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**Garbe** [45] **Mar. 14, 1972**


[54] **FUSING DEVICE**


[72] Inventor: **William F. Garbe**, Penfield, N.Y.

[73] Assignee: **Eastman Kodak Company**, Rochester, N.Y.



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[52] **U.S. Cl.** ....................**219/216,** 219/388, 250/65 ZE

[51] **Int. Cl.** ....................**H05b 1/00**

[58] **Field of Search**....................219/216, 345, 388, 353, 354, 219/461; 13/25; 108/637; 263/6 E; 338/316; 250/65 ZE, 65 T; 117/17.5



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*Primary Examiner*—C. L. Albritton
*Attorney*—W. H. J. Kline, P. R. Holmes and T. Hiatt


[57] **ABSTRACT**


A radiant-energy fusing device for fixing resinuous marking material to a support element is comprised of a partially enclosed chamber and a heater means formed of at least one thin metal strip having one surface which is treated to enhance heat emission in the wavelength region of absorption of the element and the other surface is treated to minimize all radiation.


**11 Claims, 2 Drawing Figures**

*FIG. 1*

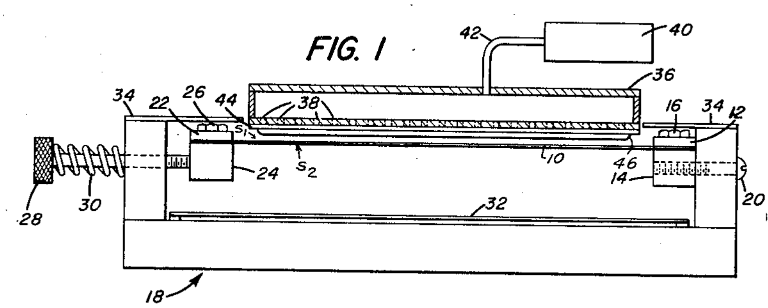

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FIG. 1

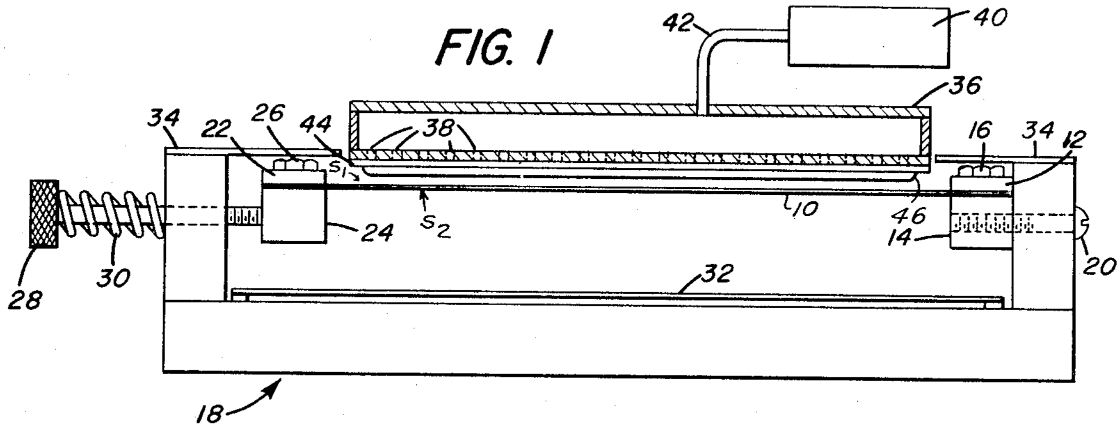
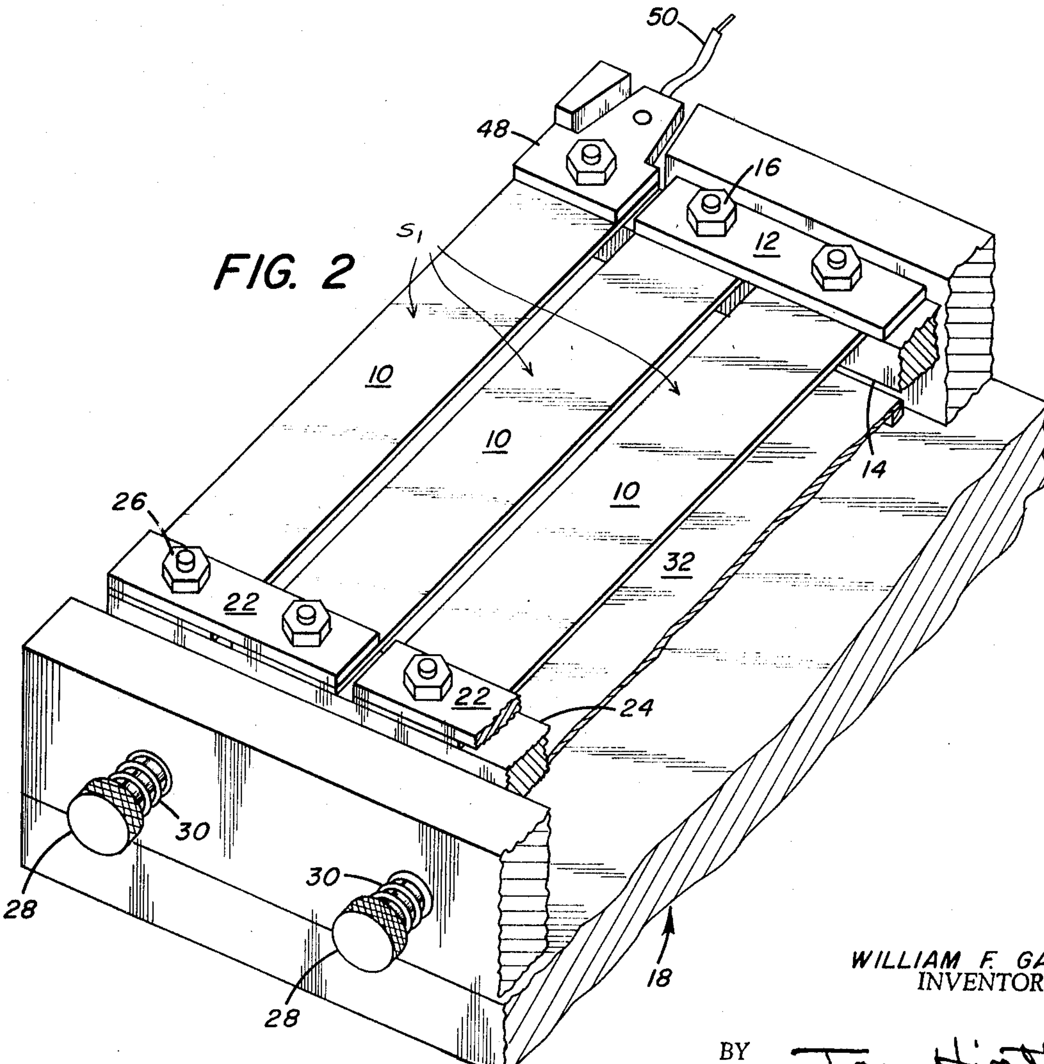



FIG. 2




WILLIAM F. GARBE
INVENTOR.

BY Tom Hiatt

ATTORNEY

# FUSING DEVICE

## FIELD OF THE INVENTION

The present invention relates to electrophotography and particularly to apparatus for fixing resinous marking material to a surface of a moving support element, and more particularly to a radiant-energy fusing device having very fast access time with low power requirements that comprises at least one thin metal strip, treated on the fusing side to increase energy emission in the preferred wavelength band and treated on the back side to minimize all radiation.

