United States Patent [19]

Smith et al.

[11] **3,741,643**

[45] **June 26, 1973**

[54] **PNEUMATIC ASSEMBLY FOR REMOVING EXCESS DEVELOPER LIQUID FROM PHOTOCONDUCTIVE SURFACES**

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[22] Filed: **Nov. 19, 1971**

[21] Appl. No.: **200,433**

[52] **U.S. Cl.** .... **355/10,** 96/1 LY, 117/37 LE, 118/DIG. 23, 239/597, 355/27

[51] **Int. Cl.** **G03g 15/10**

[58] **Field of Search** .... 355/10, 3, 27; 118/637, DIG. 23; 239/595, 597, 598; 96/1 LY; 117/37 LE

[56] **References Cited**

UNITED STATES PATENTS

329,527	11/1885	Beall	239/597
3,332,328	7/1967	Roth, Jr.	355/17 X
3,673,946	7/1972	Ragland	239/598 X
3,176,653	4/1965	Hansen	118/637
3,384,051	5/1968	Hunstiger	118/637
3,100,426	8/1963	Kaprelian	355/10 X

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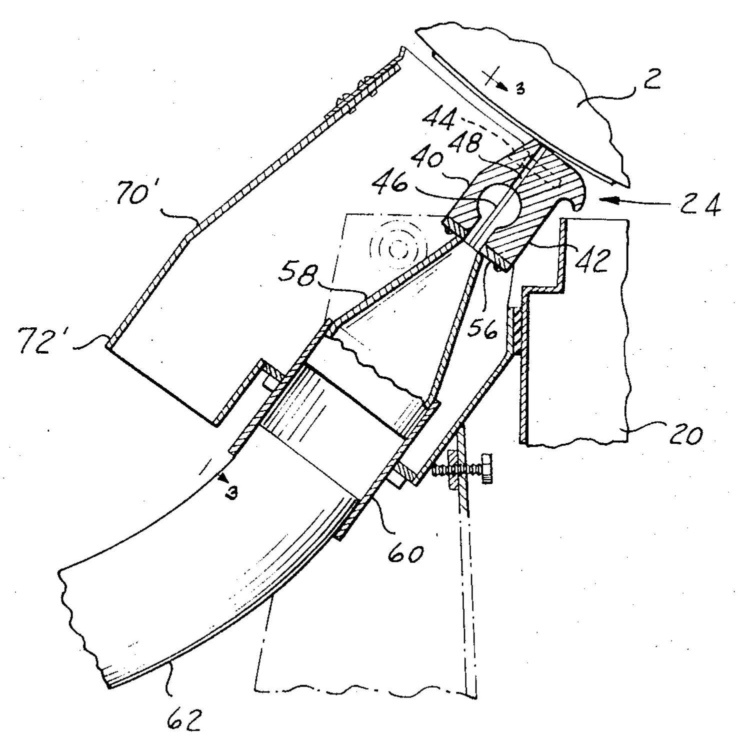
[57] **ABSTRACT**

Our invention contemplates a pneumatic assembly for removing excess developer liquid from photoconductive surfaces. Electrophotographic apparatus for exposing an electrostatically charged photoconductive surface to a pattern of light and shade to produce a latent electrostatic image and then toning that image with a liquid toner is known to the art. In order that such electrophotographic apparatus may operate over extended periods of time and produce copy without soiled background, it is necessary to remove excess liquid toner from the photoconductive surface. It has been suggested that the excess toner be removed with an elongated jet of air or air knife. We have discovered that the angle of incidence of the air jet is significant and that advantageous results are obtained by positioning the air knife so that the air jet is substantially normal to the moving photoconductive surface. We have provided means for removing an accumulation of toner contained in the developer liquid from the air knife nozzle and from the photoconductive surface adjacent the nozzle.

The removal of excess toner liquid evaporates the light components of the liquid, such as light hydrocarbon liquids, and creates some air pollution. We have provided means for preventing the discharge of evaporated hydrocarbon vapors into the atmosphere. We accomplish this by a hood around the air knife assembly into which sufficient air is bled. An amount of polluted air, equivalent to that bled into the system, is passed into a filter such as one formed of activated charcoal before being discharged into the atmosphere to remove the light hydrocarbon vapors from the discharged air.

