

Nov. 23, 1965

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3,219,799

XEROGRAPHIC FUSING APPARATUS

Filed Feb. 7, 1963

3 Sheets-Sheet 1

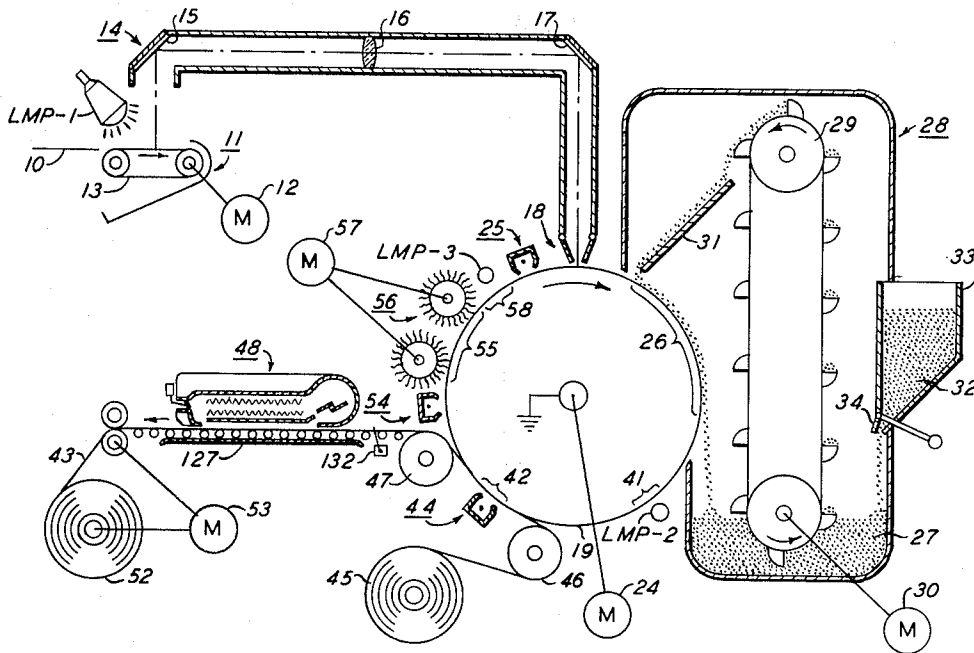


FIG. 1