## DESCRIPTION OF THE PRIOR ART

A common method by which an electrophotographically formed powder image is fixed is by heat fusing, that is, by the application of heat to the powder image which must be formed of a thermoresponsive material, such as a heat-fusible resin, which flows without image distortion when heated and which coalesces and adheres to the surface when cooled to ambient temperature.

In order to fuse resinous powder images, it is necessary to heat the powder and the paper to which it is to be fused to a relatively high temperature. For given materials a temperature range exists in which fusing will be produced. Below that temperature range the resinous powder will not properly adhere to the support surface. If the temperature is too high, there is a tendency for the support material to discolor or scorch and in some cases for the toner to explode or be vaporized.

Various techniques have been developed for fusing in prior art. Among these are oven fusing, hot-air fusing, radiant fusing, hot and cold pressure roll fixing and fusing, and flash fusing. Each of these techniques by itself has suffered from limitations and deficiencies which made them inapplicable for certain specific fusing jobs which are required in xerographic technology. In general, it has been difficult to achieve an entirely satisfactory design of heat fusers with regard to short warm-up time, low electric current requirements, adequate heat insulation and uniform heat distribution. Specifically, hot-air and oven systems tend to be slow and involve high power consumption. Hot and cold pressure systems have presented problems of offsetting, resolution degradation, poor fixing and limited quality.

