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[54] **TONER FIXING METHOD AND APPARATUS**

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[52] **U.S. Cl.** **432/60,** 432/228, 34/115, 355/3

[51] **Int. Cl.** **F27b 9/14**

[58] **Field of Search** ..... 34/115; 219/388; 263/6 E; 355/3; 432/59, 60, 62, 228

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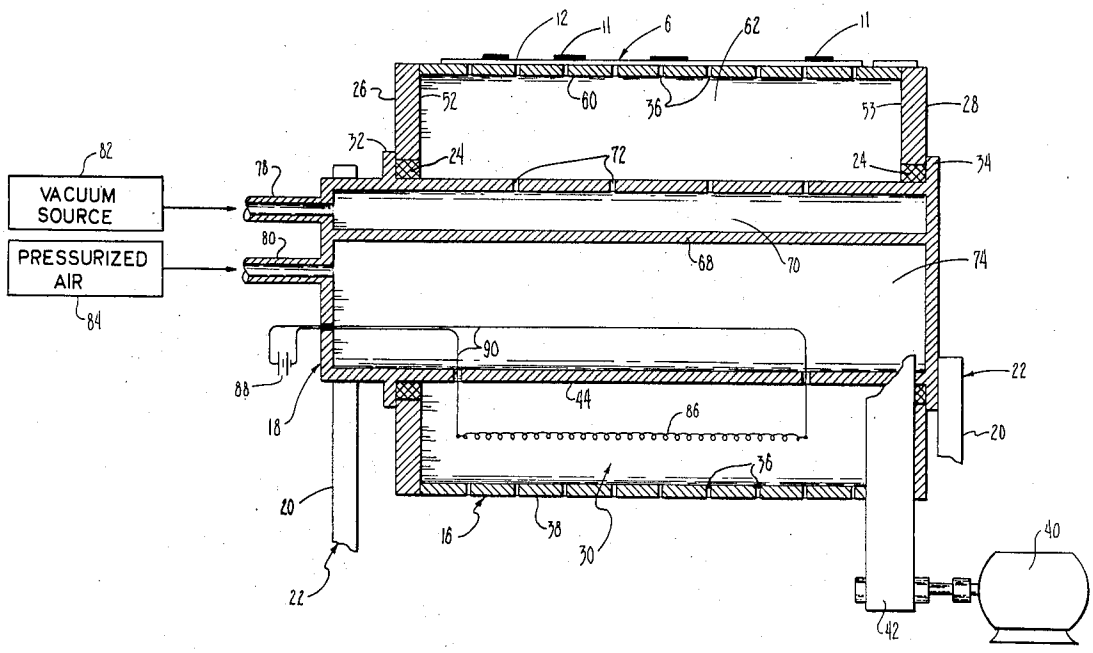
[57] **ABSTRACT**

Toner applied to paper sheets in electrostatic copying machines is fixed by wrapping the sheet about a heated drum with the toner disposed on the side of the sheet facing away from the drum. The sheet is moved into intimate contact with the drum by providing a multiplicity of passageways from the drum exterior to its interior and applying a vacuum to thereby draw the sheet against the drum. After the sheet has been retained on the drum for a sufficient length of time to fix the toner a pressurized gas is applied to the passageways to blow the paper sheet off the drum. To minimize air flow while the passageways are vacuumized such passageways can be applied to only a portion of the drum circumference equal in length to the length of the paper. The drum rotation is then indexed to correspond to the copy cycle.

