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Thettu et al.

[11] **3,816,066**

[45] **June 11, 1974**

[54] **XEROGRAPHIC FIXING DEVICE**

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[73] Assignee: **Xerox Corporation,** Stamford, Conn.

[22] Filed: **June 11, 1973**

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[52] **U.S. Cl.** ..... **432/228,** 432/233, 62/119, 165/105, 100/93 RP, 62/515

[51] **Int. Cl.** **F28d 15/00**

[58] **Field of Search** ..... 432/42–44, 432/59, 60, 62, 77–80, 227–229; 219/216, 388, 469; 165/46, 80, 89, 105; 62/293, 515 R, 333, 119; 100/93 RP, 92

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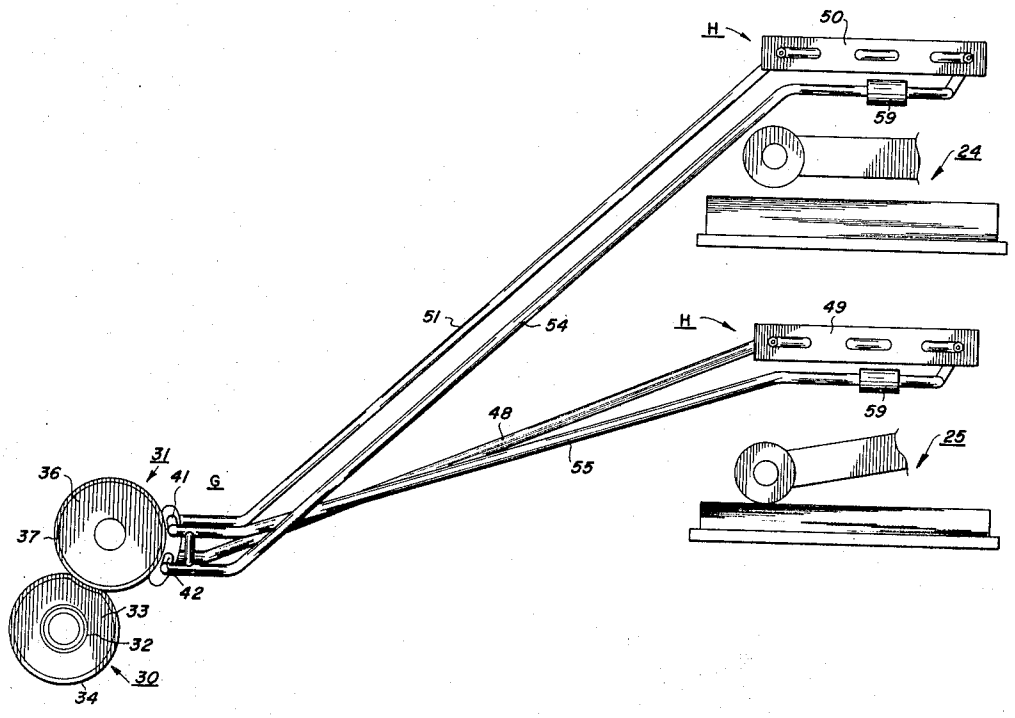
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Assistant Examiner—Henry C. Yuen

[57] **ABSTRACT**

This invention relates to a xerographic fusing device and, in particular, to apparatus and method for removing excessive heat energy from the surface of a fuser roll utilized in a xerographic image fixing apparatus.

