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Ohta et al.

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[54] **PROCESS AND DEVICE FOR HEATING AND FIXING AN IMAGE UPON A RECORDING MEDIUM**

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[73] Assignee: **Ricoh Co., Ltd.,** Tokyo, Japan

[22] Filed: **Aug. 8, 1972**

[21] Appl. No.: **278,832**

Related U.S. Application Data

[63] Continuation-in-part of Ser. No. 85,184, Oct. 29, 1970, abandoned.

[52] **U.S. Cl.** **432/227,** 34/4, 219/354, 219/216, 432/59

[51] **Int. Cl.** **F27b 9/28**

[58] **Field of Search** 432/60, 62, 228, 59, 9, 432/13, 227; 219/216, 354, 388, 411; 34/4, 1; 350/311, 319

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Assistant Examiner—Henry C. Yuen
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[57] **ABSTRACT**

An endless belt arranged to travel around a source of infrared radiation is used in fixing an image on a recording medium as the recording medium is advanced past the belt. The belt, driven in the direction of advance of the recording medium by a drive roller spaced away from the infrared radiation source, passes between the infrared radiation source and the recording medium; the belt prevents contact of the medium with the source while permitting radiation from the source to heat and fix the image on the advancing recording medium.

3 Claims, 14 Drawing Figures

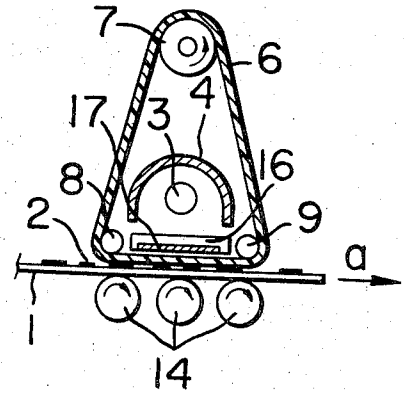


FIG. 1 PRIOR ART

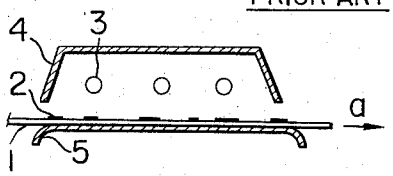


FIG. 2

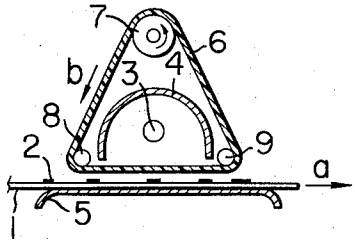


FIG. 3

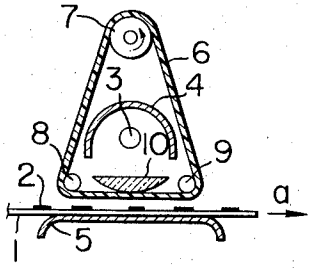


FIG. 4

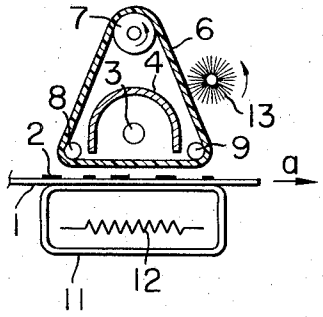


FIG. 5

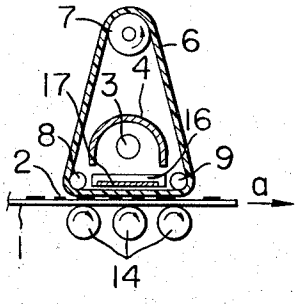
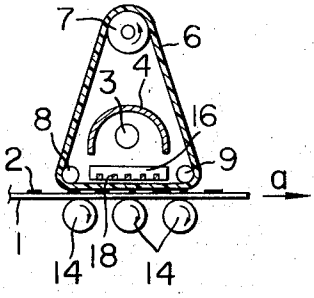