Flash fusing has been desirable for some time since it is very efficient at slow or intermittent reproduction speeds but still suitable for high-speed copying. A major problem with flash fusing as known in the prior art has been that it was not selective. Since the term "selective" has been used in various ways in connection with fusing processes in the past, it should be clearly understood that it is herein referred to as the preferential fusing of dense image areas leaving low-density or background areas unfused.

In U.S. Pat. No. 3,449,546 by P. S. Dhoble, issued June 10, 1969, a xerographic fusing apparatus is disclosed for simultaneously heating a xerographic powder image and a paper support material to different temperatures with infrared radiation, the fusing apparatus having the capability of efficiently heating the powder image to its fusing temperature while at the same time heating, without deleterious effects, the paper support material to a different temperature wherein the paper acts as a heat source to aid in the fusing process.

Radiation sources conventionally used in xerographic fusing apparatus are of two general types, both of which have several shortcomings which make them essentially not feasible for commercial use. One type uses one or more linear filament incandescent lamps and a reflector to direct the radiated energy to the paper. Since the radiating surface of the filament of such a lamp is quite small, it must be operated at a high temperature to emit enough energy to fuse the image in a practical time. Most of the energy emitted by such a high-temperature filament is in the spectral region from 0.5 to 2.0 microns which is not well absorbed by ordinary papers, thus such a source is inefficient for heating paper and, in addition, is a fire hazard.



The second type of radiation fuser is an enclosure, or oven, of rather large surface area, whose walls are maintained at a relatively low temperature by conventional electrical strip heaters. Such a fuser produces primarily long wave length infrared radiation which is well absorbed by the paper, but the fuser requires a long time to heat up to the operating temperature and thus must be kept hot when in a standby condition. This type of fuser is also a fire hazard since it operates above the ignition temperature of the paper. Thus both the incandescent filament and the oven are commercially unattractive types of fusers.

## SUMMARY OF THE INVENTION

One object of the invention is to provide a radiant-energy fusing device for fixing resinous marking material to a surface of a moving support element that attains a high efficiency by radiating primarily those wave lengths which are well absorbed by the support element.

Another object of this invention is to provide a radiant-energy fusing device for fixing resinous marking material to the surface of a moving support element that attains high efficiency by radiating primarily in the direction of the support element, thus reducing losses to the machine surroundings.

Another object of this invention is to provide a radiant-energy fusing device for fixing resinous marking material to the surface of a moving support element that has a low fire hazard.

Another object of this invention is to provide a radiant-energy fusing device for fixing resinous marking materials to the surface of a moving support element that provides uniform fusing for the resinous marking material over the entire surface of the support element.

Still another object of this invention is to provide a radiant-energy fusing device for fixing resinous marking material to the surface of a moving support element that does not have a standby power requirement so that the device can be used without delays.

A further object of this invention is to provide a radiant-energy fusing device whose radiating properties do not deteriorate when dirt, toner, etc., collect on the radiating surface.

Yet another object of this invention is to provide a radiant-energy heating device that has a very short warm-up time with low power requirements.

These and other objects and advantages will be readily apparent to those skilled in the art by the detailed description that follows of the invention.

The objects of the invention are attained by utilizing a partially enclosed chamber through which a support element is advanced in a predetermined path. A heater element is mounted within the chamber and disposed for directing heat radiation towards the support element. The heater comprises at least one thin metal strip having one surface adjacent to the path of the support element and treated to enhance heat emission in the wave-length region of absorption of the support element and its second surface being treated to minimize such radiation therefrom.

Throughout the specification and claims, reference is made to a resinous marking material. This term is meant to include not only an image formed by dry developers such as those used in a cascade development process, but also by those developers used in a liquid development process.

Throughout the specification and claims, reference is made to a support element. This term is meant to include not only paper, but other suitable support materials such as polymeric materials, provided that these materials have appropriate thermal properties so that they will not melt or be adversely affected during processing.

## DESCRIPTION OF THE DRAWINGS

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

FIG. 1 is a schematic cross-sectional representation of the fusing device in accordance with the invention;

FIG. 2 is a schematic perspective representation of the fusing device shown in FIG. 1 showing the arrangement of the heater strips.

## DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now to FIG. 1, the fusing device embodying this invention consists of at least one treated, thin metal strip 10 electrically connected at both ends with bus bars 12 and 22. One end of strip 10 is held between bus bar 12 and a fixed heater support bar 14 by connecting means 16. The fixed heater support bar 14 is rigidly attached to fuser chamber 18 by screw means 20. The opposite end of heater strip 10 is spring-mounted onto fuser chamber 18 by tensioning means comprised of spring 30 and movable support rod 28 which is attached to support bar 24. Strip 10 is clamped or otherwise held between support bar 24 and bus bar 22 by connecting means 26. The tensioning means thereby maintains heater strip 10 in tension regardless of expansion of strip 10 due to rapid temperature changes. Reflector 32 is arranged at the bottom of fuser chamber 18 to contain the radiant heat in the fusing area. Strips 34 of an electrical- and heat-insulating material such as asbestos, etc., are attached by means not shown to fuser chamber 18 to keep the heat in the fuser assembly as well as for electrical insulation from bus bars 12 and 22. Fuser chamber 18 is made of an insulating material to avoid transmission of heat given off by heater strip 10 to the rest of the apparatus. Fuser chamber 18 can be formed of any of a variety of known rigid, heat-insulating materials. Fixed heater support bar 14 and movable heater support bar 24 are also made of insulating materials such as those useful in preparing the chamber 18.

Arranged above heater strip 10 having surfaces $S_1$ and $S_2$ is a conveying means for advancing a support element 46 carrying a pattern of resinous marking material held thereon by electrostatic attraction. Element 46 is advanced in a predetermined path within chamber 18. In the embodiment shown there is arranged above heater strip 10 a vacuum plenum 36 having holes 38, as is well-known in the art, which plenum is connected to the input side of a centrifugal blower 40 by a line 42. A movable, porous reflecting transport belt 44 of low thermal capacity and low thermal conductivity is arranged below the bottom surface of the vacuum plenum 36 in order to advance the element to be fused through the chamber in a predetermined path adjacent strip 10. Drive means for belt 44 are not shown. A pattern of resinous material is formed on element 46 by any standard electrophotographic means. The element 46 is positioned on and supported by the transport belt 44 with the surface bearing the pattern of resinous material oriented towards heating strip 10. The element 46 is maintained in position on the transport belt 44 by the vacuum applied to vacuum plenum 36.

FIG. 2 shows a partial view of a preferred embodiment which contains a plurality of heater strips 10 mounted as described above. The individual strips 10 are attached in electrical series as shown in FIG. 2. The strips 10 are maintained in tension by tensioning means as desCribed above. In addition, strips 10, which are maintained in a substantially parallel relationship, are mounted so as to extend transverse to the path of element 46 (not shown in FIG. 2).

The individual strips 10 are treated on the surface $S_1$ adjacent the path of element 46 in order to enhance heat emission in the wavelength region of absorption of element 46. The treatment of this first surface $S_1$ can be a purely physical treatment such as roughening of the surface by sandblasting, acid etching, etc. In addition, the surface $S_1$ can be overcoated with an infrared absorbing material such as a deposit of black colloidal gold or other high-temperature black finishes. Particularly useful are overcoats comprised of a suspension of carbonaceous material in an organic resin capable of withstanding temperatures in excess of about 480° C. An example of such a coating would be a suspension of a graphite in a silicone epoxy resin similar to various high-temperature black paints sold by the Rust-Oleum Corp., for example. Of course, the surface $S_1$ can be both physically treated and overcoated in order to increase the appropriate emittance. Preferably, this first surface $S_1$ is treated to have a maximum radiation emission in the wavelength region of maximum absorption of the element 46.

The opposite or second surface $S_2$ of strips 10 is treated to minimize the radiation of heat. This treatment can be purely physical, such as polishing the surface to make it reflective. In addition, the surface can be provided with a separate reflective coating of low infrared emissivity which will withstand temperatures in excess of about 480° C., such as gold.

The treated strips 10 are formed of a relatively flexible metal in the form of thin elongate strips. Useful metals for this purpose would include a variety of materials such as steel, stainless steel and other thin, flexible metals having a high melting point. Typically, the strips are from about 1 to about 5 cm. in width and less than about 0.0025 cm. in thickness. It is possible to make the strips 10 thicker than this; however, the corresponding warm-up and cooldown times are considerably lengthened.