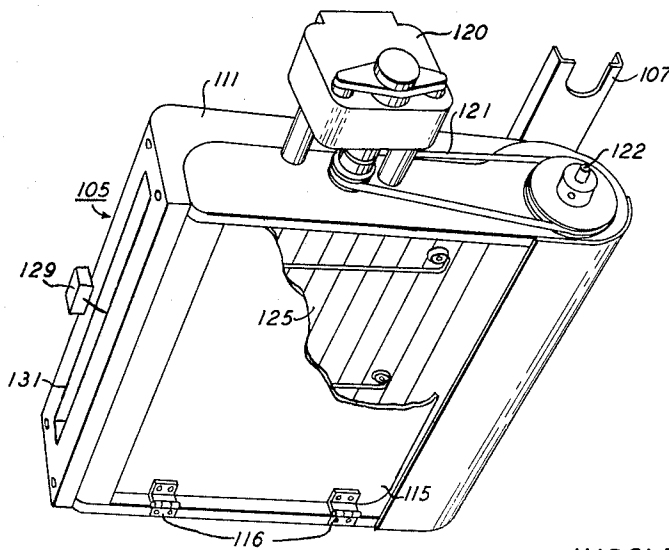


FIG. 7

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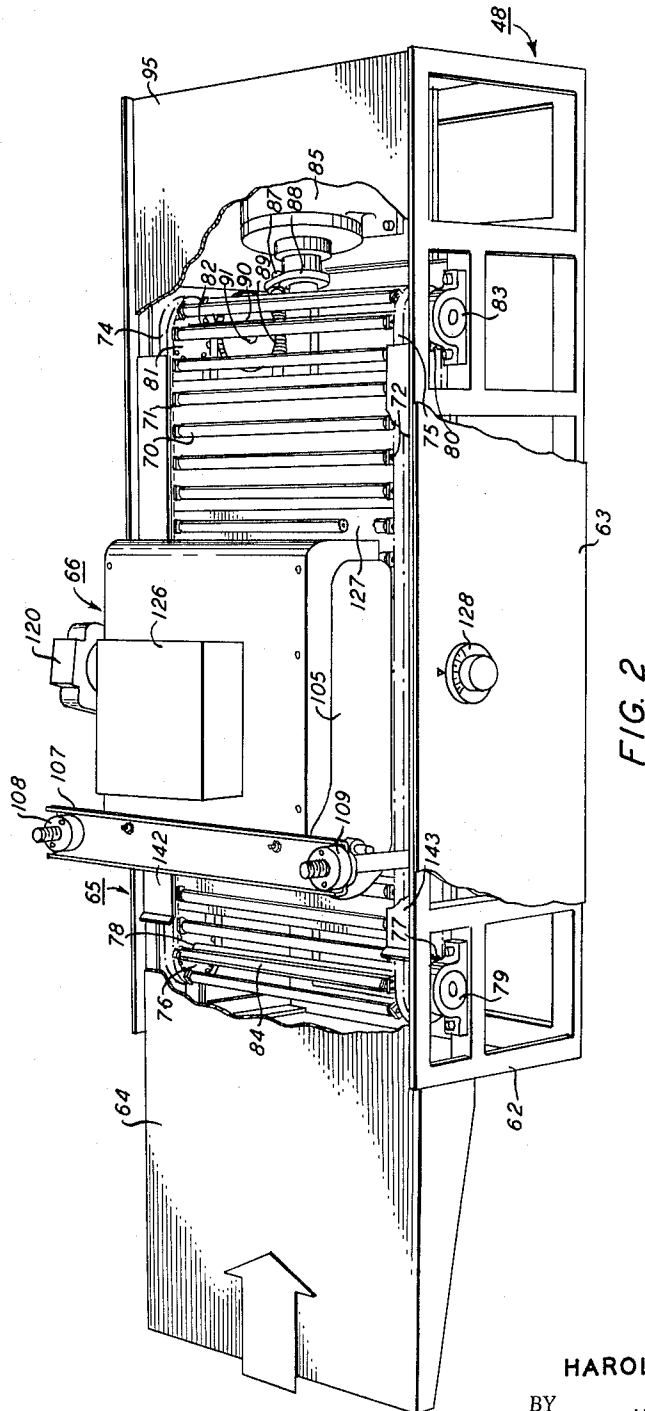
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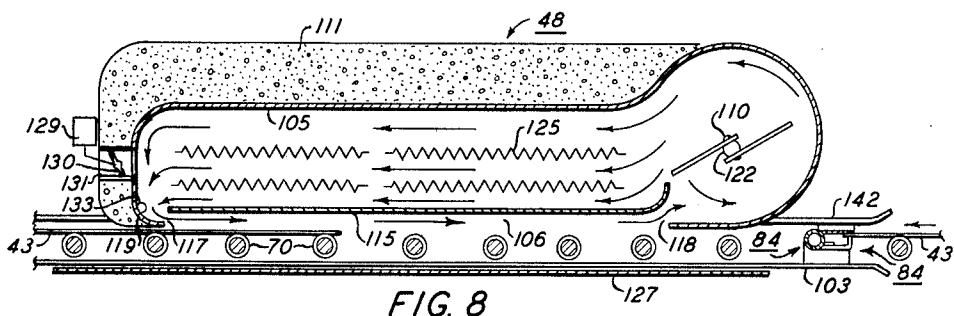