13 Claims, 4 Drawing Figures



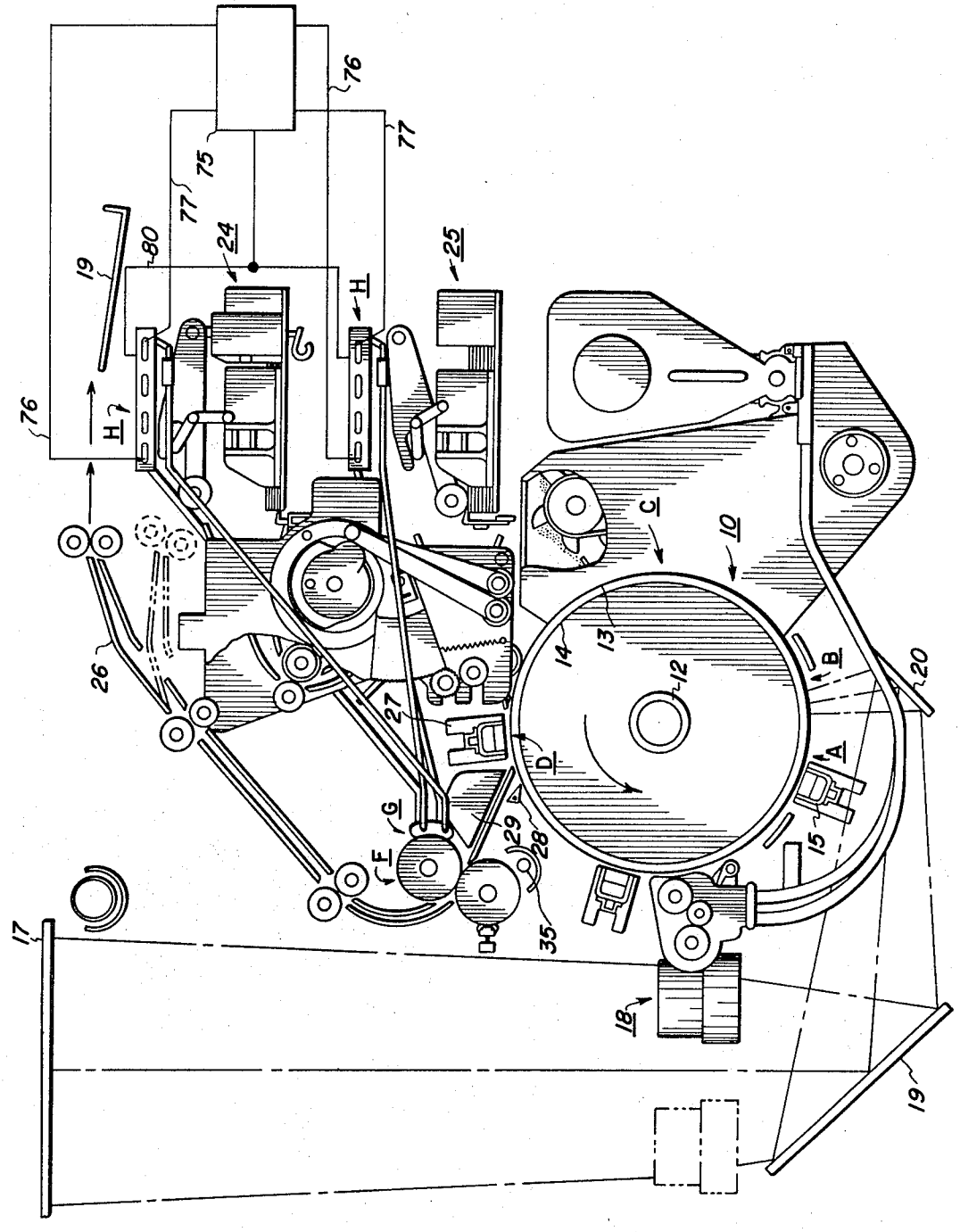

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FIG. 1

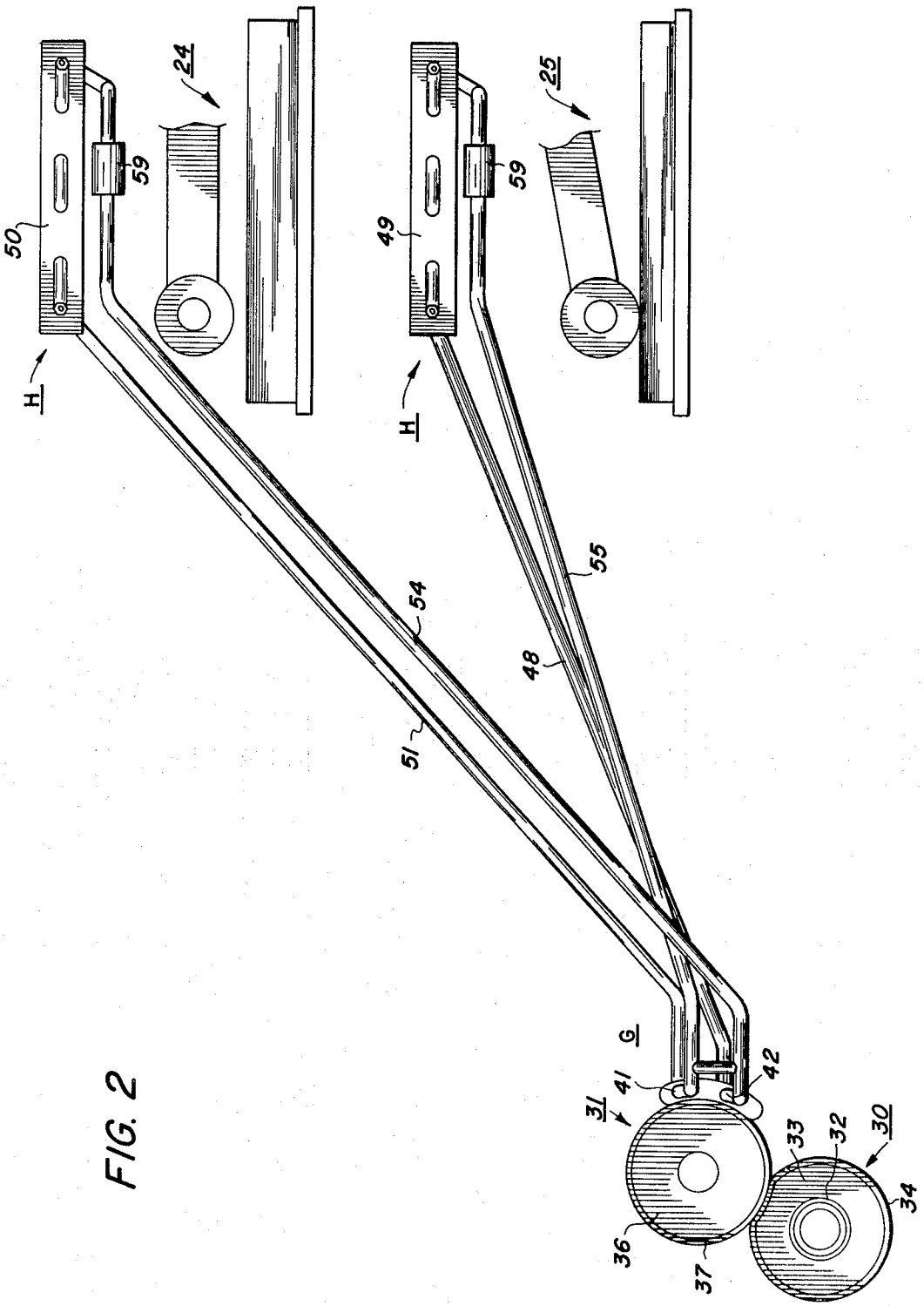


FIG. 2

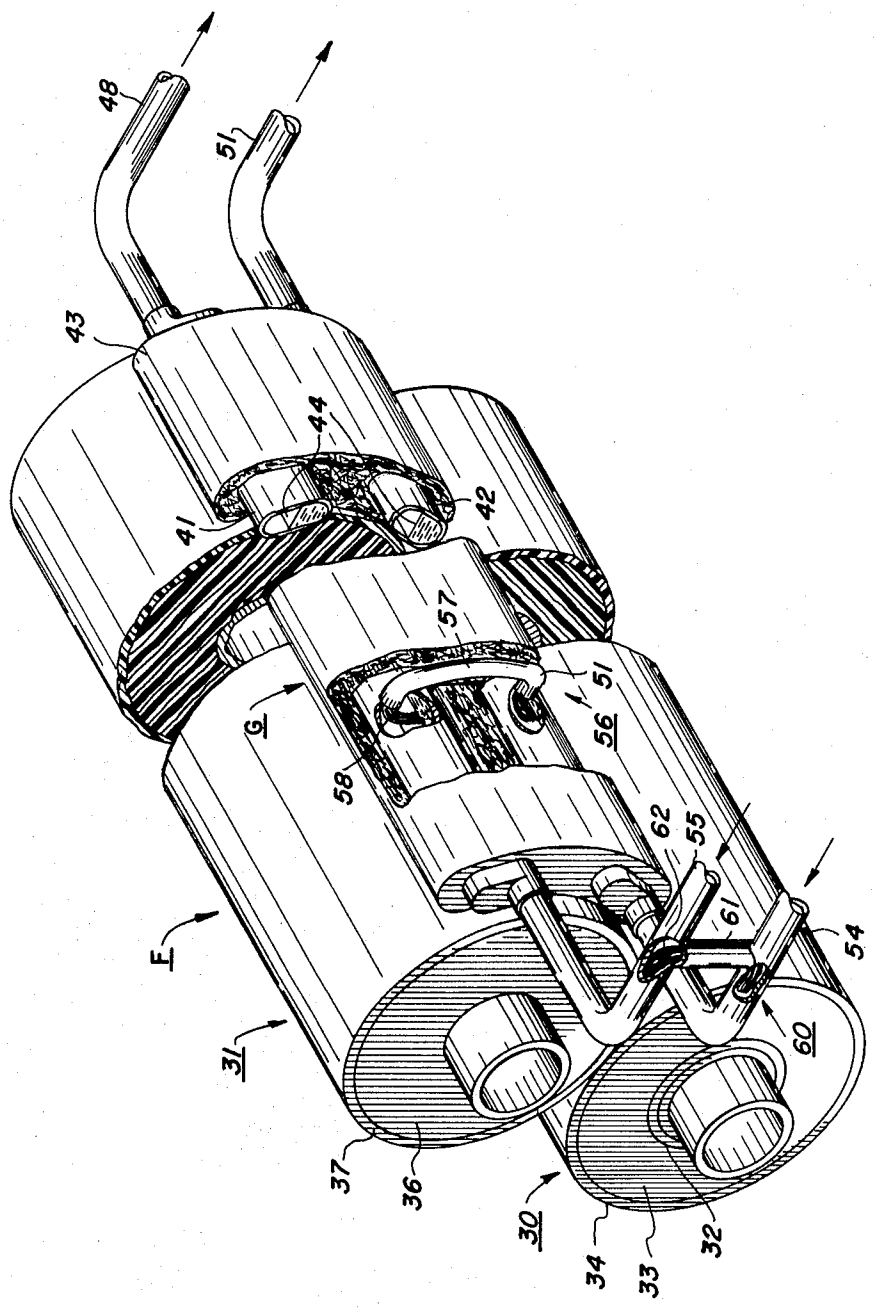


FIG. 3

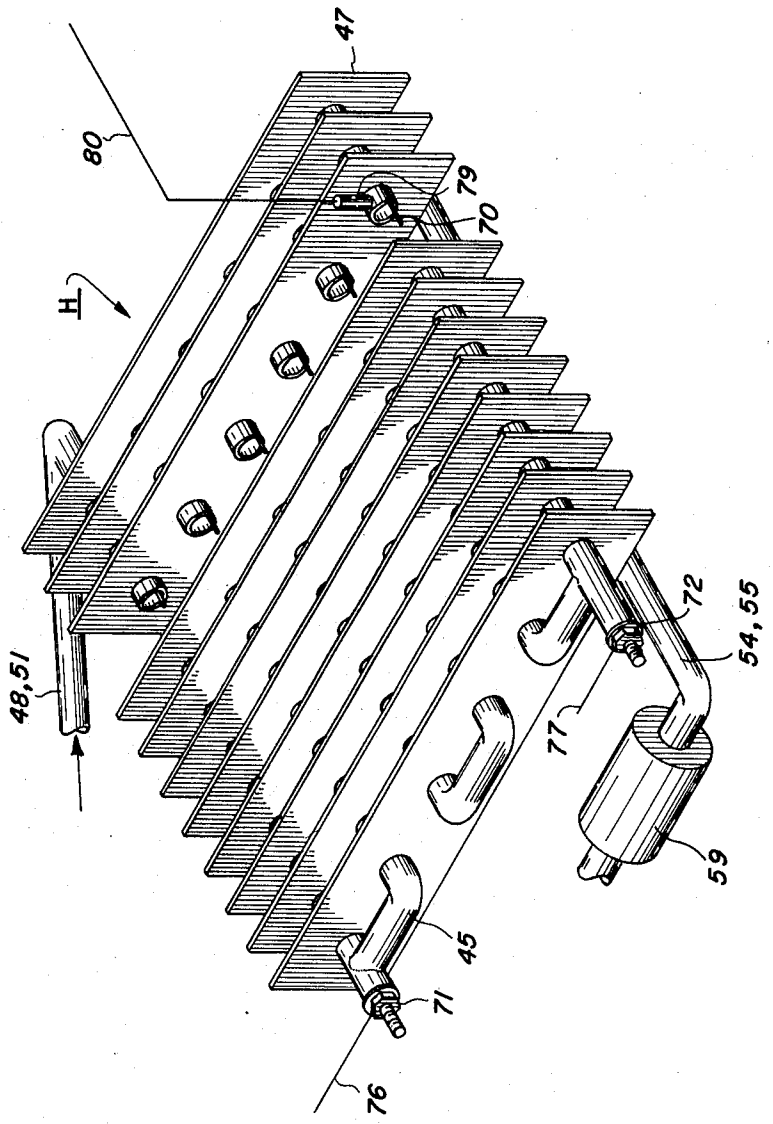


FIG. 4

XEROGRAPHIC FIXING DEVICE

In the art of xerography, a latent electrostatic image of an original is recorded upon the surface of a photosensitive plate and the latent image is then rendered visible by the application of a charged finely divided toner material. In practice, the toner is either fixed directly to the plate surface, as for example in the case of zinc oxide sheets, or transferred from the plate to a sheet of final support material, such as paper or the like, and affixed thereto to form a permanent record of the original subject matter.