11 Claims, 9 Drawing Figures



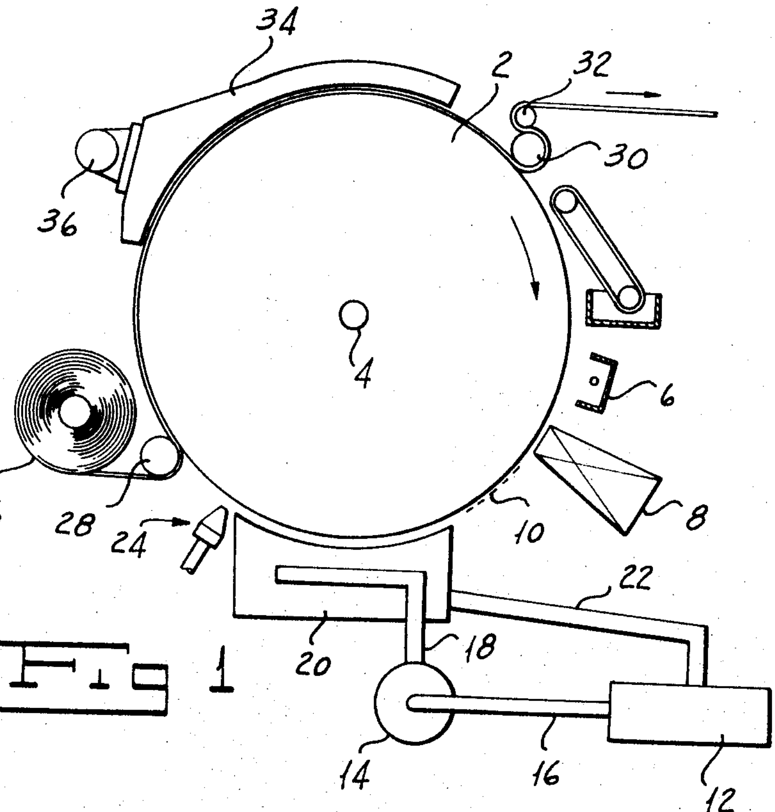


Fig 1

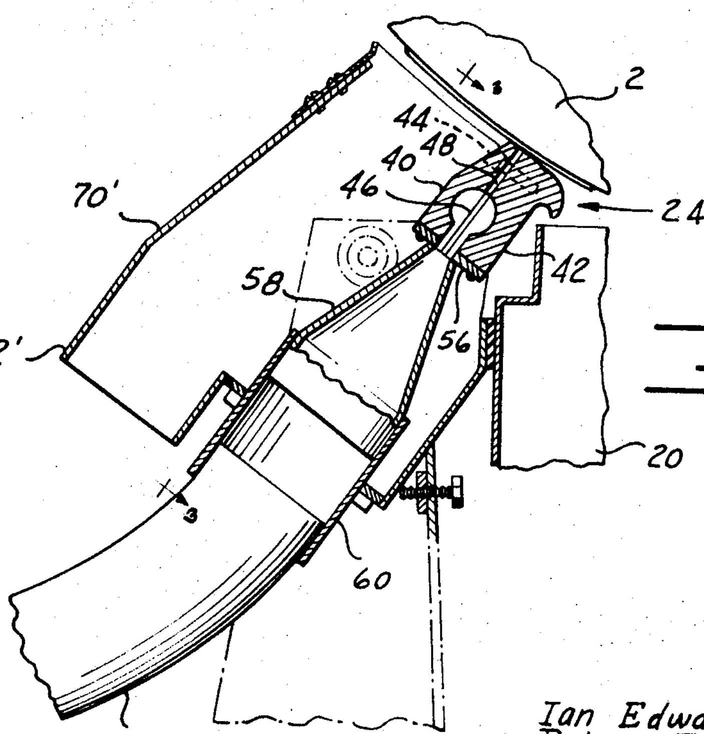


Fig 2

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Fig 3

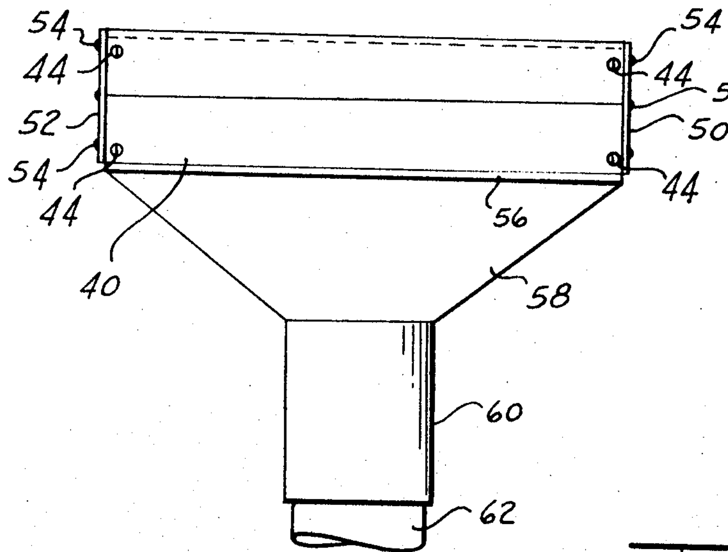
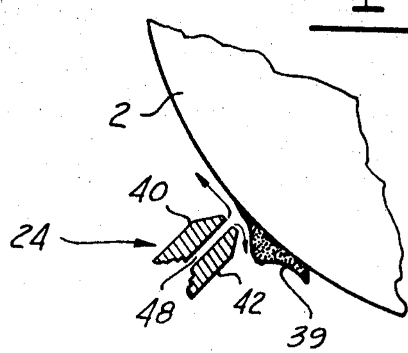


