACT OF THE DISCLOSURE

An improved heat fusing device for fixing heat fusible electroscopic marking particles onto a support sheet comprising a frame supporting a pair of pressure rolls arranged to form a nip through which the support sheet is advanced with the marking particles contacting the upper roll surface which is heated. The lower roll is made up of a deformable material having elongated slits arranged in a predetermined overlapping relationship to present uniformly greater nip widths during rotation of the rolls thereby enabling sufficient heat and pressure to be applied at the nip for a predetermined duration to fix the marking particles onto the support material without causing any distortion of the image formed by the marking particles.

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

More specifically the invention relates to an improved heated-roll fusing device which operates at high speeds. 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 order fields.

In the process of xerography 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 effected with an electrostatically charged, finely divided developing material or electroscopic marking particles (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.

One of the methods in common use for developing the electrostatic latent image is known as cascade development, and is in general used in 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

2

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.

A variety of types of finely divided electroscopic powders may be employed for developing electrostatic latent images. However, as the science 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 developing materials are manufactured and marketed commercially 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 support 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 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.

One of the important applications of the process of xerography comprises its use in automatic copying machines for general office use wherein the powder images formed on a xerographic plate are transferred to paper and then fixed thereon by heat fusing. In order to fuse resinous powder images formed of the powdered resins now commonly used, it is necessary to heat the powder and the paper to which it is to be fused to a relatively high temperature, such as approximately 325° F. It is undesirable, however, to raise the temperature of the paper substantially higher than 375° F. because of the tendency of paper to discolor at such elevated temperatures.

It has long been recognized that one of the fastest and most positive methods of applying heat for fusing the powder image to paper is to bring the powder image into direct contact with a hot surface, such as a heated flat plate.

But, as the powder image is tackified by heat, part of the image carried by the support material will stick to the surface of the heated plate, so that as the next sheet is placed on the heated plate, the tackified image partially removed from the first sheet will partly transfer to the next sheet and, at the same time, part of the tackified image from said next sheet and, at the same time, part of the tackified image from said next sheet would adhere to the heated plate. This process is commonly referred to in the printing art as "set off" or "offset," the latter term being preferred.

The offset of toner onto the heated contacting surface has heretofore led to the rejection of contact fusers in favor of other heat fixing devices, primarily coiled radiant element heaters with reflectors have the disadvantage of dissipating a large quantity of heat into the machine enclosure in which they are used, heat into the machine enclosure in which they are used, heat transfer to the

powder image is insufficient, and they present a safety hazard because of the exposed radiant element.

It is, therefore, the principal object of this invention to improve the construction of a direct contact fusing device for toner images which will rapidly fuse toner images at high speeds without causing the toner particles to smear while in a tackified state or to offset onto the device.

Another object of this invention is to improve the construction of a direct contact fusing device to attain efficient heat transfer to the toner image to be fused.

It is still another object of the invention to improve the construction of a heat fixing device that operates with minimum power supply and a minimum heat source.

A further object of this invention is to increase the surface contact between the upper and lower rollers of a heat fuser.

These and other objects of the invention are attained by means of a direct contact fusing device in which the toner image is fused by forwarding the sheet or web of paper bearing the toner image between two rolls, one of which is heated, both rolls being provided with a thin coating of an adhesive material, such as a coating of Teflon, a Du Pont Corporation product composed of tetrafluoroethylene resin. The heated roll may be provided with a silicone oil film to prevent toner offset. Both the Teflon and silicone oil have such physical characteristics that they are substantially adhesive to dry or tackified xerographic developing materials. The lower roller is provided with openings therein to provide for a wider nip width. "Adhesive" 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 repellent to sticky or tacky substances. The word is adapted in this sense herein and is so used throughout the disclosure.

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 the preferred embodiment of a xerographic reproducing apparatus adapted for automatic operation, and incorporating a roller heat fuser constructed in accordance with the invention;

FIG. 2 is an enlarged front view of the heat fuser of FIG. 1;

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

FIG. 4 shows an alternate embodiment of the lower roller.

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 the heat fuser of the subject invention.

As shown schematically in FIG. 1, the automatic xerographic reproducing apparatus comprises a xerographic plate 20 including a photoconductive backing and formed in the shape of a drum, which is mounted on a shaft journaled in a frame to rotate in the direction indicated by the arrow to cause the drum surface sequentially to pass a plurality of xerographic processing stations.

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 powdered image in the configuration of the copy being reproduced;

A transfer station, at which the xerographic powder image is electrostatically 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 remaining thereon.

The charging station is preferably located, as indicated by reference character A. As shown, the charging arrangement 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 closed within a shielding member.

Next subsequent thereto in the path of motion of the xerographic drum is an exposure station B. An optical scanning or projection system is provided to project a flowing image onto the surface of the photoconductive drum from an original.