FIG. 6



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FIG. 7
PRIOR ART

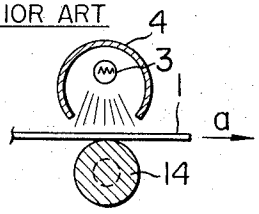


FIG. 8
PRIOR ART

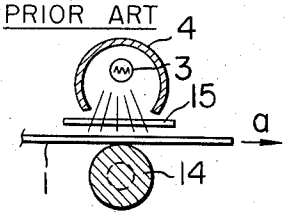


FIG. 9

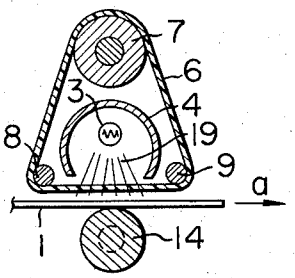


FIG. 10

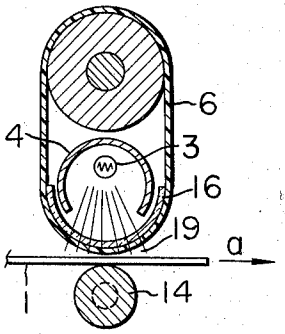


FIG. 11

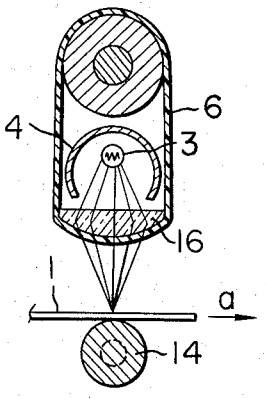


FIG. 12

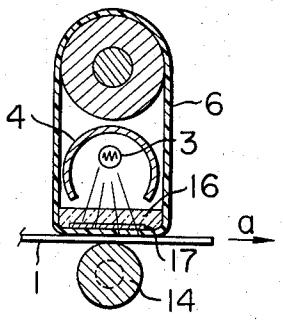


FIG. 13

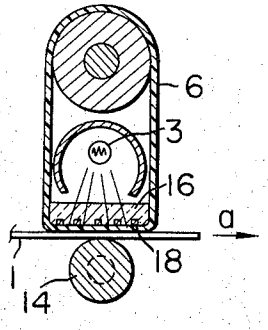
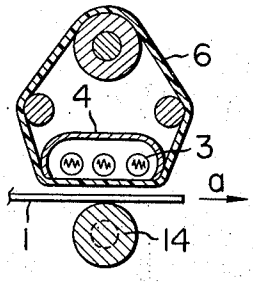


FIG. 14



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PROCESS AND DEVICE FOR HEATING AND FIXING AN IMAGE UPON A RECORDING MEDIUM

CROSS REFERENCE TO RELATED APPLICATION

This application is a continuation-in-part of applicants' copending application, Ser. No. 85,184 filed Oct. 29, 1970 (now abandoned).

BACKGROUND OF THE INVENTION

The present invention relates to the heating and fixing of an image upon a recording medium and more specifically to procedure and apparatus for fixing a visible image by heat in a dry electrophotographic process or in a thermographic process.

Heat is generally employed for fixing a visible image such as (for example) an image formed by toner containing easily fusible resin in a dry electrophotographic process. In a typical heat-fixing procedure, the image is heated to a temperature between 100°C and 150°C, so as to be fused, by exposure to an infrared ray lamp, a halogen lamp, a nichrome wire, or other suitable heat source. However, this procedure has disadvantages in that the time required for raising the temperature of the visible image to a fixing temperature is relatively long; the thermal efficiency is low; and other parts of the apparatus are heated. To overcome these problems, there have been proposed various methods, but none has been particularly successful in reducing the rise time for reaching the fixing temperature and accomplishing fully satisfactory fixing at high speed.

SUMMARY OF THE INVENTION

One of the objects of the present invention is to overcome the problems of the prior art processes and devices described above.

Another object of the present invention is to provide an arrangement in which a recording medium is kept out of direct contact with a heating means and is prevented from being overheated.

Another object of the present invention is to provide an arrangement for preventing adherence of toner to an endless belt, in a device utilizing such belt for protecting the recording medium from contact with heating means.