FIG. 8

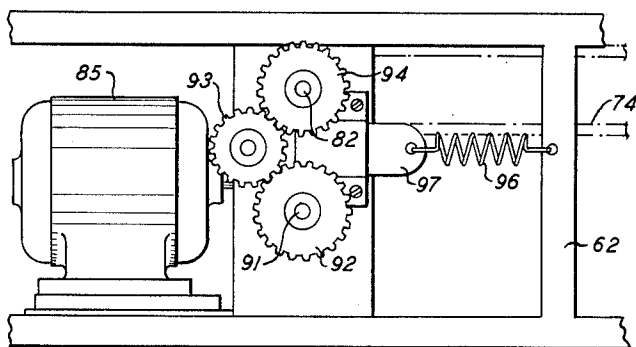


FIG. 3

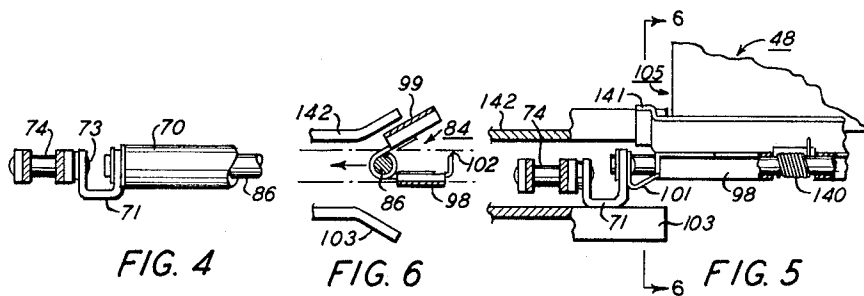


FIG. 4

FIG. 6

FIG. 5

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XEROGRAPHIC FUSING APPARATUS

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11 Claims. (Cl. 219—388)

This invention relates to a fusing apparatus for affixing a powder image permanently onto a support surface on which it has been formed. More specifically, the invention relates to xerography and to apparatus for affixing xerographically formed powder images onto a support surface.

In the process of xerography, for example, as disclosed in Carlson Patent 2,297,691, issued October 6, 1942, a xerographic plate comprising a layer of photoconductive insulating material on a conductive backing is given a uniform electrostatic 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 by an electrostatically charged, finely divided material such as an electroscopic powder that 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 to which it usually is affixed.

Most commercial machines that embody the principles of xerography as described above fuse the powder image by means of a heat fuser utilizing one or more of different kinds or arrangements of electrically energized coils radiantly exposed to the powder image and which also heats the fusing chamber to give a combined radiation and convection effect. It is important in the fusing operation to cause the powder image to soften and become adhesive without adversely affecting the support material, which usually comprises paper or other organic base. With the support material passing through the fuser at a predetermined or rapid rate, the heat generation necessary to effect fusing necessarily has required extremely high coil temperatures as well as extensive coil surface area. Thus, because of the movement aspect of the support base, the coils are maintained at a temperature far exceeding the base combustion temperature in order that the required heating relations be achieved within the time periods in which fusing must take place. If, therefore, for any reason, base movement should be interrupted or halted, there exists the inherent problem of fire and/or charring of the base material. Moreover, it has been difficult to reach an entirely satisfactory design of heat fuser with regard to short warm-up time, low electric current requirements, adequate heat insulation and uniform heat distribution, while having capacity variation able to cope with different operating speeds likely to be encountered.

Now in accordance with the instant invention, there is provided a novel form of heat fusing apparatus that not only overcomes the prior difficulties but is considerably more thermally efficient than the fusers of the prior art while substantially eliminating the problem of scorching or burning when a support base still in the fuser is slowed or stopped for any reason.

It is therefore an object of the invention to provide a novel heat fusing apparatus for affixing a resinous material onto a support base.

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It is a further object of the invention to provide novel heat fusing apparatus for fusing powder resinous images having higher thermal efficiency than fusing apparatuses heretofore.

It is a further object of the invention to provide novel heat fusing apparatus having greater flexibility than heretofore in fusing powder resinous images onto support material movable at different rates of speed.

It is a still further object of the invention to provide a novel heat fusing apparatus adapted to utilization in an automatic xerographic reproduction unit.