11 Claims, 4 Drawing Figures



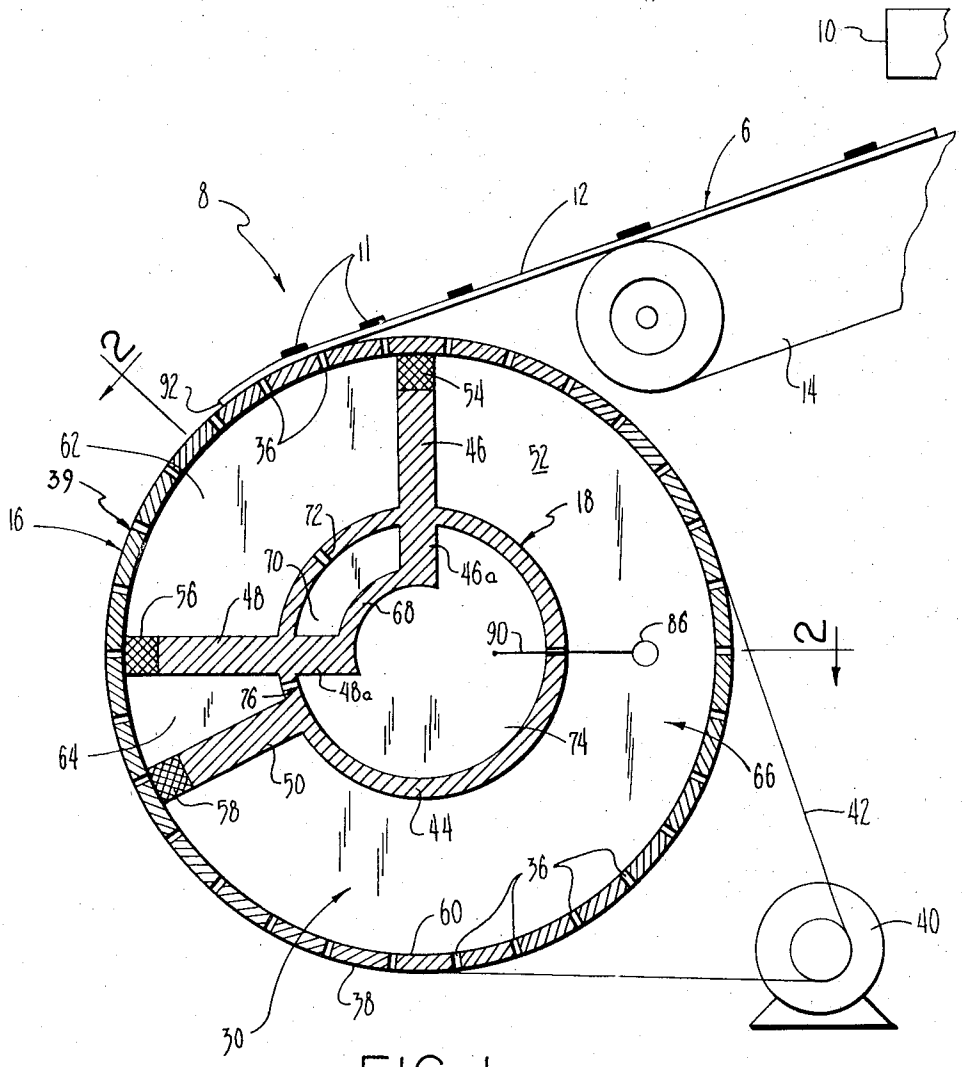


FIG. 1

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