FIG. 2 shows in detail the clamping and stretching arrangement of heater strips 10. The arrangement of bus bars 12 and 22 is such that heater strips 10 remain connected in electrical series. When approximately 100 volts are applied to the grid through terminal 48 and wires 50, heater strips 10 consume about 2.0 kw. and their temperature rises to the region of about 400–500° C. By virtue of the low mass of heater strips 10 and accompanying low thermal mass, only about 5 seconds is required to reach fusing temperature. If the voltage on the wires 50 is increased to 120 volts, the heat-up time is reduced to about 2 seconds with a power consumption approaching 3 kw. for that period.

Should toner be shaken loose from the surface of element 46 onto the top surface $S_1$ of heater strips 10, no heat loss occurs. The dark toner on the dark heat-emissive surface $S_1$ of heater strips 10 causes no problems such as are encountered when toner falls on lamps and highly polished reflectors in many prior fusing devices. This is a very serious problem with some prior art radiant fusers and causes severe heat losses that must be made up with increased power intake to insure correct fusing.

I have found that a sheet of 20 lb. Eastman Bond paper carrying a xerographically toned image formed of standard toner material will be fused when drawn through this device at a rate of 21 inches/second. The toner-bearing element is suspended three eighths of an inch above heater strips 10 during this fusing operation and the power consumption is about 2.0 kw. Various amounts of power are needed for various papers and toners and this can be readily determined by trial-and-error methods used by those skilled in the art. Different reflective surfaces for heater strips 10 and different emissive treatments for heater strips 10 may also be used to increase the efficiency of the device.

In order to show the reduced fire hazard of this device, a piece of paper is dropped onto the emissive surfaces of heater strips 10 under the condition of a power consumption of 3 kw. The paper will smoke and char in about 1 second and will quickly ignite. However, if the power is turned off less than about 1 second after the paper touches the heater by standard fire-detection systems (e.g., one which detects smoke) used with radiant fusers, the paper will only yellow without burning as the heater strips 10 cool very rapidly. The temperature range of heater strips 10 after continuous operation at about 2 kw. input appears to be between about 400°–500° C.

It should be understood that the specific embodiment of the present invention described hereinabove has been selected to facilitate the disclosure of the invention rather than to limit the particular form which the invention may assume. For instance, the fusing device may be run at a higher surface temperature without loss of efficiency due to excessive radiation of wavelengths shorter than those absorbed by the paper, if the coating on the emissive surface $S_1$ of heater strips **10** is a good emitter only in the wavelength region of beyond about 2.5$\mu$m. in which most white bond paper has its maximum absorption. Preferred emission is in the wavelength region of about 2.5 to about 6$\mu$m. Quartz, silica, some glasses and certain minerals have suitable emission properties. Similarly, other reflective materials and treatments can be used on surfaces $S_2$ of strips **10**.

Furthermore, it is possible to replace the vacuum plenum-porous transport belt conveyor means shown in FIG. **1** by other conveyor means well-known in the art. In addition, relative motion between element **46** and strips **10** can be accomplished by means other than those shown, such as by movement of the strips, etc.

Also, it is possible using other conveying means to fuse toner images on paper by feeding paper **46** through the device shown in FIG. **1** with the toner side up. In this case, the paper would be heated from below as it passes over heater strips **10**. In addition, the apparatus could be arranged such that element **46** passes under the strips **10**, in which case strips **10** would radiate downward rather than as shown.

If other conveying means are used, it is preferred that the apparatus be provided with a suitable reflective backing on the side of element **46** opposite the strips **10**. Such a reflective backing could be against element **46** as is belt **44** in FIG. **1** or the backing could simply be in close proximity without actually touching element **46**. A suitable reflective backing can be prepared from a variety of materials such as stainless steel, reflective gold, etc.

The present apparatus can also be used without the reflective backing if so desired. The heater device of the present invention can advantageously be used as a preheater for use in conjunction with a roller fuser arrangement such as that described in copending Stryjewski et al. application Ser. No. 20345, filed Mar. 17, 1970 and entitled XEROGRAPHIC FIXING DEVICE. When used as a preheater, the reflective backing typically is not used; however, it can be if desired.

Although strips **10** are shown as connected in electrical series, these strips can also be electrically connected in parallel. With this latter arrangement, the apparatus can be operated at a lower voltage thus minimizing the shock hazard.