The novel features of the invention, as well as additional objects and advantages thereof, will be understood more fully from the following description when read in conjunction with the accompanying drawings, in which:

FIG. 1 is a schematic representation of a xerographic unit embodying the fusing apparatus of the invention;

FIG. 2 is an isometric view of the fusing apparatus in accordance with one embodiment of the invention;

FIG. 3 is a partial elevation viewed oppositely of FIG. 2 and illustrating the drive mechanism therefor;

FIGS. 4 and 5 are details of the paper feed for transporting individual cut sheets;

FIG. 6 is a fragmentary section view taken substantially along the line 6—6 of FIG. 5;

FIG. 7 is an exterior isometric illustration of the heater section of the apparatus as viewed from below; and,

FIG. 8 is a side-sectional view through the heating and blower unit of the apparatus.

For a general understanding of the xerographic processing system in which the invention is incorporated, reference is had to FIG. 1, in which the various system components are schematically illustrated. As in all xerographic systems based on the concept disclosed in the above-cited Carlson patent, a radiation light image of copy to be reproduced is projected onto the sensitized surface of a xerographic plate to form an electrostatic latent image thereon. Thereafter, the latent image is usually developed with an oppositely charged developing material to form a xerographic powder image, corresponding to the latent image, on the plate surface. The powder image is then electrostatically transferred to a suitable support surface on which it is fused as by the fusing apparatus of the invention whereby the powder image is caused to permanently adhere to the support surface.

The xerographic apparatus described herein typically may be of the type disclosed in Cerasani et al. U.S. Patent 3,076,392. In the apparatus referred to, copy to be reproduced, in any form, is placed on a support tray 10 from which it is fed onto a transport mechanism generally designated 11. Suitable drive means are provided for the transport mechanism from motor 12 to endless belt 13 whereby the copy is moved past the optical axis of projection lens system 14 that is illuminated by a projection lamp LMP-1. The image of the copy is reflected by mirror 15 through an adjustable objective lens 16 and then reflected by mirror 17 downwardly through a variable aperture assembly 18 and onto the surface of a xerographic plate in the form of a drum 19.

Xerographic drum 19 includes a cylindrical member mounted in suitable bearings in the frame of the machine and is driven in a clockwise direction by a motor 24 at a constant rate that is proportional to the transport rate of the copy whereby the peripheral rate of the drum surface is identical to the rate of movement of the reflected light image. The drum surface comprises a layer of photoconductive insulating material on a conductive backing that is sensitized prior to exposure by means of a corona generating device 25 that is energized from a suitable high potential source.

Exposure of the drum to the light discharges the photoconductive layer in the areas struck by light whereby there remains on the drum a latent electrostatic image in image configuration corresponding to the light image projected from the copy. As the drum surface continues its movement, the electrostatic latent image passes through a developing station 26 in which a two-component developing material 27, which may for example be of a type disclosed in Walkup Patent 2,638,416, is cascaded over the drum surface by means of a developing apparatus 28.

In the developing apparatus, developing material is carried upwardly by conveyor 29 being driven by a suitable drive means from motor 30 and is released onto chute 31 wherefrom it cascades down over the drum surface. Toner component 32 of the developer which is consumed in developing is stored in dispenser 33 and is released in amounts controlled by gate 34.

After developing, the xerographic powder image passes a discharge station 41 at which the drum surface is illuminated by a lamp LMP-2 whereby residual charges on the non-image areas of the drum surface are completely discharged. Thereafter, the powder image passes through an image transfer station 42 at which the powder image is electrostatically transferred to a support surface 43 by means of a second corona generating device 44, also energized from a suitable potential source.

The support surface to which the powder image is transferred may be of any convenient type, such as paper, that is obtained from a supply roll 45 and is fed over guide rolls 46 and 47 and over suitable tensioning rolls being directed into surface contact with the drum in the immediate vicinity of transfer corona generating device 44. After transfer, the support surface is separated from the drum surface and is guided through the fusing apparatus of the invention designated 48 to be described in detail below. Thereafter, the support surface is fed over a further system of guide and tensioning rolls and onto a take-up roll 52 that is driven by a motor 53.