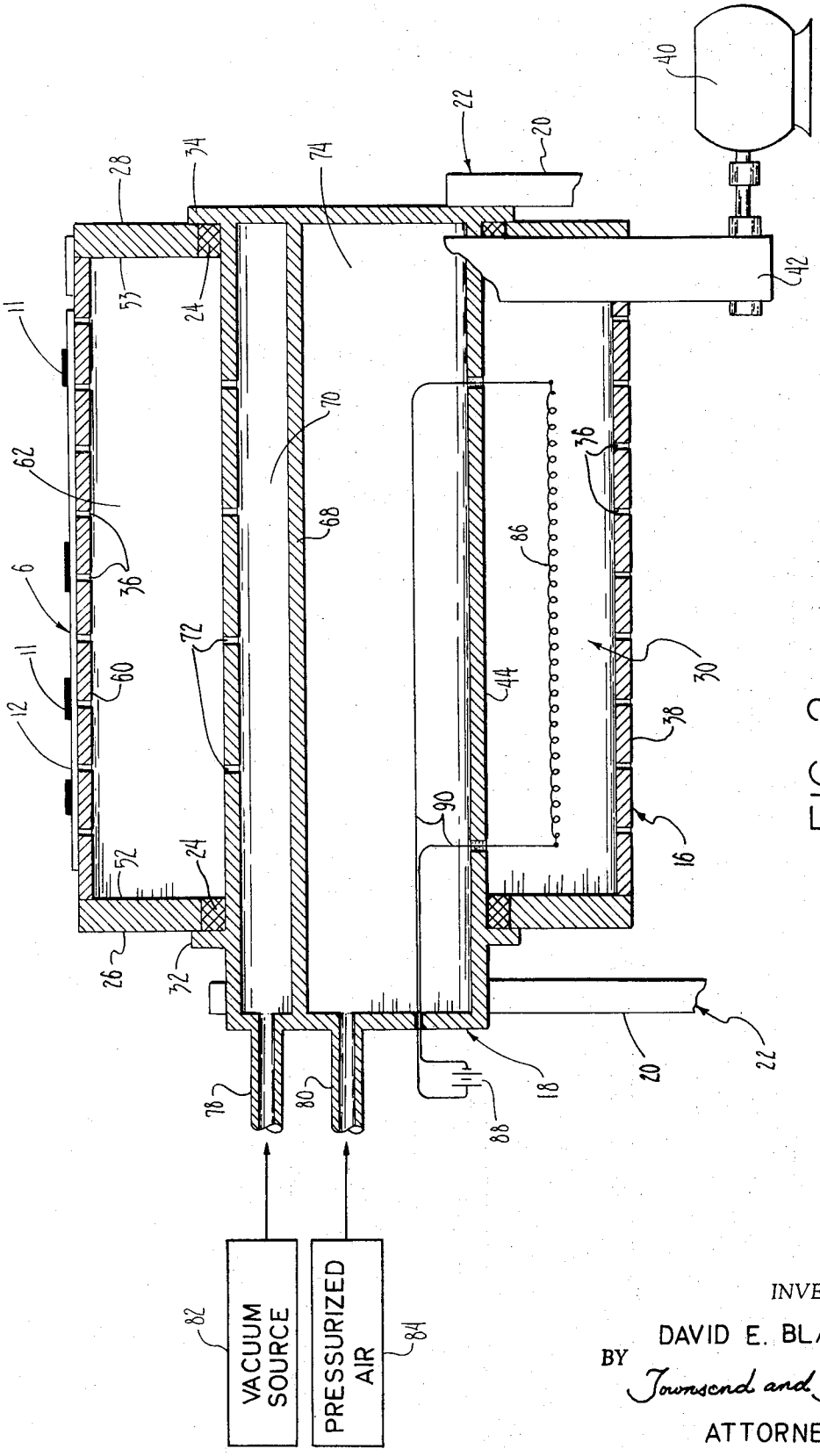

FIG. 2

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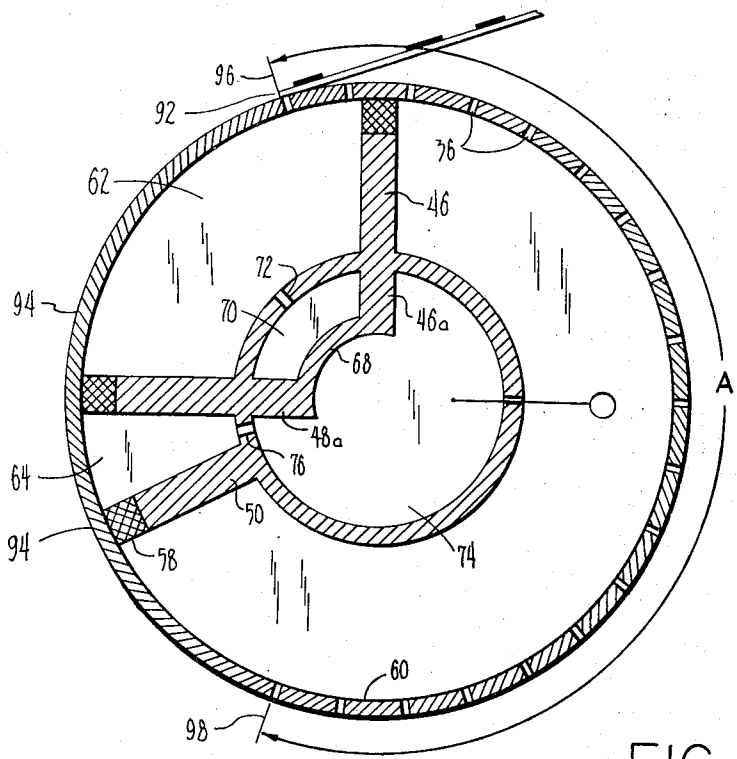