Fig 4



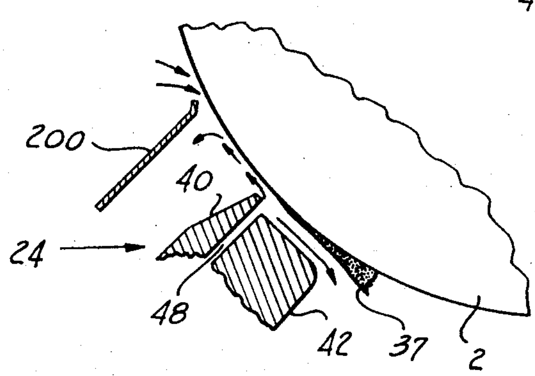


Fig 5

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Fig 6

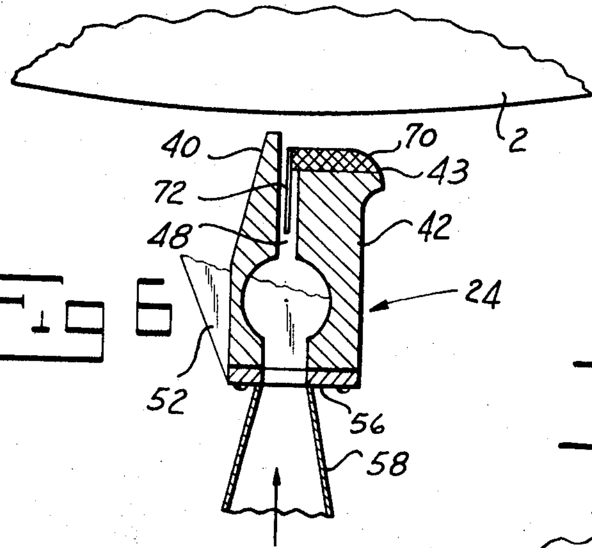


Fig 7

