June 24, 1969 W. A. STRYJEWSKI 3,452,181

ROLL FUSING DEVICE FOR XEROGRAPHIC MATERIAL

Filed Dec. 27, 1967 Sheet 1 of 2

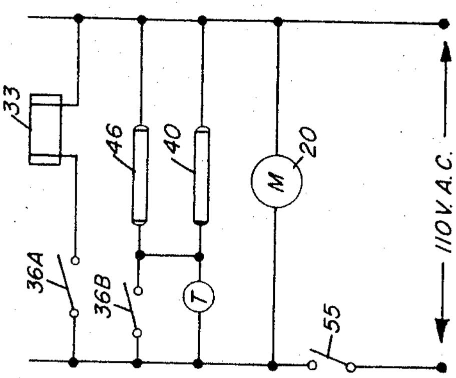

FIG. 3

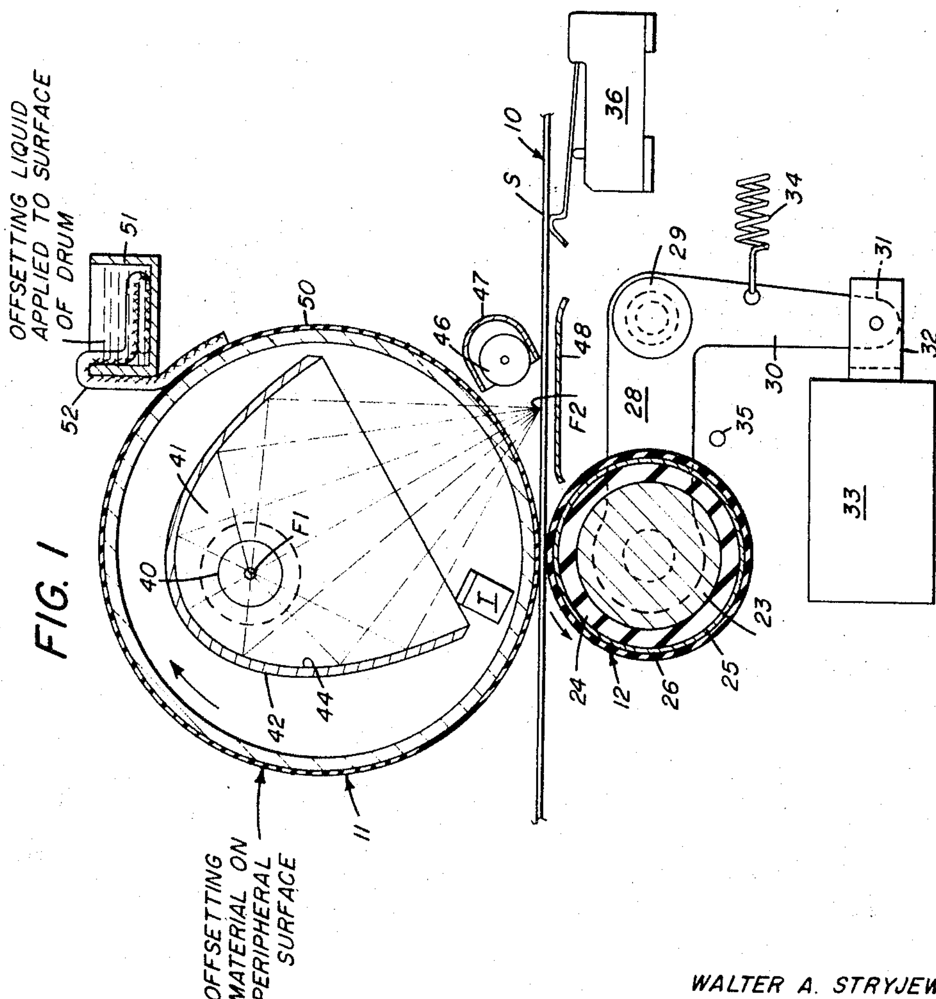

FIG. 1

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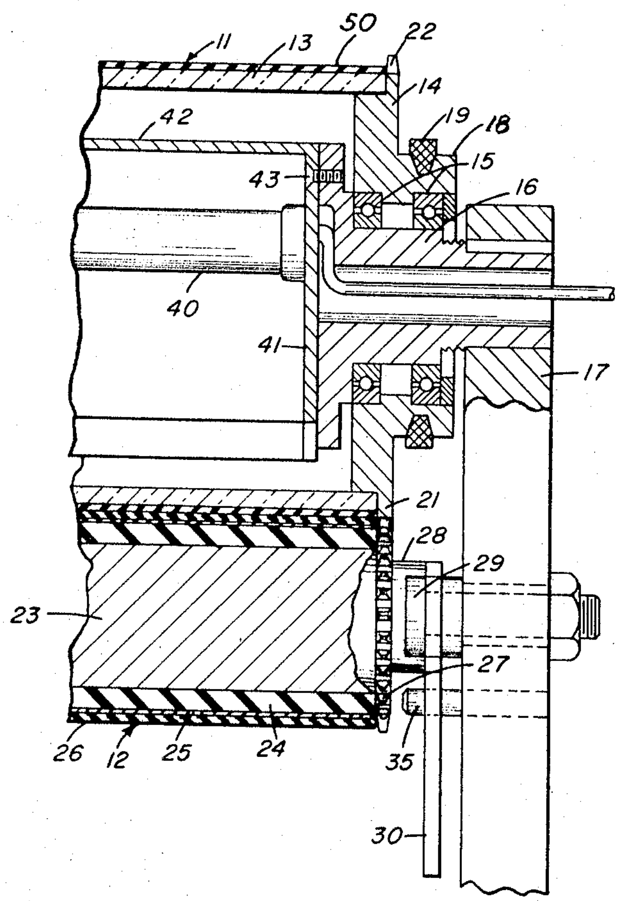
FIG. 2



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ROLL FUSING DEVICE FOR XEROGRAPHIC MATERIAL

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U.S. Cl. 219—216 14 Claims

ABSTRACT OF THE DISCLOSURE

A device for fusing an electroscopic toner image to the surface of a carrier bearing the image in which the carrier is moved through a fusing station by a thermally transparent drum and a resilient roll that are synchronously driven. A heating element and a reflector are mounted within the drum, the reflector focusing the heat generated by the heating element into a line lying in a plane generally corresponding to the image bearing surface of the carrier and upstream from the line of contact of the drum and roll relative to the direction of movement of the carrier. The toner image is heated sufficiently to at least partially tackify the toner particles prior to engagement thereof by the drum for fusing to the carrier. A second heating element can be dispersed in close proximity to the carrier to preheat the toner image at a location upstream from the focused line of heat, thereby permitting the linear speed of the carrier to be increased.

Field of the invention

The present invention relates to fusing an electroscopic toner image to the surface of a carrier bearing said toner image and more particularly to a device in which the toner image is heated to an extent sufficient to fuse it to the carrier just prior to its entry into the nip of a pair of rotating members.

Description of the prior art