FIG. 3

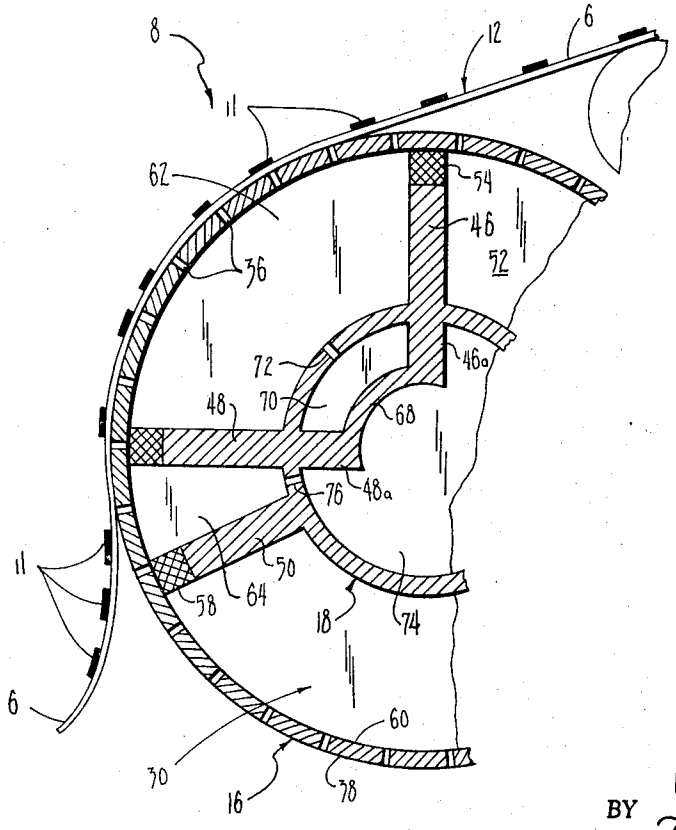

FIG. 4

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TONER FIXING METHOD AND APPARATUS

BACKGROUND OF THE INVENTION

Dry toner electrostatic copying machines require that the toner, after deposition on a sheet of paper, be firmly affixed to the paper. Conventional toners, which are a mixture of a resinous binder, a colorant, and additives, are usually fixed by melting the resinous binder of the toner so that the toner flows over and into the paper. Two main methods of supplying the necessary heat are presently employed. According to the first method, a source of radiant energy is placed above the paper with the paper side to which the toner is applied facing the source. The second method employs conductive heating in which a heated surface is placed in contact with the paper and the toner is melted by heat conduction from the heated surface.

The first method, namely the one employing a radiant energy source is simple and relatively inexpensive to construct. However, it is highly inefficient and requires a large amount of power for melting the toner. It is satisfactory only for slow copying machines having a copying rate of no more than about twenty copies per minute. For higher copying rates, the required radiant energy density would be too high and can accidentally ignite the copy paper. This danger becomes particularly accute should the copy paper jam, in the vicinity of the radiant heat source.

The second toner heating method, namely the one relying on heat conduction, prevents the above noted problems. It is efficient and consumes only a fraction of the power required by a radiant energy source of equivalent toner melting effectiveness. Commonly, electrostatic toners require melting temperatures of no more than about 350°F., well below the spontaneous ignition temperature of paper. Consequently, the heated surface against which the paper is placed can be maintained at such relatively low temperature. The danger of accidentally igniting the copy paper is thereby eliminated. Furthermore, the conduction method is fast and can be employed for high speed copying machines.