After separation of the support surface from the drum, a corona generating device 54 directs an electrostatic charge to residual powder on the drum surface which charge is usually of opposite polarity as used originally for charging. After transfer and charging, the drum surface is passed through a cleaning station 55 at which its surface is brushed by cleaning brush assembly 56, rotated by a motor 57, whereby residual developing material remaining on the drum is removed. Thereafter, the drum surface passes through a second discharge station 58 whereat it is illuminated by a fluorescent lamp LMP-3, whereby the drum surface in this region is completely flooded with light to remove any electrostatic charge that may remain thereon. Suitable light traps are provided in the system to prevent any light rays from reaching the drum surface, other than the projected image, during the period of drum travel immediately prior to sensitization by corona generating device 25 until after the drum surface is completely passed through the developing station 26.

The fusing apparatus 48 of the invention will now be described in detail by referring more particularly to FIGS. 2 through 8. As will be understood, the apparatus is adapted for fusing images onto continuous webs in the manner of FIG. 1 or alternatively can be employed for fusing individual cut sheets for which the mechanism of the fuser includes variable rate transport means to move sheets past the heat source.

The fuser includes as its primary support a rectangular open frame section 62 formed generally of welded angles and channel members in order to support the other components thereof. For the purposes of appearance, the frame member may be enclosed in a cabinet 63 extending about the four sides of the frame.

As particularly adapted for handling of cut sheets on which the powder is loosely supported, there is provided a platform member 64 extending rearward from the frame

and on which the powder bearing sheet is placed to be moved manually onto a conveyor mechanism, generally designated 65, which moves the sheet past the heater unit 66. The conveyor mechanism includes a plurality of individual parallel arranged and spaced apart tubular glass rods 70. The rods extend transversely relative to the frame length and are supported to be freely rotatable about an internal bushing 86 mounted between a pair of clips 71 and 72 (FIGS. 4 and 5), each attached via pins 73 to opposite endless chains 74 and 75. A thermally reflective plate 127 is supported below the glass rods and may, for example, be aluminum or aluminum foil.

At the front end of the frame (considering direction in which the sheet encounters the elements as shown by the arrow, FIG. 2) the chains are supported on a pair of sprockets 76 and 77 that are coupled by means of a rotatable shaft 78 journaled for rotation in a pair of journal bearings 79 supported oppositely aligned on the frame. At the back end, the chains are supported similarly on a pair of sprockets 80 and 81 (the latter of which is a drive sprocket) which are coupled by means of a rotatable shaft 82 journaled for rotation in bearings 83.

Drive for the conveyor is obtained from a variable speed D.C. motor 85 energized from a suitable potential source and the output shaft of which is connected via a belt and pulley 88 to a drive shaft 87 containing a worm 89. The worm meshes continuously with worm gear 90 secured on a common rotatable shaft 91 with a spur gear 92 (FIG. 3) to drive idler gear 93, supported on slideable plate 97, and in turn driving spur gear 94 secured to an extension of shaft 82. Idler gear 93 is spring loaded via spring 96 to provide a torque limiting means.

In order to transport the sheets there is provided gripper members designated 84 spaced at intervals about the conveyor mechanism to advance in conjunction therewith. Each gripper member (FIGS. 5 and 6) is comprised of a lower jaw 98 and an upper jaw 99 each supported about a bushing 86 absent of a glass rod 70. The lower jaw is advanced via flange 101 riveted to a clip 71 and terminates in an upwardly turned flange having teeth 102. The clip 71 rides on a fixed plate 103 to maintain the gripping plane of teeth 102 coincident with the transport plate of the sheets corresponding substantially to the peripheral top of rods 70. The upper jaw is transversely coextensive with the lower jaw and is biased upwardly by means of a resilient spring 140 coiled about bushing 86. At each side edge of the upper jaw there is an upwardly-ending turned over flange 141, adapted to pass outside the dimensional width of the heater and blower housing 105 (see FIG. 5) and caused to grip a sheet as the upper jaw advances in engagement with oppositely supported cam members 142 and 143. By this means, the powder-laden support base can be advanced at any predetermined rate as a function of the speed of motor 85 to pass below the heater unit 105, to be described, whereat the image is affixed to the base. At the back end of the cam members, the grippers release the sheet which continues to advance with the rods 70 until emerging onto a platform 95 whereat it can be removed by an operator. It should be appreciated that where the web support material emanates from a roll as a continuous member and is driven by motor in the manner of FIG. 1, the conveyor drive and grippers hereof can be dispensed with or rendered inactive.