It is well known to fuse toner particles to a carrier by means of heated rolls, or by the application of heat directly to the toner particles by means of hot vapors, etc. In apparatus utilizing any one of the aforementioned types of fusing, high temperatures are required to obtain satisfactory fusing of the toner particles to the carrier. With the use of one or a pair of heated rolls for fusing toner images, a heating element is usually arranged within each of the rolls which are usually constructed of a highly conductive and heat-absorbing material, such as copper, steel or aluminum. In this case, the softening of the toner particles and fusing of the toner particles to the carrier occur practically simultaneously, that is, at the time of contact of the carrier and toner image with the heated rolls. If the rate of movement of the carrier is relatively slow in order to accomplish good fusing, the heat penetration can cause discoloration of the carrier.

Summary of the invention

One object of the invention is to provide a device for fusing electroscopic toner images to the surface of a carrier bearing said image in which the carrier can be moved at a relatively high speed to eliminate any possibility of discoloring or charring of the carrier due to excessive heat.

Another object of the invention is to provide a device for fusing xerographic images to a carrier in which the toner particles are softened to an extent sufficient to cause fusing to the carrier prior to entry of such particles into contact with a pair of rolls.

And yet another object of the invention is to provide

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a device for fusing xerographically toned images in which an efficient transfer of heat to only the toned image and the upper surface of the carrier to which it is to be fused is obtained.

These and other objects of the invention will be apparent to those skilled in the art when the following description is read in conjunction with the disclosure of the invention shown in the accompanying drawings.