The optical scanning or projection assembly comprises a moving original, the original being uniformly illuminated and arranged in light projecting relation to the moving light-receiving surface of the xerographic drum. Uniform lighting is provided by lamps arranged adjacent the original. Scanning is accomplished by means of a carriage which is moved in timed relation to the movement of the xerographic drum and a scanning slot 22.

Adjacent to the exposure station is a developing station C in which there is positioned a developer apparatus 30 including a casing or housing having a lower or sump portion for accumulating developer material. A bucket type conveyor is used to carry the developing material to the upper part of the developer housing where it is cascaded over a hopper chute onto the xerographic drum to effect development.

Positioned next and adjacent to the developing station is the image transfer station D which includes a sheet feeding arrangement adapted to feed sheets of support material, such as paper or the like, successively to the xerographic drum in coordination with the presentation of the developed image on the drum surface at the transfer station.

The sheet feeding mechanism includes a sheet feed device 40 adapted by means of vacuum feeders to feed the top sheet to rollers 42 cooperating with the belts of paper transport 44 which, in turn, conveys the sheet to the xerographic drum. The sheet material is advanced into contact with the xerographic drum in registration with a previously formed xerographic powder image on the drum.

The transfer of the xerographic powder image from the drum surface to the sheets of support material is effected by means of a corona transfer device 51 that is located at or immediately after the line of contact between the support material and the rotating drum. In operation, the electrostatic field created by the corona transfer device is effective to tack the support material electrostatically to the drum surface whereby the support material moves synchronously with the drum while in contact therewith. Simultaneously with the tacking action, the electrostatic field is effective to attract the toner particles comprising the xerographic powder image from the drum surface and cause them to adhere electrostatically to the surface of the support material. The sheet is then stripped from the drum and directed onto a conveyor 55 whereby the sheet material is carried to a fixing device 60, the subject matter

of this invention. At the fixing device, the transferred xerographic powder image on the sheet of support material is permanently fixed or fused thereto as by heat. After fusing the reproduction is discharged from the apparatus at a suitable point for collection externally of the apparatus by means of the conveyor 65.

The next and final station in the device is a drum cleaning station E, having positioned therein a corona pre-clean device 66, a drum cleaning device 70 adapted to remove any powder remaining on the xerographic drum after transfer by means of a rotating brush 71, and a discharge lamp LMP adapted to flood the xerographic drum with light to cause dissipation of any residual electrical charge remaining on the xerographic drum.

To remove residual powder from the xerographic drum, there is disposed a cylindrical brush 71 rotatably mounted on an axle and driven by a motor, not shown.

Suitable drive means are provided to drive the drum, move the scanning carriage and sheet feed mechanism at predetermined speeds relative to each other, and to effect operation of the bucket-type conveyor and the other operating mechanisms.

Referring now to the drawings, there is shown a preferred embodiment of a heated roll fusing device 60 constructed in accordance with the invention.

In the embodiment shown, the heated roller fusing device includes frame plates 13 for supporting the upper and lower rollers of the fuser. The rollers are supported in a position parallel to each other in the frame 13.

Direct contact fusing of a powder image on a support material is achieved by forwarding a sheet of support material bearing the powder image to be fused between a heated upper roller, generally designated 101, and an unheated lower roller, generally designated 102, rotating in intimate contact under pressure. The support material, carrying the unfused toner images is advanced between these two rollers with the toner images facing the heated roller so that fusing occurs when contact is made.

As shown in FIG. 2, the upper roll 101 includes 103 partly closed at opposite ends. The roll is journaled for rotation by bearings not shown positioned in frame plates 13, respectively. The upper roller includes a quartz tube which supports a suitable resistance heating element for heating the same.

To prevent toner offset onto the heated roll contacting the unfused toner image on the support material, an offset preventing material 126 covers the outer surface of cylinder 103 of roll 101. A suitable material may be a coating of a product of tetrafluoroethylene resin sold under the trademark of Teflon by DuPont Corporation. Teflon is 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.

Upper roller, 101 and lower roller 102 are driven in timed relation to the speed of conveyors 55 and 65 by means of gears 116 and 117 respectively operatively connected by a suitable gearing arrangement. The gear 116 is secured to upper fuser roll 101. The roller 101 is driven at a speed equal to the lineal speed of the support material as it is delivered to the fuser by the endless conveyor 55 of the xerographic apparatus.

Roll 102 includes a rigid core 130 covered with a suitable resiliently deformable material 131, such as silicone rubber, which, in turn, is covered by a Teflon coating 132. An adhesive may be required to hold Teflon sleeve to the rubber to prevent slippage which could cause the Teflon to "walk" off the rubber roll. The silicone rubber is formed with openings 133 running lengthwise of the roller to allow the lower roller to deform when in contact with the upper roller 101. The Teflon coating deforms with the rubber 131 in relation to the

amount of pressure between heated roll 101 and 102 and in relation to the opening 133 to form an arc of contact for proper fusing of the thermoplastic resin on the support material.