The heating unit may be understood by referring particularly to FIGS. 2, 7 and 8. The unit consists of a housing 105 that is generally enclosed on all sides except for an opening 106 in the bottom wall and is supported via an integral transversely extending channel 107 suspended between a pair of vertical adjustment bolts 108 and 109. By means of the adjustment bolts, the housing may be spaced accurately any desired distance above the web transport plane. The housing at its forward end has a scroll shape to house a centrifugal blower 110, generally of the paddle-wheel type. In order to prevent heat loss from the housing to the ambient surroundings, a layer of

insulation 111 is applied over the housing and which may, for example, be one inch of spun alumina.

Supported within the above opening 106 substantially parallel and approximately and about $\frac{1}{4}$ inch to about $\frac{3}{8}$ inch above the web plane is a baffle plate 115 attached via hinges 116 to housing 105. It will be noticed that the baffle is designed and arranged to permit air flow generated by the blower to flow as shown by the arrows in FIG. 8 to discharge only through an opening 117 and to re-enter the fan inlet through a return opening 118 whereby to provide a continuous air recirculation. Both openings 117 and 118 are defined by the available space between the respective ends of the baffle and the housing. It will be noted also that the housing has a downwardly curved lip 119 extending into its bottom wall to impart direction to the air discharge in a manner to cause the air to pass substantially parallel to the web transport plane and in a direction opposite thereto. Drive for the blower 110 is effected by means of a shaded-pole motor 120, the output of which is connected via belt and pulley arrangement 121 to fan shaft 122.

Air from the blower is discharged to travel lengthwise of the housing to pass over electrically-energized heating elements 125 arranged spaced vertically apart and substantially parallel to each other. On passing between and in contact with the heating elements, a heat exchange takes place to raise the air temperature to a predetermined setting of thermostat 128 having a sensing bulb 133 located adjacent opening 117. The heating elements may be of any suitable composition, for example, they may be of standard toaster-type elements comprising, for example, nichrome wire on a mica backing, commercial forms of elements in which a metal sheath encloses a nickel-chromium resistance wire comported in a dielectric or the like as is known in the art for transferring electrical heat to a stream of air. The air flow, therefore, passes over the heating elements through opening 117 to pass in contact with the image support material and then return for recycling through the return opening 118. Electrical connections are made to both the motors and heater through a terminal box 126. Thermostat 128 is adapted to control air temperature by controlling the power input to heating elements 125 and can be set in accordance with requirements.

Thus, for heat fixing of a xerographic image as is known in the art, there should be effected a strong bond between the image and the support base without adversely affecting the base, that is, without scorching or burning. At the same time, the degree of fixing or bond should be substantially uniform over the entire base surface from the center to the edges. Therefore, it should be appreciated that distribution of heat in order to achieve this result is somewhat critical, in order to thermally soften the resinous image without effecting the base, particularly as encountered in the different speeds employed for the different requirements of commercial operation. By means of the invention, uniformity is achieved by the controlled distribution of the hot air flow while at the same time receiving a radiant effect from the baffle plate 115 that reaches an elevated temperature from both the air movement and heating coils above. By employing the principle of counterflow between the air and the web, heat exchange efficiency is enhanced by virtue of the hotter air contacting the warmest portion of web and vice versa. Obviously, however, the same direction of flow could be employed. Air velocities of about or even in excess of the web transport speed do not disturb the powder image which becomes immediately adhesive on exposure to the hot air.