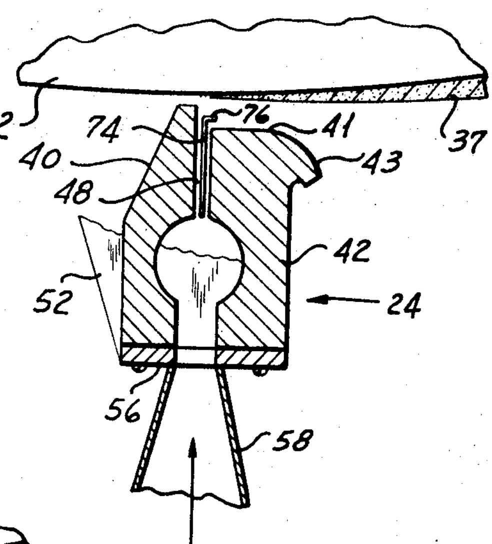
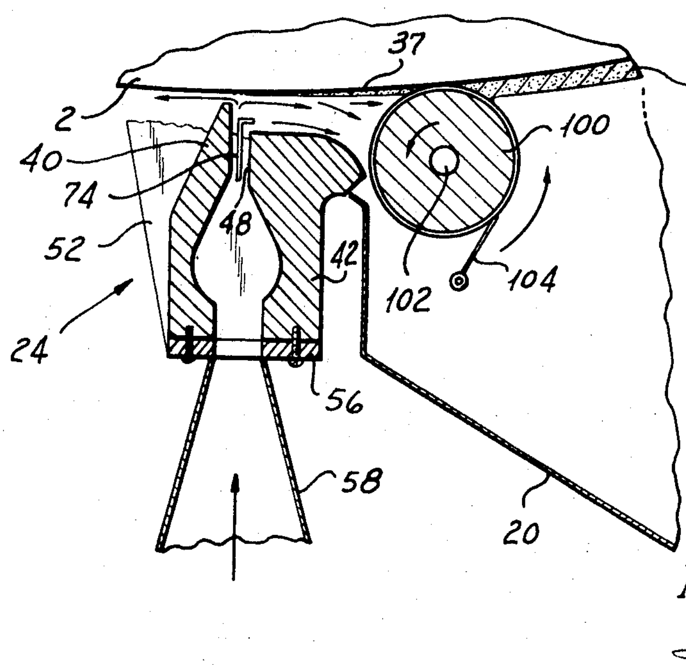


Fig 8



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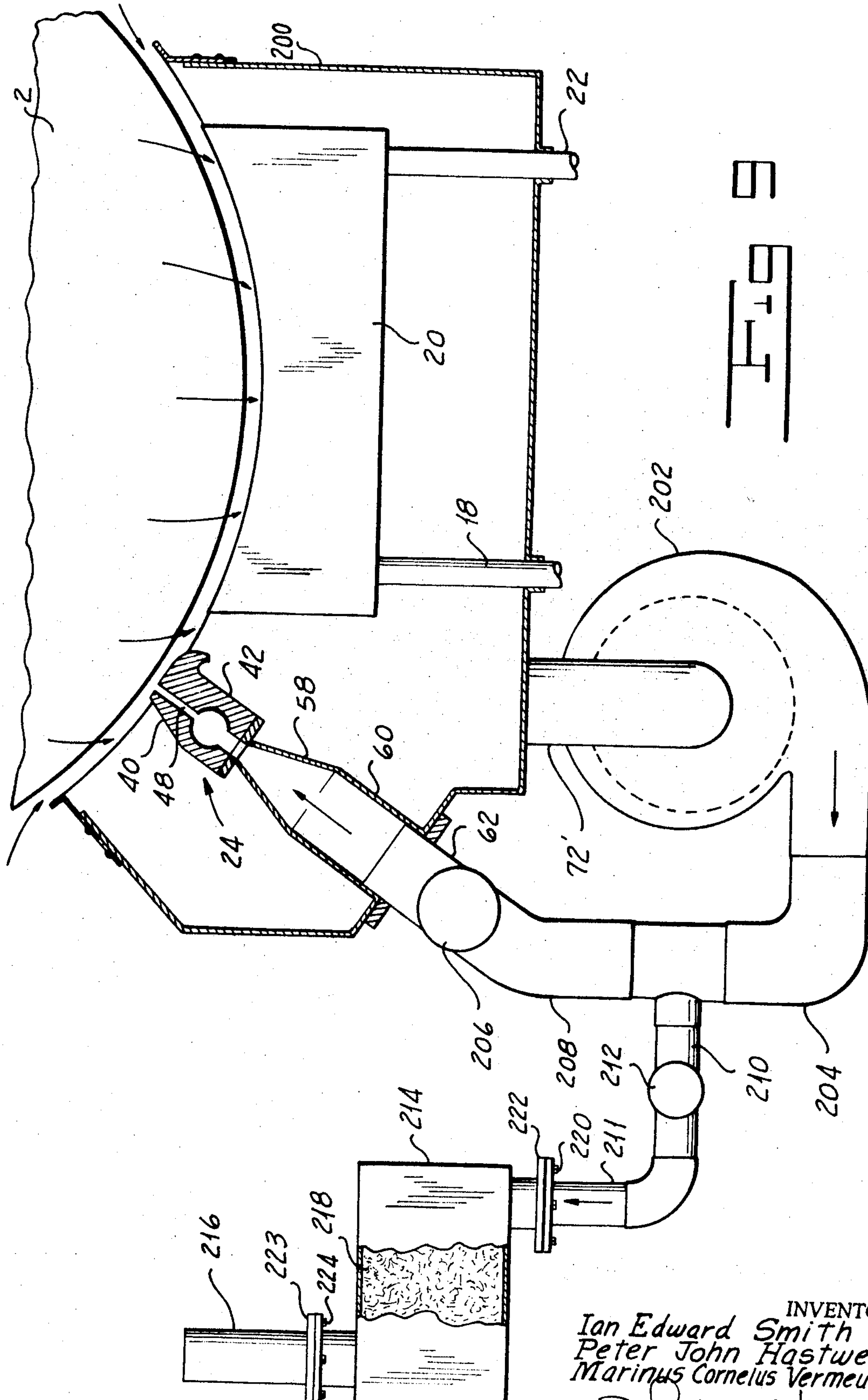