Although many image fixing processes are known and used in the xerographic art, one particular method has recently found relatively wide application and acceptance in the art. This image fixing technique is the heat pressure roll process which was originally disclosed by Hudson in U.S. Pat. No. 3,256,002. In pressure roll fusing, the toner bearing copy to be fixed is drawn through the nip of two axially aligned cooperating roll members. Conventionally, one of the rolls is provided with a resilient blanket and the surface of the roll is provided with sufficient energy to raise its temperature to a predetermined operating level. The resilient heat roll, in turn, is supported in contact against the surface of the second more rigid roll wherein an extended nip, which defines the fusing zone is formed. As the copy passes through the nip, sufficient energy is transferred from the heated roll surface to the image bearing copy sheet to accomplish the desired image fixing.

Although this type of fusing system has demonstrated itself to be valuable adjunct to the xerographic process under most operating conditions, it nevertheless has certain drawbacks associated therewith which tend to limit its application. These drawbacks are all attributable to an excessive amount of heat energy being collected on the back up roll's surface particularly when the fuser has been in operation for extended periods of time. This undesirable characteristic of the system sometimes leads to premature roll failures, unreliable fixing of two-sided or duplexed copies during extended copy runs and excessive curling of the copy sheets as they pass through the fuser nip.

It is therefore an object of the present invention to improve xerographic fusing.

It is a further object of the present invention to provide a xerographic fixing system for accomplishing two-sided image fixing over extended periods of time.

A further object of the present invention is to minimize degradation of a once fixed toner image upon a copy sheet during the fixing of a second image thereon.

A still further object of the present invention is to minimize the occurrence of roll failures in a heated pressure roll fixing system.

Yet another object of the present invention is to reduce the amount of heat induced curl in a final support sheet processed in a xerographic fusing system.

These and other objects of the present invention are attained by means of a xerographic pressure roll heat fixing system having two co-axially aligned rotating rolls including a first heated pressure roll arranged to act against the surface of a co-acting back up roll, the heated roll being arranged to transfer sufficient energy to a toner image bearing support sheet through the nip formed between the two coacting roll members and a heat transfer mechanism operatively associated with one of the roll members being arranged to remove excessive heat energy from the fusing system.

For a better understanding of the present invention as well as other objects and further features thereof, reference is had to the following detailed description of the invention to be read in connection with the accompanying drawings wherein:

FIG. 1 is a schematic drawing illustrating an automatic xerographic copying machine utilizing the teachings of the present invention having the capability of producing copies having toner images affixed to both sides thereof;

FIG. 2 is an enlarged perspective view of the heat transfer device of the present invention;

FIG. 3 is a perspective view of the evaporator units utilized in the heat transfer device of the present invention illustrating means to equalize the work load distribution between the two evaporator units; and

FIG. 4 is a perspective view of one of the condensing units utilized in the heat transfer device of the present invention.

Referring now to FIG. 1, there is illustrated a schematic representation of an automatic xerographic machine employing a heat transfer mechanism for removing energy from the xerographic heat fuser system utilized therein. The apparatus of the present invention will be explained in reference to this copying machine employing the reusable xerographic process. However, it should be clear to one skilled in the art that the present invention is not limited to use in conjunction with the reusable xerographic process and this invention has wide application in any machine environment requiring the fixing of a xerographic toner image to a sheet of final support material.

Because the xerographic process is well-known and used in the art, the processing steps herein involved will be briefly described with reference to FIG. 1. A photosensitive plate **10**, in drum configuration, is mounted upon a shaft **12** and caused to rotate in the direction indicated to pass the drum surface through a series of processing stations. The xerographic plate consists of an outer layer **13** of photoconductive material, such as selenium or the like, which is placed over a grounded support material **14**. In operation, the plate is initially charged to a uniform potential at a charging station A by means of a corona generator **15**. The uniformly charged plate is then removed into an imaging station B wherein a flowing light image of an original, which is supported upon a viewing platen **17**, is projected onto the plate surface via a mounting scanning lens **18** and mirrors **19** and **20**.

As a result of this imaging process, a latent electrostatic image of the original subject matter is recorded upon the photoconductive plate surface. The latent image is then transported on the drum surface through a developing station C wherein the latent image is rendered visible by the application of a specially prepared toner material to the plate surface. The visible image is then moved on the drum surface into a transfer station D.

A sheet of final support material is fed from either one of two supply trays, an upper supply tray **24** and a lower supply tray **25**, into transfer station in synchronous moving contact with the visible image carried on the drum surface. The support sheet and the charged toner image are both brought under a transfer corona

generator **27** which serves to electrically transfer the toner images from the plate surface to the plate contacting side of the support sheet. The sheet is then removed from the drum surface by means of a picker finger **28** and directed via a vacuum transport **29** into the nip of a heat pressure roll fusing assembly F.