It was found that power requirements of the apparatus necessary to achieve good and uniform fixing with a particular web stock is a function of the spacing distance of the baffle height above the web as well as the web speed. With greater baffle to web spacings, there was found to occur a greater induction of secondary air from the

ambient surroundings, while the greater web speeds induced increased air losses and require higher air temperatures to effect fusing in the time available in passing through the fuser. In either event, it was found that the energy consumption was substantially less than associated with fusers of the prior art. Thus, with about a $\frac{3}{8}$ -inch baffle to web spacing and individual sheet feed of 11-inch wide paper at velocities of about $1\frac{1}{2}$ inches per second, uniformly good image fusing was achieved over the paper surface with about 375 watt input whereas with the same velocity and about $\frac{1}{2}$ -inch spacing required about 350 watts of input. This was effected with an air velocity and about $\frac{1}{2}$ -inch spacing required about 350 watts of input. This was effected with an air velocity along the paper surface approximately that of the paper velocity and with an air temperature of about 575° F. During fusing under these conditions, the baffle plate was found to reach a surface temperature of about 400° F., which it is believed as stated above, radiantly contributes to the end fusing result. This is particularly so where the toner of the resinous image is basically black by virtue of pigment contained therein. By comparison, the prior art devices are known to consume approximately two to four times as much power under analogous operating requirements.

During standby with are air off, only about 250 watts are utilized to maintain the baffle plate at about 500 to 550° F., which temperature drops about 20 to 30 percent as air circulation commences. Similarly, with continuous extended web feed of about two inches per second and a $\frac{3}{8}$ -inch baffle spacing, good fusing results were achieved with a power consumption of approximately 400 watts on the average.

Since the combined heat losses are very low, the efficiency of the apparatus is very high. Furthermore, since the structure employs elements having low thermal mass, thermal lag is low and the surfaces remain relatively cool but result in fast warm up to reach operating conditions.

For a continuous web primarily as in FIG. 1, wherein the gripper transport is omitted or de-energized, a safety switch 132 responsive to the web movement immediately de-energizes the heating elements in the event of paper stoppage. Simultaneously, solenoid 129 is de-energized to permit immediate opening of spring-return two-position damper 130 (FIG. 8) supported in duct 131 whereby the apparatus is cooled as the air from the blower is discharged through duct 131 to the ambient atmosphere while the blower effectively draws ambient air across the web surface. With the individual sheet transport the heating elements and solenoid are similarly de-energized when movement ceases. In the event of a complete power shutdown, the damper opening provides an immediate natural vent.

By the above description, there has been disclosed a novel form of heat fusing apparatus for affixing powder resinous images to a support base on which the image has been previously loosely formed. The apparatus is highly effective in that softening of the resinous image to effect fusing is achieved by both radiation and convection, the latter of which is attained by a high temperature air moving across the web surface and in close contact therewith. At the same time, the thermal efficiency is very high since once operating, the air is recirculated such that losses or leakage are kept to a minimum and the primary loss which is relatively minor, is in the thermal gain to the web.

Whereas, the invention has been described primarily for use with images transferred to a support web from reusable photoconductive plates such as vitreous selenium, it is intended for use with this invention to include web members per se having photoconductive properties for forming images directly thereon. This latter form of web members may for example, comprise well-known forms of zinc oxide in a suitable binder.

Since many changes could be made in the above con-

struction and many apparently widely different embodiments of this invention can be made without departing from the scope thereof, it is intended that all matter contained in the drawings and specification shall be interpreted as illustrative and not in a limiting sense.

What is claimed is:

1. Apparatus for affixing a resinous powder image onto the surface of a support base on which the image has been formed, said apparatus comprising in combination:

(a) support means to support a web base containing a loosely adhering resinous powder image on its surface;

(b) a housing supported closely adjacent said support means, said housing being constructed substantially enclosed but having separate air discharge and return openings defined toward opposite ends in a substantially planar bottom wall arranged opposite the area of said support means on which a powder-bearing web base is to be supported;

(c) a plurality of electrically energizable heating elements disposed interior of said housing;

(d) blower means adapted to cause a continuous air recirculation passing over said heating elements through the discharge of said housing openings to between said bottom wall and along the resinous image on the web base in a direction substantially parallel to the surface of the web base and hence into the return of said housing openings; and,

(e) air flow guide means supported at the discharge of said openings for guiding air passing therethrough to discharge in a direction generally parallel to the surface of a web base on its support.