Some presently available electrostatic copying machines employ the conduction method for heating and fixing the toner. A smooth metal cylinder, sometimes coated with a thin Teflon layer, is heated to a temperature above the toner melting temperature and contacts a deformable, heat resistant polymeric roller with sufficient pressure that an extended area of contact between the two is obtained. The toned, unfixed copy paper is fed between the cylinder and the roller with the toner facing the cylinder. The deformed polymeric roller forces the paper against the heated cylinder and establishes intimate contact between the two to assure the melting of the resinous phase of the toner.

To prevent disturbance of the unfixed toner, that is to prevent smudging or destruction of the toner pattern on the sheet, a special lubricant is continuously applied to the heated cylinder. The lubricant lessens the tendency of the toner to stick to the heated cylinder. In spite thereof, toner particles can and in fact do adhere to the heated cylinder so that a cleaning apparatus is further provided. The special lubricant, a lubricant application device, and the cylinder cleaning device significantly increase the costs of fixing electrostatic toner, require constant and careful maintenance and

are a potential source of machine failure and resulting shutdown.

SUMMARY OF THE INVENTION

The present invention eliminates the drawback encountered with prior art toner fixing methods and apparatus for electrostatic copying machines. The present invention employs a heated drum or cylinder, as is known in the prior art, but faces the toned side of the copy paper away from the drum. To obtain satisfactory fixing of the toner, and that primarily means to obtain the necessary heat transfer from the drum to the toner, the copy paper is wrapped about a rotating, perforated heated drum, a section of which is vacuumized to thereby draw the paper into intimate contact with the drum and obtain the desired fast heat transfer.

In its broadest form, the method of the present invention for fixing electrostatic toner applied to a side of a sheet comprises the steps of placing the other, non-toned side of the sheet on a heated surface, forcing the other side of the sheet into intimate contact with the surface without disturbing the toner pattern on the sheet to thereby heat and fix the toner, and thereafter removing the sheet from the surface, preferably by blowing it off the surface with compressed air or gas applied to the contacting surface of the paper sheet through passageways in the heated surface.

In the preferred form of the invention, the heated surface is defined by a rotating drum having passageways, either in the form of discrete holes or in the form of passageways defined by a porous material, and suitable vacuum and pressure chambers positioned inside the drum. The chambers are arranged to maintain the vacuum and thereby the intimate contact between the drum and the paper for a sufficient length of time to fix the toner. Thereafter, pressurized air from the pressure chamber separates the paper and the drum to prevent adverse effects on the toner from exposing it to heat.

The apparatus of the present invention broadly comprises a rotatable drum having a plurality of small diameter passageways extending from an exterior surface of the drum to the drum interior, means for heating the drum to a desired temperature, and means for rotating the drum. At least two stationary sections of the drum interior are sealed with respect to each other and communicate with drum segments overlying the sections. Means are provided for applying a vacuum to one of the sections, and preferably, a pressurized gas such as air to the other section. The relative arcuate extent of the sections, in the direction of rotation of the drums, is so selected that copy paper is drawn into contact with the drum for as long as it takes to fix the toner applied to the sheet surface facing away from the drum. Thereafter, the pressurized air exiting from the passageways in the drum sequentially blows off the sheet beginning with its leading edge until the trailing edge arrives over the pressurized interior drum section.

After the initial warm-up time for the drum to bring it to its operating temperature of say 350°F. operation of the fixing apparatus is continuous. A drum rotating motor, vacuum and pressure sources, and a heating element operate continuously. The toner on copy paper received at the fixing station can be continuously fixed. Moreover, the operation of all elements associated with the toner fixing need not by synchronized with the copying cycle of the machine.

The heretofore common need for lubricating the heating drum, a device for applying the lubricant to the drum, and the need for cleaning the drum of toner deposits formed while toner being fixed contacts the drum exterior are eliminated. This reduces the initial costs for the copier and substantially simplifies and reduces machine maintenance. A potential source for machine breakdowns and unprofitable down times is thereby eliminated.