The aforementioned objects of the invention are attained by a fusing device comprising a rotatable, cylindrical drum which is made of a thermally transparent material having high radiation transmitting qualities. A resilient reflecting and heat insulating surfaced roll is mounted to cooperate with the surface of the drum for moving the carrier bearing the toner image or images therebetween. The drum and roll are rotated in synchronism by a suitable drive mechanism. An elongated heating element is mounted within the drum and is partially surrounded by an elongated elliptical reflector. The reflector is of such a design that one of its principal focal lines is coincident with the axis of the heating element and the other focal line is generally coincident with the surface of the carrier bearing the toner image along a line lying outside the drum. The reflector is so positioned that the heat generated by the heating element is focused onto the surface of the carrier just ahead of the line of contact of the drum and roll in an upstream direction relative to the direction of movement of the carrier. With this arrangement, the toner image is heated sufficiently to at least soften the toner particles to such an extent that they are at least partially fused to the carrier prior to engagement thereof by the drum.

In one of the modifications of the aforementioned device, an auxiliary heating element can be mounted outside of the drum in close proximity to the surface of the carrier in an upstream direction relative to the direction of movement of the carrier for preheating the toner particles, thereby permitting the carrier to be moved at a much faster rate to accomplish the fusing operation. The roll contacting the drum can be mounted so as to be moved into cooperative relationship with the drum only when the carrier is to be moved therebetween, such movement being controlled by a switch that is actuated by the leading edge of the carrier. The peripheral surface of the drum can be treated or coated so as to provide a transparent non-offsetting surface which will prevent toner particles from transferring from the carrier to the surface of the drum and then being offset onto undesired areas of the carrier.

Description of the drawings

Reference is now made to the accompanying drawings wherein like reference numerals designate like parts and wherein:

FIG. 1 is a vertical section through the apparatus embodying the invention and showing the principal elements of the fusing device;

FIG. 2 is a vertical section through one end of the fusing device showing the mounting arrangement for the drum, heating element and roll; and

FIG. 3 is a simple schematic wiring diagram showing the principal electrical elements associated with the fusing device.

Description of the preferred embodiment

With reference to FIG. 1 a carrier **10** comprises a material, such as paper, on one surface S of which toner particles in an image formation are lightly held by a slight triboelectric effect. The carrier **10** can be positioned manually or by suitable driving means relative to a drum **11** and a roll **12**. The carrier **10** must be positioned so that the toner image on surface S faces the drum **11**. As will be described in more detail hereinafter, drum **11** and roll **12** serve to move the carrier **10** therebetween.

As shown in FIG. 2, the drum **11** comprises a glass or quartz sleeve **13** having high thermal radiation transmitting qualities that is engaged on each end by a flanged disc **14** rotatably supported by a pair of spaced bearings **15**. Each pair of bearings **15** is carried by an arbor **16** that is mounted in one of the spaced supports **17** which can be a part of a frame for the fusing device. One of the flanged discs **14** is provided with an integral pulley portion **18** which is connected by a belt **19** either directly or through a suitable drive mechanism to a motor **20**. One disc **14** also includes a flange **21** having gear teeth **22** formed integral therewith.

Again referring to FIG. 2, roll **12** comprises a metallic core **23** to which a resilient sleeve **24** is firmly attached or adhered. The sleeve **24** is made preferably of silicone rubber covered with a heat reflecting material **25**, such as foil of stainless steel, which in turn is covered with a heat insulating material **26**, so as to withstand relatively high temperatures and not absorb heat from the carrier **10**. One end of roll **12** carries a gear **27** which is continuously in mesh with gear **22** on drum **11**. Roll **12** is normally maintained in a position in which it is disengaged from the drum, but in which position gears **22** and **27** are still engaged to provide continuous rotation of drum **11** and roll **12**. Roll **12** is rotatably mounted between a pair of spaced levers **28**, each of which is pivotally mounted on one of the supports **17** by means of a stud **29**. One of the levers **28**, as shown in FIG. 1, is provided with an arm **30**, the free end **31** of which is pivotally connected to the armature **32** of a solenoid **33**. A spring **34** having one end connected to extension **30** normally holds the roll **12** in a position in which it is disengaged from drum **11** in which position one of the levers **28** engages a movement limiting pin **35**.