FIG. 5

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PNEUMATIC ASSEMBLY FOR REMOVING EXCESS DEVELOPER LIQUID FROM PHOTOCONDUCTIVE SURFACES

BACKGROUND OF THE INVENTION

In our co-pending application, Ser. No. 155,108, filed June 21, 1971, we have disclosed a novel method of contact transfer of liquid toner developed electrostatic images. In our method, a photoconductive surface is exposed to a pattern of light and shade as usually done in electrophotographic processes and the image developed by a toner. Our toner is not a dry one, but a novel liquid developer which carries a component adapted to assume a state of tackiness so that the developed image can be transferred, while the toner is in a tacky state, from the photoconductive surface to a carrier such as paper or the like. The photoconductive surface may be mounted on a drum or on a belt which is adapted to be moved through a zone in which it is wet with the developing toning liquid. The amount of liquid picked up by the drum or belt is a function of the speed at which the belt passes through the developing zone. For example, at a rate of about forty feet per minute, an area of one square foot of photoconductive surface will pick up about seven grams of developing liquid. Since the developing liquid comprises not only the tacky toner component but a diluent such as a light hydrocarbon, this diluent must be evaporated either from the photoconductive surface or from the paper during the reproducing process. This requires energy and the evaporation of fumes which, if allowed to pass into the atmosphere, pollute it. We recognized this problem in our above-identified co-pending application and have provided an air knife for removing excess toner from the surface of the photoconductive drum or belt.

We first discovered that the angle of incidence of the air jet impinging upon the photoconductive drum or belt was significant. Contrary to what one might believe, a tangential direction of the air jet or air of the air knife against the surface of the drum did not give the best results. Surprisingly, an angle of incidence normal to the surface of the belt or along a radius of the drum gives an improved removal of excess toner liquid from the photoconductive surface. The direction of a sheet of air normal to the surface of the photoconductor, while giving better results than a nozzle directed tangentially to the surface, did produce turbulence. This turbulence caused an accumulation of toner components on the surface adjacent the relative leading edge of the nozzle in its relative motion to the drum or belt. In practice, the nozzle is stationary while the drum or belt moves, so that, when we use the term "relative leading edge," we consider the drum stationary and the nozzle moving. It is the area of the drum or belt adjacent the relative leading edge of the nozzle at which the build-up occurs. When this build-up becomes thick, part of it will detach itself from the drum and may clog a part of the nozzle. If this occurs, it will produce a line on the image being reproduced. In order to relieve the accumulation adjacent the relative leading edge of the nozzle, we provide an area along its leading edge at which some material of the nozzle is removed. This will form a configuration in which the lagging edge of the nozzle is higher than its leading edge. This produces an area between the leading edge of the nozzle and the surface of the drum through which air flows in a direction substantially at right angles to the exit direction of the sheet of air from the air knife nozzle. The direction of flow, furthermore, is toward the relative leading edge of the nozzle which serves to reduce the thickness of the toner build-up adjacent the leading edge of the nozzle, which would otherwise form owing to the relative motion and the turbulence described above.