In another embodiment of the invention for applications in which air flow into the vacuumized section of the drum interior is to be minimized the drum is synchronized with the copying cycle of the machine. The passageways extend over a length of the drum circumference which is equal to the length of the copy paper so that the passageways are covered by the paper whenever they overlie the vacuumized drum section.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. **1** is a schematic, fragmentary cross sectional side elevation of a fixing station for an electrostatic copy toner constructed in accordance with the invention;

FIG. **2** is a front elevational view of the fixing station and is taken on line **2—2** of FIG. **1**;

FIG. **3** is a side elevational view, similar to FIG. **1** and illustrates another embodiment of the invention; and

FIG. **4** is a fragmentary, side elevational view of the fixing station shown in FIG. **1** but illustrates part of the copy paper advanced past a rotating drum.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring to FIGS. **1, 2** and **4,** copy paper **6** is advanced towards a toner fixing station **8** from a copy mechanism **10** of the machine where toner **11** is applied in image copying patterns to a marked side **12.** A transport mechanism **14** feeds the copy paper at a constant speed to the fixing station.

At the fixing station, a cylindrical drum **16** is rotatably mounted on a core **18** which is carried by a suitable support structure **20** of copying machine **22.** Rotary seals **24** between removable drum end walls **26** and **28** and core **18** seal interior space **30** of the drum from the exterior. Radial flanges **32** and **34** of the core position the drum and prevent axial movements thereof. One of the radial flanges, say the right-hand flange, is removable (not shown) so that the core and the drum can be assembled.

A multiplicity of small diameter bores or passageways **36** communicate interior drum space **30** with the exterior and terminate at a cylindrical exterior drum surface **38.** The passageways can be discrete bores, drilled, punched or the like into the drum and extending in a generally radial direction, or they can be defined by a multiplicity of irregularly shaped pores by constructing the cylindrical portion of the drum of a porous material such as sintered metal. The diameter of the passageways is small, preferably in the order of no more than about 0.032 inches.

Exterior drum surface **38** can include grooves **39,** knurled depressions or the like which communicate with discrete passageways **36** and distribute a vacuum applied to the passageways more evenly. A more thorough and uniform adhesion of the copy paper to the drum is thereby obtained.

A conventional drive mechanism, such as an electric motor **40** and a belt **42** is provided for rotating the drum at a constant speed. If desired, the belt drive can be replaced by suitable gear drives or the like.

Drum core **18** is stationary, that is it does not rotate with the drum and is generally defined by a cylindrical member **44** that extends over the length of the core and rotatably supports drum **16.** Three radially extending walls **46, 48** and **50** are angularly spaced, as best seen in FIG. **1,** are disposed between inner faces **52, 53** of drum end walls **26, 28,** respectively, and their free sides mount friction seals **54, 56** and **58** which engage inner faces **52, 53** and inside **60** of the cylindrical drum. The walls and friction seals define a vacuum chamber **62** disposed between inner faces **52** and **53,** the confines of walls **46, 48** and the portions of drum inside **60** and cylindrical core member **44** included by walls **46** and **48.** Walls **48** and **50** further define a pressure chamber **64** of a lesser angular extent than the vacuum chamber and which is also air tight with respect to the vacuum chamber as well as to a remainder **66** of the interior drum space **30.**

Extensions **46A** and **48A** protrude from cylindrical member **44** towards the center thereof and are interconnected by a circular section **68** to define a vacuum duct or conduit **70** that communicates with the vacuum chamber **62** via a plurality of axially (in the direction of the drum) arranged and spaced apart openings **72.** A resulting pressure conduit **74** defined by the remainder of the hollow interior of cylindrical core member **44** communicates with pressure chamber **64** via bores **76.** Pipes **78** and **80,** respectively, are connected to a vacuum source **82** and a source of pressurized air **84.**

A conventional heater such as a resistance heater **86** derives its energy from an electric power source **88** via conductors **90.** Conventional thermostats (not shown) are employed to maintain the temperature of drum **16** at a predetermined or preset value.

In operation, copying mechanism **10** of copier **22** deposits toner **11** in accordance with an electrostatic field on marked side **12** of copy paper **6.** Conveyor **14** then transports the sheet at a predetermined speed to fixing station **8** where drum **16** rotates at a rate so that its exterior surface **38** speed equals the speed of the advancing copy paper **6.**

Vacuum source **82** and pressurized air source **84** continuously are energized and, respectively, supply a vacuum and pressurized air to vacuum chamber **62** and pressure chamber **64.** Friction seals **54, 56** and **58** prevent air leakage from the chambers. Those of the passageways **36** overlying vacuum chamber **62** form small vacuumized areas on exterior drum surface **38** at their outer terminal point while those of the passageways overlying pressure chamber **64** discharge a continuous stream of air from their outer terminal points.