Roll **12** is moved into cooperative relationship with drum **11** by solenoid **33** which is controlled by means of a switch **36** which has two sets of contacts **36A** and **36B** and is arranged in the path of movement of the carrier **10**. As the carrier **10** is moved toward the drum **11**, the leading edge thereof actuates switch **36** to a closed position, whereby solenoid **33** is energized and roll **12** is moved toward drum **11**. Solenoid **33** is maintained in an energized state so long as the carrier **10** holds switch **36** closed and can be provided with a conventional delay or holding circuit so that roll **12** is held in cooperative relationship with drum **11** until the trailing edge of the carrier has been moved past the line of contact of drum **11** and roll **12**. This biasing arrangement of roll **12** allows it to be moved or displaced slightly relative to drum **11** when a carrier **10** is moved therebetween to accommodate for the thickness of the carrier. When roll **12** is moved toward drum **11**, gears **22** and **27** become fully engaged and the movement of drum **11** and roll **12** is then in synchronism so that an even and uniform movement of carrier **10** is obtained. The drum **11** and roll **12** could also be driven in synchronism by a belt system or other drive means which will permit one to be moved relative to the other when a carrier is presented for fusing and at the same time provide continuous movement of both the drum and roll.

An elongated heating element **40** is mounted within drum **11** and between the side walls **41** of an elongated elliptical reflector **42**. The side walls **41** are secured to the arbor **16** by means of screws **43** as shown in FIG. 2. The axis of heating element **40** can be coincident with the axis of drum **11** or positioned relative to the axis of the drum but still parallel thereto. The heating element **40** is preferably a tungsten filament lamp although any other type of radiant heat generator can be used.

The reflecting means **42** comprises an elongated, elliptical surface **44** which is of high reflectance or plated and polished to provide a high degree of reflectance. The focal lines of the elliptical reflector are such that one lies within the drum and the other outside the drum, both lines being generally parallel to each other, to the axis of drum **11** and to the axis of heating element **40**. The focal line F1 which is within the drum, is preferably coincident with the axis of the heating element **40** and the focal line F2, which is outside the drum, is preferably coincident with a plane generally corresponding to the plane of the image bearing surface S of the carirer **10**. It is a well known principle that such a reflector will focus the radiation generated by the heating element **40** from the focal line F1 as a relatively narrow band to the focal line F2 which lies outside of the drum **11**. With such a reflector, practically all of the heat is therefore focused as a narrow band in the plane of the image surface S and transverse to the direction of movement of the carrier **10**. It has been found that the focal line F2 should be located upstream from the line of tangency or contact of drum **11** and roll **12** relative to the direction of movement of carrier **10**. The focal lines F1 and F2, which are parallel to each other, determine the major axial plane of the reflector **40**, the axial plane being angularly disposed relative to focal line F1 in a direction opposed to the direction of movement of carrier **10**. With reference to FIG. 1, such plane would be normal to the plane of the drawing and pass through the points representing focal lines F1 and F2. The distance between the line of contact of drum **11** and roll **12** and focal line F2 can be approximately one-quarter inch. With such a separation between the line of heating and the line of contact, the carrier **10** can be moved at a relatively high linear speed and accomplish good fusing of the toner particles to the carrier, the speed being dependent on various parameters, such as the type of toner, the heat generated by the heating element **40**, etc. The heating of the toner particles on the carrier **10** prior to engagement by drum **11** softens the toner particles sufficiently to provide good fusing to the carrier when contacted by the drum. Since the roll **12** is urged toward drum **11**, the pressure exerted by roll **12** also aids in obtaining good fusing of the toner particles.

It has been found that higher linear speeds of the carrier **10** can be attained with good fusing of the toner particles to the carrier when the toner particles are also subjected to the heat generated by an auxiliary heating element prior to that generated by the heating element **40**. As shown in FIG. 1, an auxiliary heating element **46** is mounted upstream from the focal line F2 and in the nip between drum **11** and carrier **10**. The heating element **46** can be partially surrounded by an elongated reflector **47** so that the heat is directed to the surface of carrier **10**. The heating element **46** must be of necessity relatively small and positioned sufficiently far into the nip between drum **11** and carrier **10** in order that the toner particles do not again harden before coming into contact with the line of heat at focal line F2. While heating element **46** has been shown as a tubular lamp, the same results can be obtained by means of a heating wire or similar device which will permit the element to be moved still further into the designated nip. A reflector **48** is positioned below the plane of movement of carrier **10**, see FIG. 1, to reflect any heat transmitted through the carrier and to reflect the heat at focal line F2 and/or from the heating element **46**, when a carrier **10** is not present, thereby shielding any part of the mechanism therebelow.

