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R. G. OLDEN ET AL

2,857,682

HEATING APPARATUS

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2 Sheets-Sheet 2

Fig. 2.

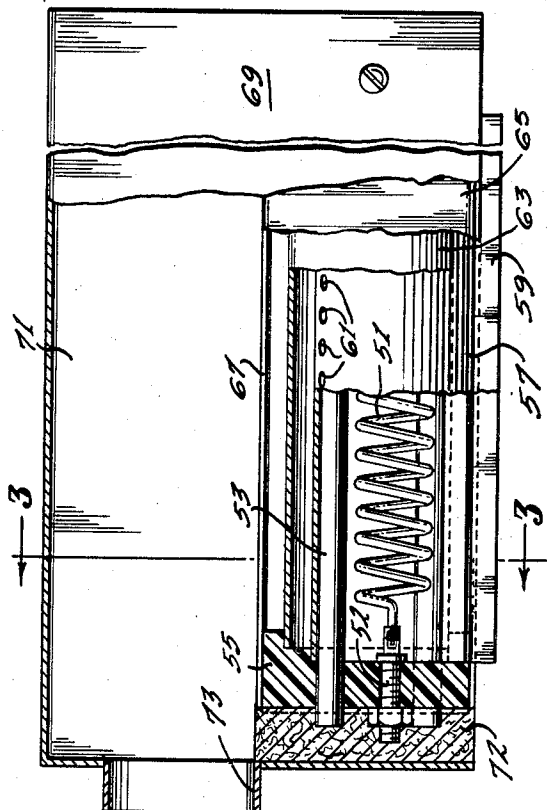
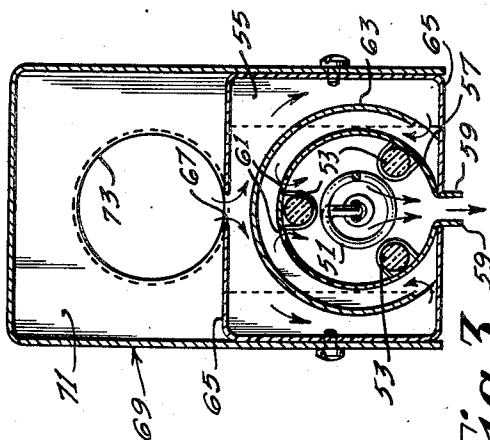


Fig. 3.

Fig. 4

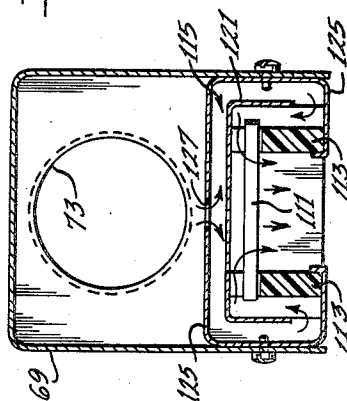


Fig. 5.

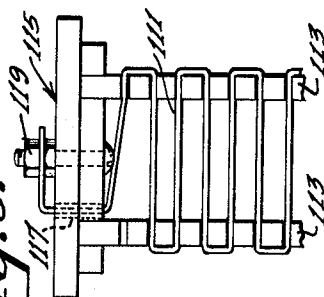
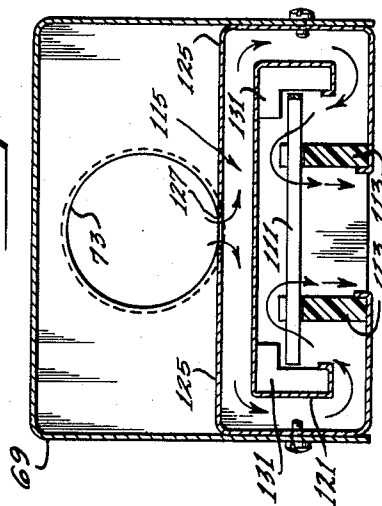


Fig. 6.



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HEATING APPARATUS

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4 Claims. (Cl. 34—54)

The present invention relates to heating apparatus, and more particularly to novel heating apparatus for progressively imparting heat to an exposed surface, such, for example, as the surface of an electrophotographic print bearing a developer powder image whereby to fuse the powder, or components thereof, to provide a permanent print.