Wall **46** defining the upstream (in the direction of rotation of the drum) end of the vacuum chamber is so positioned that when conveyor **14** feeds copy paper to the fixing station leading edge **92** of the paper contacts the drum exterior at or slightly downstream of wall **46** so that the leading edge contacts vacuumized passageways **36.** This contact immediately forces the sheet against the drum surface since the small vacuum areas of the passageways draw the paper into intimate contact with the drum. Continued rotation of the drum draws additional copy paper onto it at the same rate

with which the copy paper is discharged by conveyor **14.**

The angular separation between vacuum chamber defining walls **46** and **48** is so selected that the time interval during which the drum moves through the corresponding angle is sufficient for fixing the toner, that is for melting the resinous phase thereof. In the drawings, the separation between the walls is illustrated to be 90°. It will be understood that other angular separations between these two walls can be obtained by varying the drum diameter, the drum temperature and/or the paper feeding speed.

When the leading edge **92** arrives at downstream wall **48** it begins to overlie pressure chamber **64.** At that point, the heretofore vacuumized passageways **36** become pressurized and discharge a continuous flow of air from the pressure chamber to the exterior. The leading edge and following copy paper portions are thereby blown off the drum periphery and peeled away from the drum as shown in FIG. **4.**

The copy paper can be fed to the drum continuously and in any desired intervals. Since the drum periphery is uniform there is no need for synchronizing the drum rotation and the fixing of the toner with the copying cycle of the machine. Moreover, the many vacuumized passageways distributed over the drum exterior result in a firm and intimate drum to paper contact which quickly conducts heat from the drum to the toner. In fact, the time required for fixing the toner in accordance with the invention, by facing it away from the drum is only slightly longer than the time required for fixing the toner in accordance with the prior art in which it was placed in direct contact with the drum surface. The difference is so slight that it does not noticeably affect the operation of the copying machine and easily allows slack during operation of the machine at even the highest copying rates presently employed.

Referring now to FIG. **3,** in another embodiment of the invention, a partially perforated or porous drum **94** is employed. The construction of all components including the drum core **18** are the same as the one shown in FIGS. **1** and **2** and described above. However, passageways **36,** or corresponding pores if a porous material is employed, extend only partially about the drum periphery from a leading edge **96** over an arc "A" to a trailing edge **98.**

In use, drum **94** is driven in synchronism with the copying mechanism of the machine so that leading copy paper edge **92** coincides with leading passageway edge **96** of the drum. The drum rotates at a rate so that its surface speed equals the feeding speed for the paper. Arc "A" over which the passageways extend is of the same length as the length of the copy paper so that during each cycle, that is each time a copy paper is advanced to the fixing station for fixing the toner all passageways moving over vacuum chamber **62** are covered by paper. There is, therefore, no substantial air flow into the vacuum chamber which enables a reduction in the required size of vacuum source **82** (shown in FIG. **2**). When no copy paper is advanced to the fixing station drum **94** is stationary and is indexed so that leading edge **96** of the passageway array is positioned just upstream, that is to the right of upstream wall **46** defining the vacuum chamber.

I claim:

1. A method for fixing electrostatic toner applied to one side of a sheet comprising the steps of: sequentially placing another side of the sheet from a first, leading edge of the sheet to a second, trailing edge of the sheet on a heated surface, applying a force to bias the sheet into intimate contact with the surface to thereby heat and fix the toner, and removing the sheet from the surface by applying pressurized gas to said another side of the sheet to thereby blow the sheet off the surface.