The automatic copier herein disclosed has the capability of producing either single sided copy, that is, copy bearing a toner image on one side thereof, or double sided copy. In the case of a single sided copy, the final support sheets are fed from either supply tray into the transfer station and then into the fuser assembly. Upon leaving the fuser assembly, the sheet is forwarded directly into a collecting tray **19** where the copies are stored and held until such time as the operator has need for them. When a two-sided copy is to be produced, movable transport **26** is moved to a lowered or dotted line position. The sheets of final support material are initially fed from the lower tray **25** through the transfer and fusing stations and delivered into the upper tray **24** where the sheets are stored until such time as the machine is ready for a second copy run. Upon the initialization of a second copy run, the movable transport is raised and the once imaged copy sheets are fed from the upper tray back through the transfer station and the fusing station wherein a second toner image is transferred onto the back side of the sheet. The now two-sided copy is fed into the collecting tray.

Referring now more specifically to the fuser assembly F, (FIG. **2**) the fuser basically consists of a lower heated roll **30** and an upper back up roll **31.** The heated roll is constructed of a support cylinder **32** over which is placed a relatively thick resilient blanket **33.** A thin layer **34** of low surface energy material, such as trifluoroethylene, is placed over the outer periphery of the heated roll surface. The blanket and the outer layer placed thereover are both formed of materials having low thermal conductivity, the purpose of which will be explained in greater detail below. The back up roll is formed of a relatively rigid core **36** over which is placed a sleeve **37** of trifluoroethylene.

The fuser rolls are supported in a frame (not shown) and are arranged to be rotated at synchronization speeds in the direction indicated. The lower fuser roll is biased into deforming contact against the surface of the more rigid upper roll to provide an extended nip therebetween in which sufficient energy is transferred from the heated roll surface to the toner image bearing side of the copy sheet, moving therebetween to accomplish image fixing. In operation, a radiant source **35** is positioned to irradiate the outer surface of the lower roll just prior to the surface contacting the image side of a copy sheet moving through the fuser nip. Because the lower roll is constructed of a material exhibiting a low thermal conductivity, the rate at which energy flows in to the roll is minimized. As a consequence, a preponderance of the total energy delivered into the fuser roll system is stored on the lower roll surface where it can be readily and efficiently transferred to the toner image bearing side of the copy sheet brought into contact therewith. For further information concerning this type of fusing system, reference is had to U.S. Pat. No. 3,498,596 which issued in the name of Moser.

During image fusing, it has been found advantageous to minimize the flow of heat passing through the nip into the back up roll. To this end, the trifluoroethylene sleeve **37** is also constructed of a material having a relatively low thermal conductivity within the fusing temperature range of the system. In this manner, most of the energy brought into the fuser nip on the lower roll surface is available for use in the fusing process rather than being conducted across the nip and wasted in heating the back up roll structure.

This particular arrangement also enhances the fusing system's ability to fix double sided copy. The back up roll, because of its low thermal conductivity, acts as a barrier to retard the amount of heat energy flowing through the fuser nip and thus keeps the back side, or first image side of the sheet contacting the back up roll, relatively cool during the period that the second or opposite side of the sheet is being fixed. In this manner, the first fused images are prevented from being remelted during the second image fixing pass.

However, particularly during periods of extended usage, the temperature of the back up roller is inadvertently increased to a point whereby it can no longer effectively function in the desired manner to accomplish high quality double-sided image fixing. For example, when fusing most conventional toner materials to a sheet of plain paper, the surface temperature of the heated roll entering the nip is preferably at or about 375° to 385°F. Under these operating conditions, it is desirous that the surface temperature of the back up roll entering the nip be maintained at somewhere close to 210°F in order to prevent image degradation. It also has been found that when a heat build up is allowed to occur in the back up roll structure, the quality of the copy produced is further degraded because a heat induced curl is usually produced in the copy sheet. These excessively high temperatures created in the nip tend to drive off the material moisture contained in the support material causing the sheet to dry out in an unwanted curled posture. The apparatus of the present invention is specifically designed to eliminate these and any other undesirous features found in a pressure roll fusing system which is produced by a build up of excessive energy within the system.

In order to prevent a heat build up from occurring in the fusing system, a thermodynamic cooling device, generally referenced **40,** is herein utilized to remove excess energy from the back up roll structure. The cooling system includes an evaporator stage G made up of two evaporators **41** and **42** which are substantially enclosed within a heat sink blanket **43.** The blanket, in turn, is supported in thermal communication with the surface of the back up roll upstream from the fuser nip. In practice, the heat sink blanket is formed of a graphite impregnated material which is capable of conducting heat rapidly away from the roll surface. Although any suitable material may be used to form a blanket, it is preferred that the blanket be formed of a commercially available brush-like material manufactured under the tradename of "Grafoil" by Union Carbide Corporation — Carbon Products Division — 270 Park Avenue, New York, New York 10017.