As mentioned hereinabove, toner particles will tend to transfer from the carrier to the surface of a heated roll or drum with offsetting of these particles onto the carrier in desired areas relative to another part of the same image or on another image. It has been found that coating or placing a sleeve of a transparent offset-preventing material on the peripheral surface of drum **11** serves to eliminate such migration or transfer of the toner particles. This migration can be further reduced by applying an offset-preventing liquid to the offset-preventing material on the surface of drum 11. It is known that a material, such as tetrafluoroethylene polymer (Teflon) can be applied to the surface of drum 11, either as a coating or as a sleeve, and in combination with silicone oil will serve to prevent such migration of the toner particles. Applicant has found that coating the peripheral surface of drum 11 with silicone varnish and applying silicone oil to the coated surface also provides a combination of material and liquid which will effectively prevent toner migration. As shown in FIG. 1, the silicone varnish layer is designated by the numeral 50 and the offset-preventing liquid, such as silicone oil, is contained in a well 51 and applied to and across the width of the silicone varnish layer on drum 11 by means of a wick 52. Flurocarbon surfactants can also be applied to the peripheral surface of drum 11 to prevent migration of the toner particles. One of the prime requisites of the offset-preventing material and liquid is that both must be good transmitters of radiation and, secondly, that no chemical reaction occurs in the range of temperatures necessary for fusing the toner particles. Both silicone varnish and silicone oil meet these requirements. Applicant has also found that a flurocarbon monomer can be used as a transparent layer on drum 11 to prevent toner migration and that hydrogenated vegetable oil and glyceride can be used as an offset-preventing liquid.

In using the fusing device described hereinabove, switch 55 is first closed to energize motor 20, thereby rotating drum 11 and roll 12 through gears 22 and 27, and heating elements 40 and 46, the latter elements being controlled by a thermostatic control T which limits the heat to be generated to a standby requisite. When a carrier to be fused is moved toward the drum, the leading edge first engages the switch 36, thereby closing its contacts 36A and 36B. The solenoid 33 is then energized (contact 36A) and moves roll 12 into cooperative relationship with drum 11 so that both are rotating in synchronism prior to engaging the carrier 10. Thermostatic control T is shorted out (contact 36B) to provide heating elements 40 and 46 with full line voltage to provide the necessary heat output for fusing. As the carrier moves toward the fusing station, the toner particles are first heated by element 46 and then by the heat generated by heating element 40 and focused thereon by reflector 42, so that by the time the toner particles are engaged by drum 11, they are tackified to the extent that they need only be squeezed together and pressed into the surface of carrier 10 by drum 11 and roll 12 to complete the fusing operation. It will be obvious to those skilled in the art that because of the heat applied to the toner particles prior to engagement by drum 11, the temperature of the transparent sleeve 13 need not be as high as would normally be required if only the drum 11 were accomplishing the complete fusing of the toner image. The distance between the line of contact of drum 11 and roll 12 and the focal line F2 of reflector 42 can be varied to provide optimum fusing in accordance with the rate of movement of the carrier 10, for example, with a distance of about one-quarter inch between the line of contact of drum 11 and roll 12 and the focal line F2, the linear speed of carrier 10 can be about 10 inches per second.

The invention has been described in detail with particular reference to preferred embodiments thereof, but it will be understood that variations and modifications can be effected within the spirit and scope of the invention as described hereinabove and as defined in the appended claims.

I claim:

1. A device for fusing an electroscopic toner image to the surface of a carrier bearing said toner image, comprising:

a rotatable, substantially thermally-transparent drum;

a movable member for engaging said carrier in cooperation with said drum along a line of contact generally parallel to the axis of said drum and for moving said carrier along a predetermined path therebetween with the image bearing surface of said carrier facing said drum;

means for moving said drum and member in synchronism;

a heating element mounted within said drum; and

means arranged relative to said heating element and within said drum for focusing the heat generated by said heating element through said drum and substantially into a line lying in a plane generally corresponding to the plane of movement of the image bearing surface along said path, said line of focused heat being disposed generally parallel to said line of contact and upstream therefrom relative to the direction of movement of said carrier;

whereby said toner image is heated sufficiently to at least partially tackify the toner particles prior to engagement thereof by said drum for fusing to said carrier.

2. A fusing device in accordance with claim 1 wherein said movable member comprises a roll having a heat reflecting medium in close proximity to said drum.

3. A fusing device in accordance with claim 1 wherein said heating element is elongated and said focusing means comprises an elongated, elliptical surface having one focal line generally coincident with the axis of said heating element and the other focal line lying outside of said drum and generally coincident with the plane of movement of said image bearing surface.