2. The apparatus according to claim 1 including means to advance the web base on its support means at a predetermined rate.

3. The apparatus according to claim 2 including means responsive to web movement to vent said housing in the event web movement ceases.

4. Apparatus for affixing a resinous powder image onto the surface of a support base on which the image has been formed, said apparatus comprising in combination:

(a) support means to support a web base containing a loosely adhering resinous powder image of its surface;

(b) a housing supported closely adjacent said support means, said housing being constructed substantially enclosed but having an opening defined in a bottom wall arranged opposite the area of said support means on which a powder-bearing web base is to be supported;

(c) a substantially planar baffle plate extending incompletely across said housing opening in a direction generally parallel to the plane of a web base supported on said support means and defining with said housing separate air discharge and return passages toward opposite ends thereof;

(d) a plurality of electrically energizable heating elements disposed interior of said housing;

(e) blower means adapted to cause a continuous air recirculation passing over said heating elements through said discharge passage to between said baffle plate and along the resinous image on the web base in a direction substantially parallel to the surface of the web base; and,

(f) air flow guide means supported at the discharge of said passages for guiding air passing therethrough to discharge in a direction generally parallel to the surface of a web base on its support.

5. Apparatus for affixing a resinous powder image onto the surface of a support base on which the image has been formed, said apparatus comprising in combination:

(a) transport means to transport a web base containing a loosely adhering resinous powder image on its surface;

(b) a housing supported closely adjacent the transport

plane of said transport means, said housing being constructed substantially enclosed but having an opening defined in a lower wall arranged opposite an area of said transport plane in which a powder bearing web base is to move;

(c) a substantially planar radiantly emissive baffle plate extending incompletely across said housing opening in a direction generally parallel to said transport plane and defining with said housing separate air discharge and return passages toward opposite ends thereof;

(d) a plurality of electrically energizable heating elements disposed interior of said housing;

(e) blower means within said housing adapted to cause a continuous air recirculation passing over said heating elements through said discharge passage to between said baffle plate and the image on the moving web base in a direction substantially parallel to the surface of the web base and return to said housing;

(f) thermostatic means operably connected to said heating elements to effect a combined baffle plate and air temperature at least adequate to effect fusing of the image to the base; and,

(g) air flow guide means supported at the discharge of said passages for guiding air passing therethrough to discharge in a direction generally parallel to the surface of a web base on its support.

6. The apparatus according to claim 5 wherein said baffle plate is spaced about 1/4 inch to about 5/8 inch above the plane of the web base.

7. The apparatus according to claim 6 wherein said air flow across the surface of the web base is generally counter to the transport direction of the web.

8. The apparatus according to claim 7 wherein the air flow velocity of the air contacting the web is approximately the same as the transport velocity of the web.

9. In an automatic xerographic unit that includes means for forming a xerographic resinous powder image onto the surface of a support base; fusing apparatus for fusing the image to the base, said apparatus comprising in combination:

(a) transport means to transport the web base substantially in a plane at a predetermined rate; said transport means including an advanceable gripper member adapted to grip the leading edge of a base to be transported, and cam means positioned to open and close said gripper member at predetermined locations;

(b) a housing supported closely adjacent the transport plane of said transport means, said housing being constructed substantially enclosed but having an opening defined in a bottom wall arranged opposite an area of said transport plane in which a web base is to move;

(c) a radiantly emissive baffle plate extending within said housing at least partially across said opening in a direction generally parallel to said transport plane;

(d) a plurality of electrically energizable heating elements disposed interior of said housing; and,

(e) blower means within said housing adapted to cause a continuous air recirculation passing over said heating elements to out of said housing adjacent a first end of said baffle plate to across the image on the moving web base in a direction substantially parallel to the surface of the web base and return to said housing adjacent a second end of said baffle plate.

10. The fusing apparatus according to claim 9 including means to vent said housing in the event of inoperation of said transport means.

11. The fusing apparatus according to claim 10 in which said vent means comprises means defining an opening in a wall of said housing, and damper means operative to close said opening concomitant with operation of said transport means and to open said opening when said transport means are inoperative.

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