Another object of the present invention is to provide an arrangement, in a device of the character just mentioned, for facilitating the easy removal of any toner that may become adhered to the endless belt.

Another object of the present invention is to prevent overheating of the endless belt.

According to one aspect of the present invention, a nonadhesive endless belt is used in heating an image formed by heat-fixable toner upon a recording medium as the medium is advanced along a defined path past the belt. The endless belt travels around a heating means, e.g., a source of infrared radiation incorporated in a heating roller or disposed in proximity to a belt-engaging guide element. The belt also travels around a drive roller which is spaced apart from the heating roller or guide element so that the belt may be suitably cooled by the time it returns to the locality of the infrared radiation source during each cycle of belt travel, i.e., to prevent overheating of the belt. The belt, which is driven in the direction of advance of the recording medium, may be brought into direct contact with the recording medium or may be spaced apart therefrom by a suitable distance. Preferably a rotary cleaning brush may be in contact with the belt for removal of any toner and/or other contaminants that may become adhered to the belt. This arrangement is especially advantageous when the belt is brought into direct contact with the recording medium.

Stated in other words, in the method and device of the present invention, an image to be fixed is directly heated with infrared radiation from an appropriate source that directs the radiation through a moving belt toward the image as an image-bearing recording medium advances along a defined path. The function of the belt in the present invention is to prohibit contact of the recording medium with the infrared radiation source while permitting radiation from the source to heat and fix the image on the medium. That is to say, the belt is of such character as to permit significant transmission of infrared radiation therethrough, i.e., from the source onto the image-bearing recording medium, so that radiation from the source can pass through the belt to heat the image directly, as desired to achieve especially rapid heating. The belt itself is also heated by the source, and heat radiated (when the belt is spaced from the recording medium) or conducted (when the belt is in contact with the recording medium) from the belt cooperates with infrared radiation transmitted through the belt from the source in heating the toner image on the recording medium.

A supplemental or preliminary heating means may be provided in order to improve the temperature rise of the endless belt, and thereby to enhance the fixing speed, by preheating the belt to a constant predetermined temperature so that the belt temperature may be essentially immediately further raised by the principal heat source to a temperature for cooperating in fusing the toner.

While illustrative reference has been made above to the heating of images formed by toner, a device in accordance with the present invention may be used for heating a heat-sensitive substance such as, for example, a heat-sensitive paper or a stencil.

The present invention will become more apparent from the following description of the preferred embodiments taken in conjunction with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a sectional side elevational view of one type of prior art device for heating and fixing an image upon a recording medium;

FIG. 2 is a sectional side elevational view of a device embodying the present invention in a particular form;

FIG. 3 is a view similar to FIG. 2 of another embodiment of the invention;

FIG. 4 is a view similar to FIG. 2 of a further embodiment of the invention;

FIG. 5 is a similar view of still another embodiment of the invention;

FIG. 6 is a similar view of a further embodiment of the invention;

FIG. 7 is a sectional side elevational view of a second form of prior art device for heating and fixing an image on a recording medium;

FIG. 8 is a similar view of another prior art device similar to that of FIG. 7 but incorporating a stationary guide;

FIG. 9 is a sectional side elevational view of a further embodiment of the invention;

FIG. 10 is a similar view of another embodiment of the invention;

FIG. 11 is a further similar view of another embodiment of the invention;

FIG. 12 is a still further similar view of another embodiment of the invention;

FIG. 13 is another similar view of another embodiment of the invention; and

FIG. 14 is a still further similar view of another embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

In FIG. 1 to FIG. 14, same parts are designated by same reference numerals.