Both evaporators are axially aligned in a stacked configuration adjacent to the back up roll surface with each evaporator extending in a longitudinal direction across the surface of the roll. Normally, each evaporator is partially filled with a working substance, in this case a liquid, to a predetermined level line. When the surface temperature of the back up roll exceeds a predetermined operating level, the working substance is caused to evaporize and the vapors are collecting in a

chamber 44 which is provided within each evaporator above the liquid level line. It should be clear to one skilled in the art that the term vapor as herein used refers to a fluid which exists in a gaseous state at or near its particular condensation point. In this particular case, it is preferred that the vapor of the working substance be formed at a predetermined temperature under atmospheric conditions.

The vapor chamber 44 of each evaporator is connected to one of the two condensers by means of a vapor line. In practice, the upper evaporator 41 in the stack is connected to condenser 50 associated with the upper sheet supply station 24 via vapor line 51. Similarly, the vapor chamber of the lower evaporator 42 is connected to the second condenser 49 associated with the lower sheet supply station 25 via vapor line 48. It should be noted that each condenser is located at a higher elevation than the associated evaporator unit whereby the vapors collected in the vapor chambers are caused to flow upwardly, under natural flow conditions, into the associated condenser unit.

As shown in FIG. 2, each condenser is positioned directly above the sheet stack contained within the associated supply region. Although not clearly shown, each support station is preferably constructed to create a relatively enclosed, humidically isolated region within the machine into which heat energy given up by the condenser is discharged. As more clearly seen in FIG. 4, each condenser includes a horizontally aligned condensing coil 45 which is positioned substantially parallel to the support stack being serviced. Each condenser coil is provided with a series of perpendicularly aligned cooling fins 47 which serve to reduce the thermal resistance on the condenser side of the system thereby facilitating the discharge of energy into the support stack supply regions. As the vapors move through the condenser coils, the vapors are allowed to cool below their respective due point, thus giving up the latent energy of evaporation acquired. This energy, in turn, is discharged from the system directly into the sheet support regions where it is used to control the moisture or humidity content therein. For the purpose of the present invention the excessive heat energy removed from the fuser sections need not be discharged into the paper supply area but can be discharged into any region which is thermally isolated from the fuser area.

The condensate collected in the condenser stage is returned to the evaporator stage thus closing the thermodynamic system. In order to balance the work load between evaporator units, the condensate or liquid return lines are crossed so that the upper condenser delivers condensate to the lower evaporator and the lower condenser similarly delivers condensate to the upper evaporator. Condensate is returned under the influence of gravity from the upper condenser via liquid return line 54 will liquid return line 55 services the upper condenser. It should be noted that an expansion valve 59 is positioned in each of the liquid return lines to throttle the condensate before it is returned to the evaporators.

The apparatus herein described represents a closed thermodynamic system wherein energy is both absorbed and rejected from the system under isothermal conditions. The system further relies upon a natural flow of the working substance through the system thereby eliminating the need for pumps or the like. As noted above, it is desirous to maintain the back up roll surfaces at between 200°F and 220°F. As a consequence, it is possible to use water, which evaporates at about 212°F under atmospheric conditions, as a working substance in the present invention. In practice, the amount of working substance within the system and/or the size of the lines connecting the evaporator and condenser stages are regulated so that the system, under normal working conditions provides about 500 watts into the support tray regions.

When the machine is held in a standby mode of operation, i.e. when the machine is on but no copies are being produced, the power to the fuser is reduced and thus the flow of energy into the sheet support regions is minimized. An auxiliary heating unit, associated with each condenser, is herein provided to augment the energy output of the system during periods when the machine is in a standby condition or during periods when a low volume of copy is being produced. As best seen in FIG. 4, an electrical resistance heater 70 is positioned along the inner walls of each condenser coil. The terminal ends of the heater are connected to output terminals 71 and 72 and the output terminals, in turn, electrically connected to a source of power 75 (FIG. 1) via leads 76, 77. A thermal sensing device 79 is embedded within each condenser coil and is electrically connected to the power supply by means of a lead 80. In operation, the sensing element monitors the temperature of the condensate fluid within the condenser coils. The term fluid is herein used in reference to the working substance contained within the condensers and the fluid can exist as either a gas or a liquid or both. When the sensed temperature of the fluid falls below a predetermined level, the power supply is actuated thus providing energy to the heating elements which, in turn, heats the fluid to a predetermined temperature. Auxiliary power to the heaters will remain on until such time as the working substance begins to flow through the closed system indicating that energy is once again passing from the evaporator to the condenser. Although not shown, any sufficient device for measuring the flow of the working substance through the system can be so employed to inactivate the auxiliary power supply.