2. A method for fixing electrostatic toners including a heat curable substance in an electrostatic copying machine, the method comprising the steps of rotating a cylindrical drum having a multiplicity of relatively small passages extending from a drum interior to the drum exterior, applying a vacuum to a section of the interior only to thereby communicate the vacuum to the drum surface through first ones of the passages only, applying a pressurized gas to another section of the drum interior for passing gas through second ones of the passages from the other section to the drum exterior, sealing the sections from each other, heating the drum, passing sheets having an electrostatic toner applied to one side thereof to the drum, and contacting the other side of the sheet with the drum at a location on the drum exterior coextensive with the vacuum section, whereby the vacuum firmly holds the sheet against the heated drum to cure the substance and fix the toner and, thereafter, pressurized gas passing through the passages removes the sheet by blowing it off the exterior drum surface.

3. A method according to claim **2** wherein the step of passing the sheets comprises the step of cyclically advancing sheets to the drum, and wherein the step of rotating the drum comprises the step of continuously rotating the drum independently of the cyclical sheet advancing step.

4. A method according to claim **2** wherein the rotating step includes the step of synchronizing the drum rotation with a cyclically operating portion of the copying machine.

5. A method according to claim **4** wherein the step of applying the vacuum comprises the step of applying a vacuum to substantially only the portion of the drum which underlies the sheet.

6. A method for fixing a curable electrostatic toner applied to a side of a paper sheet in an electrostatic duplicating machine which automatically advances the paper to a fixing station, the method comprising the steps of: rotating a drum positioned at the fixing station, heating the drum to the desired curing temperature for the toner, guiding a leading edge of the paper advancing towards the fixing station against the drum, contacting another side of the sheet with the exterior drum surface, subjecting at least portions of the exterior drum surface to a vacuum to thereby force the paper sheet into intimate contact with the exterior drum surface, maintaining the sheet in contact with the drum surface for a sufficient length of time to effect the curing of the toner with heat conducted through the sheet only, sequentially removing the vacuum from adjacent the leading edge towards a trailing edge of the sheet as sheet portions have remained in intimate contact with the drum for a predetermined length of time, and sequentially withdrawing the paper from the drum as the vacuum is removed by applying a pressurized gas to said another side of the sheet to thereby blow the sheet off the drum.

7. Apparatus for fixing curable electrostatic toner and the like applied to one side of a thin sheet, the ap-

paratus comprising: a rotatable drum including a plurality of small diameter passageways extending from an exterior surface of the drum to a drum interior, means for feeding the sheet to the drum and for contacting another side of the sheet with the exterior drum surface, means for heating the toner on the one side of the sheet to a temperature sufficient to cure it, the last mentioned means including only means for heating the drum, means for rotating the drum, means sealing at least two relatively stationary sections of the drum interior with respect to each other and communicating the sections with drum segments only overlying the sections, and means for applying a sufficient vacuum to at least one of the sections to effect a heat transfer from the drum to the toner on the one side which cures the toner.

8. Apparatus according to claim **13** wherein the passageways are defined by spaced apart, small diameter bores extending from the drum exterior to the interior in a generally radial direction and including groove means on the exterior surface communicating with the bores for distributing the vacuum in the bores more uniformly over the exterior surface.

9. Apparatus according to claim **7** including means coupled with a second chamber for passing a pressurized gas to the second chamber for discharge of the gas through the passages to thereby blow off portions of the sheet as the toner becomes cured.

10. In an electrostatic copying machine having means for forming an electrostatic field adjacent one side of a sheet of paper, and means for applying a toner to the paper side in accordance with the electrostatic field to form toner patterns on the paper, the toner being heat curable to adhere it to the paper and fix it thereon, the improvement comprising: a platen, means for heating the platen to a temperature sufficient to cure the toner, means for pressing another side of the paper with such force against the heated platen that all heat energy for curing the toner is transferred from the platen and through the sheet to the toner, means for maintaining contact between the paper and the platen for a sufficient length of time to cure the toner with heat transmitted through the sheet and thereby fix and adhere it to the paper, and means for varying said force downstream of the contact maintaining means to thereby remove the sheet from the platen after curing of the toner.

11. Apparatus according to claim **10** wherein the platen comprises a cylindrical drum, and wherein the varying means comprises means for subjecting the other side of the sheet to a pressure greater than the pressure on the one side of the sheet to thereby separate the sheet from the drum.

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