FIG. 1 is a schematic diagrammatic view illustrating a prior art heating and fusing device. A visible image (toner image) 2 to be fixed is formed upon a recording medium 1. The recording medium 1 is, for example, an electrophotosensitive member coated with a special zinc oxide with resin binder, an electrostatic recording member or an ordinary paper upon which is transferred a visible image. Upon advancement of the recording medium 1 in the direction indicated by the arrow *a*, the radiation rays from a heat source 3 such as an infrared ray heater heat the toner image 2 and fuse and fix it to the recording medium 1. The heater 3 is provided with a reflector 4 in order to attain a high thermal efficiency. The recording medium is advanced upon a guide 5 by a belt (not shown) and feed rollers (also not shown) located in the forward side and in the rear side of the heating and fusing device. The disadvantage of this arrangement is that the toner image 2 absorbs a large amount of heat from the heater 3, so that the recording medium 1 is expanded or compressed. Therefore, the recording medium 1 is curled and brought into contact with the heater 3 so that the recording medium 1 is burnt or scorched.

FIG. 2 illustrates a device embodying the present invention and adapted to heat and fix a toner image on a recording medium such as the image 2 on medium 1 already described with reference to FIG. 1. This device includes a source 3 of infrared radiation partially surrounded by a reflector 4 to enhance thermal efficiency. The recording medium 1 bearing the toner image 2 is advanced in the direction indicated by the arrow *a* upon a guide member 5 by suitable means (not shown), again as in the device of FIG. 1. The reflector 4 directs radiant energy from the source 3 toward the recording medium upon guide member 5.

In accordance with the invention, in the device of FIG. 2 there is provided an endless belt 6 fabricated of a material which is substantially transmissive to infrared radiation from source 3, which is thermostable at the temperatures encountered in operation of the device, and which is non-adhesive. One example of a suitable type of belt is a belt made of polyfluoroethylene fiber. Another example, having similar effectiveness for fixing toner images, is a belt having a thickness of about 0.5 mm. made of the material commercially available under the trade name "Daiflon," manufactured by Daikin Kogyo KK. The belt is wrapped around a drive roller 7 and a pair or guide rollers 8 and 9. The guide rollers are disposed in adjacent relation to the infrared radiation source 3 on opposite sides thereof, respectively, while the drive roller 7 is spaced apart from the source 3 and from the guide member 5 for the recording medium. The belt is driven, by the drive roller, in the direction indicated by arrow *b* at the same speed as that of the recording medium 1 advancing in the direction *a*.

As the recording medium 1 advances upon the guide member 5 along the defined path indicated by arrow *a*, the portion of the belt 6 between the guide rollers 8 and 9 is advancing in the same direction and at the same speed, this portion of the belt being then interposed between the source 3 and the recording medium 1 upon the guide member 5. That is to say, the source 3 and guide member 5 are positioned in opposed relation with respect to the belt 6. The source 3 directs infrared radiation through the portion of the belt advancing between the rollers 8 and 9, and the toner image 2 on the correspondingly advancing recording medium 1 is fused and fixed by this radiation which passes through the belt. At the same time, radiant energy from source 3 heats the portion of the belt interposed between the source and the recording medium, and heat radiated from the belt (i.e., when the belt is spaced from the recording medium) cooperates with the radiation transmitted through the belt (directly from the source) in heating and fusing the toner image; if the belt is arranged to be in contact with the recording medium, heat conducted from the belt cooperates with radiant infrared energy passing through the belt from the source in heating and fusing the image. As the heated belt then travels away from the source 3 and over the drive roller 7, which is spaced apart from the source, it loses heat; in this way, excessive heating of the belt is prevented, because during each complete traverse the belt is carried away from the source 3 owing to the disposition of roller 7 in relation to the source 3.

The belt, during its advance between the rollers 8 and 9, may either be pressed against the recording medium 1 or spaced apart therefrom. If the belt were stationary, especially when in contact with the recording medium, the fusing toner image would tend to adhere to the belt and thereby might be distorted; furthermore, if the belt were stationary, the high temperature to which it would be heated by the source 3 would subject the belt to expansion and contraction adversely affecting the durability of the belt. These problems are avoided by operating the drive roller to rotate the belt in the manner described above.

In the embodiment illustrated in FIG. 3, a condenser lens 10 is interposed between the source 3 and the endless belt 6 for directing radiation from the source through the belt, thereby preventing the dispersion of the radiant energy and improving the thermal efficiency.