4. A fusing device in accordance with claim 1 wherein said heating element is elongated and said focusing means comprises an elongated, elliptical surface having the major axial plane thereof disposed angularly about the axis of said heating element in a direction opposed to the direction of movement of said carrier, one focal line of said elliptical surface being within said drum and generally coincident with the axis of said heating element and the other focal line lying outside of said drum and generally coincident with the plane of movement of said image bearing surface.

5. A fusing device in accordance with claim 1 including a second heating element disposed in close proximity to the plane of movement of the image bearing surface of said carrier and positioned to preheat said toner image at a location upstream relative to the direction of movement of said carrier from the location at which said line of heat is focused on said image bearing surface by said reflector means.

6. A device for fusing an electroscopic toner image to the surface of a carrier bearing said toner image, comprising:

a rotatable, substantially thermally-transparent drum having a substantially thermally-transparent layer of offset-preventing material on its peripheral surface;

a rotatable, resilient roll for engaging said carrier in cooperation with said drum along a line of contact generally parallel to the axis of said drum and for moving said carrier along a predetermined path therebetween with the image bearing surface facing said drum;

means for rotating said drum and said roll in synchronism;

an elongated, radiant heating element mounted within said drum with its axis generally parallel to the axis of said drum;

reflector means arranged relative to said heating element and within said drum for focusing the heat generated by said heating element through said drum and substantially into a line lying in a plane generally corresponding to the plane of movement of the image bearing surface of said carrier along said path, said line of focused heat being disposed generally parallel to said line of contact and upstream therefrom relative to the direction of movement of said carrier;

whereby said toner image is heated sufficiently to at least partially tackify the toner particles prior to engagement thereof with said drum for fusing to said carrier.

7. A fusing device in accordance with claim **6** including means for applying an offset-preventing liquid to the offset preventing material on said drum.

8. A fusing device in accordance with claim **7** wherein said transparent layer is a tetrafluroethylene polymer and said said offset-preventing liquid is a silicone oil.

9. A fusing device in accordance with claim **7** wherein said transparent layer consists of one of a tetrafluroethylene polymer, a silicone varnish and a flurocarbon monomer, and said offsetting liquid consists of one of silicone oil, a hydrogenated vegetable oil and a glyceride.

10. A fusing device in accordance with claim **6** including a second heating element disposed in close proximity to the plane of movement of the image bearing surface of said carrier and positioned to preheat said toner image at a location upstream relative to the direction of movement of said carrier from the location at which said line of heat focused on said image bearing surface by said reflector means.

11. A device for fusing an electroscopic toner image to the surface of a carrier bearing said toner image, comprising:

a rotatable, substantially thermally-transparent drum having a layer of substantially thermally-transparent offset-preventing material on its peripheral surface;

a rotatable, resilient roll movable between a first position in which it is disengaged from said drum and a second position in which it contacts said drum along a line generally parallel to the axis of said drum, said roll being displaceable from said drum when said carrier is moved therebetween for moving the latter along a predetermined path with the image bearing surface of said carrier facing said drum;

means responsive to actuation by the leading edge of said carrier for moving said roll from said first position toward said second position;

an elongated, radiant heating element mounted within said drum with its axis generally parallel to the axis of said drum; and

reflector means arranged relative to said heating element and within said drum for focusing the heat generated by said heating element through said drum and substantially into a line lying in a plane generally corresponding to the plane of movement of the image bearing surface along said path, said line of focused heat being disposed generally parallel to said line of contact and upstream therefrom relative to the direction of movement of said carrier;

whereby said toner image is heated sufficiently to at least partially tackify the toner particles prior to engagement thereof with said drum for fusing to said carrier.

12. A fusing device in accordance with claim **11** including means for applying an offset-preventing liquid to said layer of offset-preventing material on the peripheral surface of said drum.

13. A fusing device in accordance with claim **11** wherein said reflector means comprises an elongated, generally semi-elliptical surface having one focal line generally coincident with the axis of said heating element and the other focal line lying outside of said drum and generally coincident with the plane of movement of said image bearing surface.

14. A fusing device in accordance with claim **11** including a second elongated heating element disposed in close proximity to the plane of movement of the image bearing surface of said carrier and positioned to preheat said toner image at a location upstream relative to the direction of movement of said carrier from the location at which said line of heat is focused on said image bearing surface by said reflector means.

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