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

I claim:

**1**. A radiant-energy fusing device for thermally fixing resinous marking powder to a support material comprising:

a. a radiant power source comprising at least one metal strip having a first side treated for minimizing radiation therefrom and a second side treated for emitting radiation therefrom predominately at wavelengths above 2.5 $\mu$m. at energy levels capable of heating the support material and the marking powder; and

b. drive means for effecting relative movement between said radiant power source and the support material to expose the support material and the resinous powder to the radiant energy for a limited time wherein the marking powder is heat fixed to the support material without causing thermal damage thereto.

**2**. A radiant-energy fusing device for thermally fixing resinous marking powder to a support material comprising:

a. a radiant power source comprising at least one metal strip having a first side treated for minimizing radiation therefrom and a second side treated for emitting radiation therefrom predominately in the band from 2.5 $\mu$m. to 6 $\mu$m. at energy levels capable of heating the support material and the marking powder; and

b. drive means for effecting movement of the support material relative to said radiant power source to expose the support material and the resinous powder to the radiant energy for a limited time wherein the marking powder is heat fixed to the support material without causing thermal damage thereto.

**3**. A radiant-energy fusing device for thermally fixing resinous marking powder to a support material comprising:

a. a power supply;

b. heater means comprising at least one metal strip having a first side treated for minimizing radiation therefrom and a second side treated so that radiation emanating therefrom is predominately in the region from 2.5 $\mu$m. to 6 $\mu$m;

c. means for electrically connecting said power supply to said heater means wherein said metal strip is heated to a temperature in the range of approximately 400° C. to 500° C. for generating radiation at an intensity sufficient to heat the support material and the marking powder; and

d. conveyor means for moving the support material relative to said metal strip whereby the radiation communicates with the support material and the marking powder for a limited time so that the marking powder is heat fixed to the support material without causing thermal damage thereto.

**4**. A radiant-energy fusing device for thermally fixing resinous marking powder to a support material comprising:

a. a power supply;

b. heater means for directing radiation toward the support material comprising an elongate strip having a first side polished to minimize radiation therefrom and a second side positioned facing the support material and coated with a suspension of carbonaceous material in an organic resin so that radiation emanating therefrom is predominately in the band above 2.5 $\mu$m.;

c. means for electrically connecting said power supply to said heater means wherein said strip is heated to a temperature in the range 400° C. to 500° C. for generating radiation at an intensity sufficient to heat the support material and the marking powder; and

d. conveyor means for moving the support material relative to said heater means at a substantially uniform rate whereby the radiation communicates with the support material and the marking powder for a limited time so that the marking powder is heat fixed to the support material without causing thermal damage thereto.

**5**. A radiant-energy fusing device for thermally fixing resinous marking powder to a support material comprising:

a. a power supply;

b. a partially enclosed chamber;

c. a radiant power source comprising a plurality of electrically conductive strips mounted in a common plane within said chamber, each of said strips having a first side polished to minimize radiation therefrom and a second side facing the support material having a coating of siliceous compound so that radiation emanating therefrom is predominately in the region of **2.5** $\mu$m. to **6** $\mu$m.;

d. means connecting said plurality of conductive strips and said power supply in a series configuration for applying voltage thereto wherein said strips are heated to a temperature in the range of 400° C. to 500° C. for generating radiation in the direction of the support material at an intensity sufficient to heat the support material and the marking powder; and

e. conveyor means for moving the support material transverse to said heater means, in a plane substantially parallel to said common plane, and at a substantially uniform rate whereby the radiation communicates with the support material and the marking powder so that the powder is heat fixed to the support material without causing thermal damage thereto.

**6**. A fusing device as described in claim **5** wherein said siliceous compound is quartz.

**7**. A fusing device as described in claim **5** wherein said siliceous compound is glass.

**8**. A fusing device as described in claim **5** wherein said siliceous compound is silica.

9. A fusing device as described in claim 5 wherein said strips are comprised of steel, each strip having a width less than approximately 5 cm. and a thickness of approximately 0.0025 cm.

10. A fusing device as described in claim 9 wherein the marking powder is thermally fixed to the support material when said strips are operated at an approximately 2 kw power dissipation level.

11. A fusing device as described in claim 5 wherein the radiation communicates with the support material and the marking powder for less than approximately 3 seconds.

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