In the embodiment illustrated in FIG. 4, a preliminary or supplementary heater 11 (shown as replacing, and serving the function of, guide member 5) is located in opposed relation to the source 3 in order to prevent delay in temperature rise owing to heat absorption by the recording medium 1. The preliminary heater 11 is heated by a heating element 12 to a temperature from 50° – 90°C, or to a temperature about 20°C lower than the fusing temperature of the toner. Therefore, when the recording medium 1 is fed between the endless belt

6 and the preliminary heater 11, it may be immediately heated so that its temperature rise may be improved. The endless belt 6 is continuously cleaned by a cleaning device 13 and is applied with a charge of polarity opposite to that of the toner image 2 so that the toner may be easily removed from the endless belt 6. The cleaning device is, for example, a brush, a soft roller, etc. In addition, a thermostable agent for preventing the adhesion of the toner image, such as silicon oil, may be applied upon the endless belt 6.

FIG. 5 illustrates an embodiment of the invention in which a member 16 formed of thermostable glass (i.e., a glass that is thermostable at the temperatures encountered in operation of the device) is interposed between the infrared radiation source 3 and the belt 6, and has incorporated in it a preliminary or supplementary heating means. Specifically, in FIG. 5 the member 16 incorporates a portion 17 of the glass commercially available under the trade name "Nesa" which is an electrically conductive glass. Current from a suitable source (not shown) is made to flow through the conductive glass surface 17 in order to generate the Joule heat. The recording medium 1 is brought into contact with the belt 6 and is advanced in the direction indicated by the arrow *a* at the same speed as that of the belt 6 by feed rollers 14.

FIG. 6 illustrates an embodiment having a heating element 18 comprising a nichrome wire embedded in grooves of the thermostable glass member 16. In other respects, the device of FIG. 6 is similar to that shown in FIG. 5.

The spacing between the belt 6 and the recording medium 1 may be 0 to 20 mm. If the recording medium 1 is made of a paper which tends to be deformed by heat, the feed rollers 14 may be made of an elastic substance and the recording medium may be advanced in contact with the belt 6. When the recording medium 1 is made of a metal or metal laminate which will not be deformed by heat, it is preferable to provide a spacing between the belt 6 and the recording medium 1.

The prior art heating and fusing device shown in FIG. 7 employs a roller 14 for feeding the recording medium instead of the fixed guide 5 shown in FIG. 1. The prior art device illustrated in FIG. 8 is similar to that of FIG. 7 but includes a fixed guide 15 interposed between the infrared radiation source 3 and the path of advance of the recording medium 1. Because the guide 15 is held stationary, it is heated to a high temperature. Consequently, its durability is adversely affected. Furthermore, toner tends to adhere to the guide 15 and as a result the image on the recording medium may be distorted when it makes contact with the guide 15.

FIGS. 9 – 14 illustrate further embodiments of the present invention employing an endless infrared radiation-transmissive belt 6 in order to eliminate the defects encountered in the prior art device of the type shown in FIG. 8. In the device illustrated in FIG. 9, the endless belt 6 is wrapped around the rollers 7, 8 and 9 and the recording medium 1 is fed between the flat undersurface of the endless belt 6 and the feed roller 14 so that the toner image may be fused by the radiation rays irradiated from the infrared source 3, which pass through the belt to melt the toner image directly.

In the embodiments of FIGS. 10 – 13, a transparent member 16 interposed between the source 3 and the belt 6 serves as a guide for the belt in place of the guide rollers 8 and 9 and may also serve as a concentrating lens and/or supplementary heating means. The device of FIG. 10 includes a curved guide member 16 replacing the rollers 8 and 9 of FIG. 9. This member 16 is made of a material such as a glass commercially available under the trade name "Pyrex" having a small coefficient of friction, and the belt 6 is wrapped around the stationary guide member 16. In this embodiment, the infrared source 3 is surrounded by the reflector 4 and the curved guide member 16 so that the thermal efficiency may be further improved.