An electrophotographic process serves to produce visible reproductions or prints. The process includes the steps of converting a light image to a latent electrostatic charge image and converting the latent charge image into a visible image. The latent electrostatic image is developed by a developer powder which is held electrostatically to selected areas of a photoconductive surface. The developer powder includes a coloring material and may include finely divided thermoplastic material. The visible powder image thus formed is made permanent, or fixed, by heating the record to melt the thermoplastic portions of the record surface coating, or developer powder, to fuse the powder directly to the surface of the record.

When the record carrying the photoconductive surface is an elongated, moving strip or web upon which it is desired to make a plurality of reproductions at a rapid rate, the problem arises in providing sufficient heat in a limited time to fuse the powder image, yet to prevent scorching or burning of the record if movement of the web is substantially slowed or stopped. Apparatus constructed in accordance with the present invention is particularly applicable to heating such a record, progressively, and at high speeds.

An object of this invention is to provide novel apparatus for imparting heat to a surface or body by the movement of a directed stream of heated air.

Another object of this invention is to provide an improved electrostatic printing system for the printing and fusing of developer powder images.

Still another object of this invention is to provide novel apparatus for fusing powder images on a sheet moving at a relatively high rate and to prevent the scorching of the sheet when it is substantially slowed or stopped.

A further object of this invention is to provide novel apparatus for the high temperature fusing, by convection means, of a powder image to a moving record.

A still further object of this invention is to provide novel apparatus for the high temperature fusing of a powder image on a relatively fast moving record.

Apparatus in accordance with the present invention includes, in an electrostatic printing system, means for feeding a continuous record. A fuser includes a novel heater assembly and a blower, and means responsive to the rate of feed of the record for controlling the heater and for changing the direction of air flow through the heater assembly. The novel heater assembly includes a heating element and an arrangement of baffles for directing the flow of air from the outer portions of the heater assembly toward the center thereof where it passes over the heater element and is directed to the moving record. The arrangement provides for maximum heating of the air flowing through the heater assembly with a minimum power requirement for the heater element.

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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 connection with the accompanying drawings, in which:

Figure 1 is a diagrammatic view illustrating an electrostatic printing system, and particularly the control means for directing a flow of air through a heater assembly;

Figure 2 is a view in elevation, partially broken away, of one form of heater assembly in accordance with the present invention;

Figure 3 is a sectional view, in elevation, taken along the line 3—3 of Figure 2 looking in the direction of the appended arrows;

Figure 4 is a sectional view, similar to Figure 3, of another form of heater assembly in accordance with the present invention;

Figure 5 is a fragmentary plan view of a portion of the heater of Figure 4; and

Figure 6 is a sectional view, in elevation, similar to Figure 3 of still another form of heater assembly in accordance with the present invention.

The apparatus to be described, embodying the invention in illustrative forms, may be operated with a developer mix comprising a developer powder and a carrier material consisting of magnetic particles such as alcoholized iron. Generally, any of a large number of developer particles, known in the art, is suitable for mixing with iron particles to form a developer mix which can readily be fixed by apparatus embodying the present invention. A developer powder above iron in the triboelectric series is generally suitable for developing a direct image upon a negatively charged surface, or a reverse image upon a positively charged surface. Examples of developer powders in this class are powdered shellac and rosin, each pigmented with a suitable coloring material such as carbon black. For purposes of illustration, there is described herein by way of example the development of a direct image upon a negatively charged surface. In disclosing the invention, reference will be had to a record receiving member in the form of a paper sheet or web having a photoconductive coating which may comprise zinc oxide suspended on a vehicle such as a resin.

Referring now to Figure 1 of the drawing, a web 11 carries a photoconductive coating on its lower surface as it is fed from a supply spool 13. The photoconductive surface is exposed to the influence of an electrostatic charging device 15 to provide a distributed electrostatic charge over the surface. The charging device 15 may comprise a plurality of fine wires 17 carried by a pair of spaced insulating members. It will be understood that the insulating members are spaced in such a manner that the wires 17 span the width of the web 11. It will be understood that light is preferably excluded during the charging step. A source of high voltage 19 is connected to the wires 17 so as to give them a negative charge with respect to a ground plate 21. The charged web is exposed to a light image from a luminous image projector 23 of any known kind. The web bearing the charge image, or latent image, in the form of an electrostatic charge then passes over a roller 24 to a developer unit 25 in which the developer powder is applied to the web surface. The developer unit may comprise a container 27 for a developer mix including a developer applying drum 29 driven by a motor 31. The web then passes over rollers 33 and 35 to a fuser, to be described hereinafter more in detail, including a heater assembly 37 and a blower assembly. The web is heated to melt either the developer powder or the web surface coating to provide a permanent image on the web. A feed roller 39 is driven by a motor 41. A pressure roller 43 serves to press the web against the roller 39 so that it may be drawn through the several recording stages or stations described herein.