While this form of the invention is operative, we found over extended periods of time, as for example after 3000 copies, a significant build-up of toner deposit takes place at the relative leading edge of the nozzle. We were successful in removing the excess toner from the photoconductive surface but were now faced with another problem, that of the build-up just mentioned. We were able to eliminate this build-up by providing the area of the nozzle adjacent its relative leading edge with a porous structure so that air would pass through the porous structure to the blind surface of the leading edge of the air knife nozzle at which a dead air area tends to exist. We also solved this problem by the use of a baffle to direct a sheet of air over the relative leading edge of the nozzle to eliminate the dead air space.

After we had solved the problem of build-up in the manner just described, we found that we had introduced another problem, namely, that the air stream would divide and part of it would pass along the direction of travel of the drum while the other part of the air stream would pass in the opposite direction. The portion of the air stream passing in the same direction as the travel of the drum or belt produced pollution and contamination of the paper and machine parts. By this we mean that the atmosphere adjacent the transfer point was laden with evaporated toner liquid and in some cases the liquid would condense on the drum, machine parts and paper adjacent the transfer station. This problem was solved by providing a hood or manifold around the nozzle area. The air for the air knife takes suction from the manifold and passes to the center of the centrifugal blower, the outlet of which furnishes air to the air knife. In passing through the blades of the centrifugal blower, entrained toner particles are thrown out of the air by centrifugal force. We found the inner casing of the centrifugal fan coated with toner after a period of operation. The removal of toner particles prevents the nozzle of the air knife from becoming clogged by the recirculation of the removed toner particles. The interior of the air knife remains clean.

Since it is undesirable to pass the vapors of the diluent into the atmosphere especially at high reproduction rates, we provide a hood completely about the toner tank and the air knife. This hood is such that air from the atmosphere can be continuously bled into the toner and air knife area hood and passed to the inlet of the centrifugal blower. At a rate of flow of eighteen cubic feet per minute to the air knife, we find that we can operate the blower to discharge twenty-two cubic feet per minute. The discharge of the blower is provided with a bleeder outlet which passes through a filter of activated charcoal or the like. About four cubic feet per minute, for example, are drawn into the hood from the outside air. This is controlled by the spacing of the hood from the surface of the drum. It will be seen that sufficient fresh air is being fed to the system and sufficient polluted air is being removed from and purified by the filter, so that the air circumambient of the machine is pollution-free.

If a higher boiling diluent is employed, the build-up of toner liquid on the drum is much heavier than with a lighter hydrocarbon diluent. This will require the use of a higher velocity air knife which requires the employment of a higher air pressure as the air supply to the air knife. In order to avoid using the higher pressure which requires bigger and more expensive equipment to achieve, we reduce the thickness of the film of developing liquid on the photoconductive surface mechanically through a roller. This roller is positioned relatively upstream from the air knife and is spaced adjacent the drum and out of contact with it so that it acts as a film thickness metering means. It is driven by appropriate means at the same linear velocity as the photoconductive surface. The excess developing liquid which is removed mechanically from the surface of the photoconductor is scraped from the metering roller by means of a wiper or doctor blade and re-passed into the toner tank. By driving the roller at the same speed and in the same direction as the surface of the photoconductor, no shear is introduced and the liquid is carried around on the surface of the roller to a position where it can be wiped therefrom.

SUMMARY OF THE INVENTION

One object of our invention is to provide a novel pneumatic assembly for removing excess developer liquid from photoconductive surfaces.

Another object of our invention is to provide an improved air knife which will remove excess toner from a photoconductor surface in an efficient manner.

Another object of our invention is to provide an air knife which will remove liquid toner from a photoconductive surface without permitting clogging of its nozzle after use over long periods of time.

A further object of our invention is to provide a pneumatic assembly for removing excess developer liquid from photoconductive surfaces without contaminating the air circumambient to the electrophotographic apparatus.

Other and further objects of our invention will appear from the following description:

In general, our invention contemplates the provision of an air knife disposed to eject a sheet of air normal to a photoconductive surface which may be carried by a drum or moving belt or the like. This surface is adapted to carry a latent electrostatic image which has been developed by exposure to a liquid toner which may advantageously be toner particles or a toner organosol suspended or emulsified in a light hydrocarbon liquid in which the toner particles or organosol are insoluble. The configuration of the air knife is such that it will produce a secondary sheet of air directed toward the relative leading edge of the air knife nozzle. The main sheet of air prevents a build-up of toner on the photoconductive surface. This auxiliary sheet of air prevents accumulations of toner upon the nozzle itself. A hood surrounds the air knife assembly. Air from the air knife takes suction from within the hood and delivers air to a centrifugal blower, the output of which feeds the air knife. A volume of air equivalent to that passing into the hood from the outside air is bled from the discharge of the centrifugal blower and passed through means for absorbing the hydrocarbon vapors such as a bed of activated charcoal or the like.