Under extreme operating conditions, wherein continuous copy is made over a prolonged period of time, steps must be taken to prevent the individual evaporators from becoming overworked and thus burning out. To this end, a series of equalizing devices, generally referenced 56, are herein provided between the two evaporator units. As shown in FIG. 3, each equalizer is made up of a hollow tubing 57 which enters the vapor chamber of each evaporator unit well above the normal fluid level line maintained therein. An absorptive wick 58 runs through the tubing and extends downwardly into the fluid supply area of each evaporator unit. In operation, the wicks, through capillary action, function to equalize the fluid level contained in each unit. In the even that one evaporator unit becomes overworked, and the wicks will deliver fluid from the opposite underworked evaporator unit into the fluid deplete overworked unit thus preventing the overworked unit from burning out or otherwise being damaged.

A similar interconnection 60 is also provided between the liquid inlet lines 54 and 55 prior to the lines entering the evaporators. As can best be seen in FIG. 3, the inlet interconnector is quite similar in construction to the equalizing devices extending between the

evaporator units in that it consists of a hollow tube or connector **61** running between the two liquid return lines which contain a wick element **62.** If a vapor of the working substance inadvertently passes the throttling valve, or otherwise enters one of the liquid return lines, the wick will sense this unbalanced condition and take corrective action to draw liquid from the opposite line, again via capillary action, thus returning the system to the desired working conditions.

While the invention has been described with reference to the structure herein disclosed, it is not necessarily confined to the specific details set forth and this application is intended to cover any modifications or changes as may come within the scope of the following claims.

What is claimed is:

1. In a pressure heat roll image fixing apparatus of the type wherein a heated roll is moved into pressure contact against a coacting back up roll to form a fusing nip therebetween through which images bearing support sheets are drawn, the improvement comprising

evaporator means positioned in thermal communication with said back up roll to remove heat energy from the surface of said roll,

said evaporator means being wrapped in a blanket material having relatively high thermal conductivity and a relatively low coefficient of friction with respect to said roll surface, and

means operatively connected to said evaporator means for discharging the heat energy removed from said roll surface into a receiver which is thermally isolated from said roll surface.

2. The apparatus of claim **1** wherein said evaporator removes heat energy from the fuser roll surface under isothermal conditions.

3. The method of removing heat energy from a xerographic fusing roll surface to maintain the surface temperature at a predetermined level including

thermally contacting a fusing roll surface with a working substance capable of vaporizing at about the predetermined temperature level and which is insulated by a material having a relatively low coefficient of friction with respect to the roll surface whereby said working substance vaporizes when the roll surface exceeds said predetermined level,

moving the evaporants of the working substance to an area thermally isolated from said fusing system, and

condensating said evaporants whereby the heat energy stored therein is rejected into said thermally isolated area.

4. The method of claim **3,** further including the step of returning the condensate of said working substance back into thermal communication with said fusing system.

5. The method of claim **4,** further including the step of throttling the condensate prior to returning said condensate back into thermal communication with said fusing system.

6. Apparatus for reducing the surface temperature of a xerographic fuser roll to a predetermined temperature including

a pair of parallel aligned evaporator units positioned in thermal communication with the fuser roll surface, said units being partially filled with a working fluid capable of evaporating at about the predetermined temperature,

a pair of condenser units for receiving the evaporants of the working substance from said evaporator units, said condensers being located in a region thermally isolated from said fuser region,

a vapor line connecting one of each evaporator units to one of each condenser units, and

a liquid return line for returning condensate from each condenser unit to an evaporator unit opposite that from which said condenser receives evaporants.

7. The apparatus of claim **6,** having further means to maintain the working fluids contained in each evaporator unit at substantially the same level.

8. The apparatus of claim **6,** wherein each evaporator is located at a lower elevation than the condenser units whereby the evaporants and condensates of the working substance are caused to flow therebetween under natural flow conditions.

9. The apparatus of claim **6,** wherein said evaporators are supported within a blanket having a relatively high thermal conductivity, said blanket being positioned in contact against at least a portion of said fuser roll surface.

10. The apparatus of claim **9,** wherein said blanket has a low coefficient of friction in regard to said fuser roll surface.

11. The apparatus of claim **6,** further including an expansion valve in each of the condensate return lines.

12. The apparatus of claim **6,** having connecting means running between the liquid return lines for equalizing the amount of condensate carried in each of said lines.

13. The apparatus of claim **7,** wherein said means to maintain the fluid level in each evaporator at substantially the same level includes

a closed conduct between each evaporator, said conduct opening into each evaporator above the normal fluid level contained therein, and

a wick element running through said conduct with both ends of said wick positioned below the fluid level of each evaporator unit.

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