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Referring now to Figures 2 and 3 of the drawing, one form of heater assembly 37 comprises an elongated, helical coil 51 supported by three equally spaced ceramic rods 53. The ceramic rods are supported in apertures provided in rectangular end blocks 55. The coil 51 is connected to terminals 52 mounted in the end blocks 55. A thin, metallic, cylindrical, inner shell 57 surrounds and supports the ceramic rods 53 and is set in recesses in the end blocks 55. The inner shell is discontinuous at its lower side and has outwardly formed flanges 59 which define a discharge nozzle extending the length of the shell 57, for directing the air to the surface of the web 11. Two longitudinal rows of openings 61 are provided in the inner shell opposite from the flanges 59. A second, intermediate, metallic shell 63, also forming part of a cylinder, is also set in recesses in the end blocks 55 and is mounted concentric with and substantially surrounding the inner shell. The intermediate shell is also discontinuous at its lower side. Two U-shaped outer shells 65 are mounted laterally over the rectangular end blocks 55 and substantially enclose the above described assembly. The lower edges of these outer shells 65 abut the inner shell flanges 59 to close off the bottom of the assembly, with the exception of the nozzle. The upper edges of the outer shells 65 do not meet, but are spaced apart to define a tapered slot 67.

The above described shell assembly is housed in a rectangular housing 69 which is deeper than the shell assembly and is open at the bottom. The shell assembly forms a closure for the housing, and forms an upper closed chamber 71 in the housing. A material 72, such as asbestos cement, may be used to seal the end spaces between the shell assembly and the housing. A flanged air inlet opening 73 is provided at one end of the housing 69 to provide for air flow into and out of the chamber 71. The tapered slot 67 in the shell assembly provides for uniform air distribution from the chamber 71 over the length of the shell assembly. The above described heater assembly is elongated and is positioned transversely of the direction of feed of the web so that the discharge nozzle lies very close to the web surface.

During the fusing operation, the air flow through the heater assembly is as shown in Figure 3. Forced air enters the chamber 71 through the inlet opening 73 and passes downwardly through the tapered slot 67. The air is then deflected to either side of the intermediate shell 63 and passes downwardly between the outer shell 65 and the intermediate shell. The air then passes upwardly between the intermediate shell 63 and the inner shell 57 and through the apertures 61 into the inner shell. The air then passes downwardly over the heating coil 51 and out of the nozzle formed by the flanges 59 which directs the air to the web. With this arrangement of shells or baffles, the air is first circulated adjacent the outer walls of the shell assembly and is worked tortuously toward the heating coil in the center of the assembly. This provides for gradual heating of the air before it reaches the coil 51 and accomplishes maximum heating of the circulated air flowing from the nozzle, and at the same time the outer walls of the heater assembly are maintained relatively cool so that the heat losses are small.

Referring again to Figure 1 of the drawing, the forced air flow is provided by a small blower 81, which may be of any known type. The blower 81 is connected to the inlet opening 73 of the housing 69 through a four-way air valve 83 having a rotatable vane for selectively interconnecting different pairs of ports in the valve. The input and output connections of the blower 81 are connected, respectively, to valve ports 85 and 87. Valve port 89 is connected to the housing 69 and valve port 91 is open. When the valve is positioned as shown in Figure 1, the blower 81 draws air through the ports 91 and 85 and forces air through the ports 87 and 89 into the housing 69.