In the device illustrated in FIG. 11, instead of the curved guide member 16 shown in FIG. 10, a partially cylindrical lens is employed so that the radiation rays from the source 3 may be concentrated through the belt along a line or in the form of a band upon the recording medium.

In the device illustrated in FIG. 12, the thermostable glass member 16 has an electroconductive "Nesa" glass portion 17 which is energized so that the glass 16 may be preheated to a temperature of 50° – 80°C.

In the device illustrated in FIG. 13, a suitable heating element 18 such as nichrome wire is embedded in the thermostable glass 16 so that it may be preheated to a temperature of 50° – 80°C.

In the device shown in FIG. 14, the reflector 4 is used as a guide member for the endless belt 6 so that the infrared radiation source 3 may be placed in a closely spaced apart relation relative to the feed roller 14. Consequently, the fixing process may be accomplished with lower wattage. In this embodiment, the preliminary heater such as one shown in FIGS. 12 and 13 may be eliminated.

The feed roller 14 for transporting the recording medium 1 has preferably a peripheral speed equal to that of the endless belt 6.

What is claimed is:

1. A device for heating and fixing an image upon a recording medium advancing in a given direction along a defined path, comprising

a. heating means comprising a source of infrared radiation for directing said radiation toward an image-bearing surface of a recording medium advancing along said path;

b. an endless belt substantially transmissive to infrared radiation for prohibiting contact of the recording medium with said source while permitting said radiation to heat and fix an image on the medium, said belt being disposed adjacent said path between said path and said source;

c. means for driving said belt in said given direction, said belt being arranged to travel around said heating means and said driving means;

d. a guide member disposed in opposed relation to said heating means with respect to said belt;

e. said source being a source of radiant energy disposed in spaced relation to said belt; and

f. a condenser lens interposed between said radiant energy source and said endless belt for condensing radiant energy from said source through said belt.

2. A device for heating and fixing an image upon a recording medium advancing in a given direction along a defined path, comprising

a. heating means comprising a source of infrared radiation for directing said radiation toward an image-bearing surface of a recording medium advancing along said path;

b. an endless belt substantially transmissive to infrared radiation for prohibiting contact of the recording medium with said source while permitting said radiation to heat and fix an image on the medium, said belt being disposed adjacent said path between said path and said source;

c. means for driving said belt in said given direction, said belt being arranged to travel around said heating means and said driving means;

d. a guide member disposed in opposed relation to said heating means with respect to said belt; and

e. supplemental heating means for heating said guide member to and maintaining said member at an elevated temperature lower than the temperature required for fixing the image on the recording medium, said supplemental heating means comprising a transparent member interposed between said first-mentioned heating means and said belt in facing relation to said guide member, and means in said transparent member for producing heat.

3. In apparatus for heating and fixing an image upon a recording medium, in combination,

a. means for guiding an image-bearing recording medium in a given direction along a defined path;

b. heating means comprising a source of infrared radiation for directing said radiation toward an image-bearing surface of a recording medium advancing along said path;

c. an endless belt substantially transmissive to infrared radiation for prohibiting contact of the recording medium with said source while permitting said radiation to heat and fix an image on the medium, said belt being disposed adjacent said path between said path and said source;

d. means for driving said belt in said given direction, said heating means, said belt and said guiding means being mutually disposed and adapted such that an image formed on a recording medium advancing along said path is exposed to and fixed by heat from said belt;

e. said heating means being disposed and adapted to heat preferentially the portion of said belt positioned at a locality close to said path, and said belt being arranged to move between said first-mentioned locality and a second locality spaced away from said heating means, the preferentially heated portion of the belt being interposed between said heating means and said path; and

f. means disposed adjacent said heating means for guiding said belt past said heating means and in spaced relation thereto, said heating means comprising a source of radiant energy, and said belt-guiding means being a fixed transparent member interposed between said radiant energy source and said belt and engaging said belt and adapted to permit transmission of radiant energy from said energy source to said belt.

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