The openings 133 are shown as thin overlapping slots but may be of various shapes. An alternate shape is shown in FIG. 4 wherein the openings are formed of overlapping eccentrics. The coating provides a protective covering on the rubber 131 to prevent deterioration of the rubber due to heat and/or contact with offset preventing liquid, the application of which is to be hereinafter discussed.

The roll 102 is rotatably supported on support shaft 14 by bearings (not shown) in the side supports 135. The side supports are pivotally mounted on the frame plates 13.

Roll 102 is raised into pressure contact with roll 101 by operation of a pair of cams 140 secured to a shaft 141 rotatably mounted in the side frame plate 13. The cams 140 engage followers 142 which are secured to the side supports 135.

Roll 101 and roll 102 must maintain identical velocity at their point of contact at all times when an image is being fused on the support material.

In the embodiment shown in FIGS. 2 and 3, the outer diameters of rolls 101 and 102 are not equal, however, both rolls are driven by different size gears providing for the lineal speed at the roll's point of contact to be the same for both rolls. However, when pressure is applied to roll 102 forcing it into contact with heated roll 101, the distance between the centers of rolls 101 and 102 decreases. The radius from the center of roll 101 to its point of contact with roll 102 remains constant owing to the material from which the roll is constructed. The radius of roll 102, from its center to point of contact with roll 101, is decreased by the pressure to provide a larger arc of contact to assure proper fusing.

As a sheet of support material is advanced between the rolls 101 and 102, the powder image on the support material will contact the peripheral heated surface of roll 101 whereby the powder image becomes tackified and, in this tackified condition, the powder would tend to offset onto this roll except that it is partially prevented from doing so by a Teflon coating on the roll. However, to further prevent even this limited tendency of offset of toner onto the heated contact surface of roll 101, an applicator is used to supply a thin film of offset preventing liquid, such as silicone oil, to the Teflon coating 126 on roll 101.

A supply of silicone oil to be applied to roll 101 is maintained in an oil pan 160 fastened to the frame plates 13 by suitable means (not shown). An applicator roll 162 is used to convey a thin film of oil as the applicator roll is rotated in the silicone oil, to a wick 163, such as a Teflon felt pad secured as by staples, not shown, to a wick support plate 164 in a manner whereby the pad rests on the peripheral surface of roll 101 and the applicator 162. To affect rotation of the applicator roller in one direction, the roller is driven by a suitable drive (not shown).

For a given temperature of the upper roller 101, the fusing rate will depend on the contact arc length of the support material against this roller and the dwell time, i.e., the time the toner image remains between the rollers. To insure the maximum dwell time the lower roller 102 is formed with opening 133. This allows the fuser to operate more efficiently while holding the speed of the rollers constant. Contact arc length depends on the softness of the rubber in roller 102 and on the amount of pressure between rollers 101 and 102. However, with the openings formed as in the instant invention, it is possible to use a higher durometer rubber while obtaining an apparent lower durometer due to the openings in the lower roller. Also it is desirable to provide a uniform

pressure at all times between the upper roller 101 and the lower roller 102.

In the embodiment of the apparatus shown, the hardness of the rubber used to form roller 102 was in the range of 25 to 65 durometer, and preferable, the hardness of the rubber should exceed 40 durometer. By providing openings in the lower roller the contact arc length can be increased while using the same hardness of the rubber in the lower roller. Also the speed of the rollers can be increased without increasing the heat provided in the upper roller which results in a higher dwell time.

While the invention has been described with reference to the structure disclosed herein, it is not confined to the details set forth, and this application is intended to cover such modifications or changes as may come within the purposes of the improvements of the scope of the following claims.

What is claimed is:

1. In an improved contact heat fusing device for fixing heat fusible electroscopic marking particles carried on a support material in image configuration, said device including in combination
 - frame means,
 - a first roll journaled in said frame means,
 - a second roll having deformable material of high durometer rubber ranging from about 40 to about 65 durometer formed in the shape of a ring and an outer protective coating of offset preventing material, said ring being arranged on a support cylinder, the peripheral surface of said first roll being covered with a coating of an offset preventing material, means to apply an offset preventing liquid to said offset preventing material on said first roll, means to heat said first roll having direct contact with the heat fusible electroscopic marking particles carried on the support material,

driving means connected to said first roll and to said second roll rotating said rolls to advance a support material carrying electroscopic marking particles in image configuration through a nip formed therebetween,

wherein the improvement comprises said second roll being formed with elongated slits coextensive with the roll length and spaced in predetermined overlapping relationship intermediate the roll surface and said support cylinder to present a greater nip width uniformly during rotation of said rolls thereby enabling sufficient heat for a predetermined time period to fix the marking particles onto the support material without distortion of the image.

2. The apparatus as recited in claim 1 wherein the elongated slits are formed in the shape of rectangles.

3. The apparatus as recited in claim 1 wherein the elongated slits are formed in the shape of oblong circles.

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29—132; 95—89; 219—388, 469; 250—65; 263—6