The valve vane is rotated by means of an arm 93. The

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plunger of a solenoid 95 is connected to the arm 93 by means of a connecting link 97. The solenoid is shown in what is assumed to be an energized condition wherein the valve vane is positioned to direct the air as above described. The solenoid is controlled through a control circuit 99 which in turn is controlled by a tachometer 101. The tachometer registers the rate of feed of the web 11 through a drive roller 103 and an associated pressure roller 105 which are in engagement with the web 11. When the web 11 attains a predetermined rate of feed, the solenoid 95 is energized through the control circuit 99 to assume the position shown in the drawing. At the same time, the heating coil 51 is connected to a power source 100 through the control circuit.

When the rate of feed of the web 11 falls below a predetermined rate, the control circuit causes the coil 51 and the solenoid 95 to be de-energized. The solenoid is then released, and the valve vane is rotated counter-clockwise 90°. In this position of the valve, the blower draws air through the ports 89 and 85 and forces the air through the ports 87 and 91. Air is then drawn through the heater assembly from the nozzle to the inlet port 73 to cool the coil 51 and to carry residual heat in the coil 51 away from the surface of the web 11.

Referring now to Figures 4 and 5 of the drawing, another form of heater assembly in accordance with the present invention includes a heating element consisting of a metallic ribbon 111, such as a .005 inch x .125 inch "Nichrome" ribbon, which is supported on two strips 113 of insulating material. The strips 113 are supported in parallel relation between rectangular end blocks 115 and are provided with spaced teeth along their upper edges. The "Nichrome" ribbon 111 is supported horizontally between the teeth of the strips 113 and is strung in a zig-zag fashion between the two strips. The ribbon passes through an aperture 117 in each of the end blocks and is secured to terminals 119.

The strips 113 are mounted flush with the lower edges of the end blocks 115 and intermediate the side edges of the end blocks. An inner U-shaped shell 121 is supported over, and spaced from, the heater element 111 by projections 123 on the end blocks 115. The side walls of the inner shell 121 extend downwardly and are laterally spaced from the strips 113 to provide an air path between the side walls and the strips. The lower edges of the shell 121 do not extend downwardly to the plane of the lower edges of the end blocks 115 and strips 113.

Two substantially U-shaped outer shells 125 are mounted laterally over the end blocks 115 and substantially enclose the above described assembly. The lower edges of the outer shells are turned upwardly around the lower edges of the strips 113 and close off the bottom of the assembly with the exception of the space between the two strips 113. The upper edges of the outer shells do not meet, but are spaced apart to define a tapered slot 127 in the upper wall of the assembly.

The above described shell assembly is also housed in a rectangular housing 69 in the same manner as the heater assembly of Figures 2 and 3. Air flows from the chamber 71 through the tapered slot 127 in the manner previously described. The path of air through this heater assembly is similar to the path of air through the previously described assembly. In this assembly the discharge opening is defined by the two strips 113. This assembly might be used where the power requirements prevent the use of the helical coil 51.

Referring now to Figure 6 of the drawing, still another form of heater assembly, in accordance with the present invention similar to that of Figures 4 and 5, is shown. The heating element again comprises a metallic ribbon 111 supported on strips 113 which are in turn supported in parallel relation between rectangular end blocks 115. The ribbon passes through the end blocks 115 and is secured to terminals as described.

In the assembly of Figure 6, the ribbon 111 is sup-

ported between the teeth of the strips 113 but is not strung simply between the teeth of the two strips. The strip 111 is formed so that the ends of the various loops extend laterally beyond the strips 113 and lie in their air paths formed between the strips 113 and a U-shaped inner shell 121. The inner shell 121 is supported in inverted position by projections 131 on the end blocks 115.

Two U-shaped shells 125 are mounted laterally over the end blocks 115 to substantially enclose the heater assembly as previously described. This shell assembly is again housed in a housing 69. The air flow through the assembly of Figure 6 is again similar to that of the previously described assemblies. The discharge opening is defined by the two strips 113. In the assembly of Figure 6, however, the air passes over portions of the heating element 111 in two stages of its flow and therefore provides increased transfer of heat to the air. This last described assembly may be used where more heat is necessary in order to permit an increase in the rate of feed of the web 11.

An important feature of the various forms of fuser described herein is that the heating element is positioned adjacent the discharge nozzle of the heating assembly, hence, as close as possible to the surface to be heated. This provides increased efficiency of the fuser since the heat lost between the heating element and the surface is minimized and maximum heat is carried to the surface. Another important feature of the fuser is that the air path through the heater assembly accomplishes uniform distribution of the air through the assembly before it actually contacts the heating element. This results in increased transfer of heat from the heating coil to the air. A further feature of the heater assembly structure is that the air enters the assembly and first circulates adjacent the outer walls of the assembly, then circulates through a tortuous path toward the center of the assembly and the heater element. With this arrangement, the heat which is radiated from the heating element to other parts of the assembly is transferred to the circulating air before it reaches the heater element. As a result of this, the air is pre-heated and this radiated heat is not lost to the atmosphere. An accompanying advantage is that the outer walls of the heater assembly are maintained relatively cool.

It is clear that with the high temperatures involved with the heater elements of the types described, the web or sheet which is heated would catch on fire if it were kept stationary adjacent to the discharge nozzle for a short time. Even a reduction of the paper speed might result in scorching and thereby seriously damaging a print. Accordingly, still another important feature of the fuser is the control means for removing power from the heater element and for reversing the flow of air through the heater assembly when rate of feed of the web is reduced, as described in the foregoing.

In view of this last named feature, it is very desirable that the fuser have a short warm-up time and a short cooling time. These are also features of the described heater assemblies. Since the heater elements are spaced very near to the surface to be heated and in view of the heat transfer efficiency of the assembly, less power is required for the heater element to produce a required amount of heat at the surface. In the use of these assemblies, the heater element may well run black, rather than red hot. This, of itself, reduces the required warm-up time. The warm-up time is further reduced in view of the fact that the heat lost from the heater assembly is at a minimum. When the heating element is disconnected from its power source, due to a decrease in web speed, it is desirable to cool the heating assembly as rapidly as possible in order to prevent the above mentioned scorching. This is accomplished, of course, by reversing the flow of air through the heater assembly. This is further accomplished by the fact that the heat radiated to the various parts of the heater assembly is

carried away by the reverse flow of air. Also, the radiant heat from the heater element is more readily absorbed by the various shells of the heater assembly since they have been maintained relatively cool as described above.

The several fuser assemblies described have a high heat exchange efficiency and compare very favorably with non-convection types of fusers, particularly with respect to the power required, the fuser warm-up time, and the time required for fusing a given surface area.

What is claimed is:

1. Heating apparatus comprising a blower and a heater assembly for directing a stream of heated air onto a moving strip, means in said heater assembly defining an air path beginning at the outer walls of said assembly and terminating at a central chamber, a heater element disposed in said central chamber, means defining a discharge nozzle connected to said central chamber, a flow reversing means connecting said blower and said heater assembly, means for detecting the rate of movement of said strip, and control means responsive to said detecting means for actuating said flow reversing means.

2. In electrostatic printing apparatus means for supporting and moving an image receiving strip, a fuser comprising a blower and heater assembly for directing a stream of heated air onto said strip, means in said heater assembly defining an air path beginning at the outer walls of said assembly and terminating at a central chamber, a heater element disposed in said central chamber, means defining a discharge nozzle connected to said central chamber, a flow reversing means connecting said blower and said heater assembly, means for detecting the rate of movement of said strip, and control means responsive to said detecting means for actuating said flow reversing means.

3. In electrostatic printing apparatus means for supporting and moving an image receiving strip, a fuser comprising a blower and heater assembly for directing a stream of heated air onto said strip, means in said heater assembly defining an air path beginning at the outer walls of said assembly and terminating at a central chamber, a heater element disposed in said central chamber, means defining a discharge nozzle connected to said central chamber, a power source for said heater element, a flow reversing means connecting said blower and said heater assembly, means for detecting the rate of movement of said strip, and control means responsive to said detecting means for connecting said heater element to said power source and for actuating said flow reversing means.

4. In electrostatic printing apparatus, means for supporting and moving an image receiving strip, a fuser comprising a blower and heater assembly for directing a stream of heated air onto said strip, means in said heater assembly defining an air path beginning at the outer walls of said assembly and terminating at a central chamber, a heater element disposed in said central chamber, means defining a discharge nozzle connected to said central chamber, a power source for said heater element, a flow reversing air valve connecting said blower and said heater assembly, electromagnetic means for actuating said valve to reverse the flow of air through said heater assembly, means for detecting the rate of movement of said strip, and a control circuit responsive to said detecting means for connecting said heater element to said power source and for energizing said electromagnetic means.

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