Where higher boiling hydrocarbons are used, it becomes desirable, in order to avoid increasing the velocity of the air in the air knife, to use an auxiliary roller mechanically to reduce the film thickness before subjecting the film of liquid toner on the photoconductive surface to the action of the air knife assembly.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings, which form part of the instant specification and which are to be read in conjunction therewith, and in which like reference numerals are used to indicate like parts in the various views:

FIG. **1** is a diagrammatic view of an electrostatic copying machine employing a rotary drum carrying a photoconductive member and showing the relative position of the air knife, with respect to the drum and the toning zone.

FIG. **2** is an enlarged view with parts in section showing one form of an air knife.

FIG. **3** is a side elevation taken along line **3—3** of FIG. **2** (with parts removed) showing the air knife per se.

FIG. **4** is a diagrammatic view illustrating one defect in the form of the air knife as shown in FIG. **2.**

FIG. **5** is a diagrammatic view with parts in section showing the manner in which a modified form of air knife tends to correct the defect of the air knife shown in FIG. **2.**

FIG. **6** is a fragmentary sectional view showing an improved form of an air knife.

FIG. **7** is a fragmentary sectional view showing another embodiment of an improved air knife construction.

FIG. **8** is a fragmentary sectional view showing the improved air knife of FIG. **7** in conjunction with an auxiliary roller for use with toners employing higher boiling hydrocarbon diluents.

FIG. **9** is a diagrammatic view showing our improved air knife in combination with an anti-pollution system.

DESCRIPTION OF THE PREFERRED EMBODIMENT

More particularly, referring now to the drawings, we have shown a diagrammatic view of an electrostatic copying machine in FIG. **1,** in which the drum **2** is formed with a photoconductive surface and is adapted to revolve about a supporting shaft **4** in the direction of the arrow. An electrostatic charging device **6** is employed to charge the surface of the drum with an electrostatic charge, it being understood that the drum is used in a light-proof casing (not shown). An image of an original to be copied is focused upon the charged photoconductive surface by an exposure device **8,** as is well known to the art, to leave a latent electrostatic image represented by the pattern of electrons **10** shown on the drum. The charged image is then developed by a liquid toner such as is described in our co-pending application above identified The liquid toner is stored in a tank **12** from which it is adapted to be pumped by pump **14** which takes suction from the tank **12** through pipe **16.** The toner is discharged though pipe **18** into a developing zone **20** in which it is applied to develop the latent image. The excess toner passes from the developing zone through pipe **22** back to the tank **12.**

The excess toner on the developed image and the photoconductive surface is removed by an air knife indicated generally by the reference numeral **24.** A roll of paper or other web material **26** is drawn over roller

28 in contact with the developed image and remains in contact with the drum until it reaches roller 30 where it passes over guide roller 32 and is pulled to a cutting station by appropriate means (not shown since these are known to the art). The hood 34 is adapted to heat the back of the paper 26 by hot air furnished to the hood 34 from manifold 36 to which the hot air is supplied from an appropriate source (not shown). It will be observed that the air knife 24 is positioned normal to the photoconductive surface.

Referring now to FIG. 2, the air knife 24 is formed of a pair of elongated members 40 and 42 clamped together by bolts 44, as can be seen more readily by reference to FIG. 3. A gasket 46 performs the dual function of spacing member 44 from 42 to provide an elongated nozzle 48. We provide end plates 50 and 52 which are secured to the members 40 and 42 by means of machine screws 54, as can be seen by reference to FIG. 3. The end plates also serve to fix the spacing between the members 40 and 42 so that the width of the nozzle is predetermined. The bottom of the nozzle thus formed is closed by a plate 56 to which an air distributor manifold 58 is secured. The air distributor manifold 58 terminates in an air duct 60 to which an air hose 62 is affixed. Air is supplied to the assembly by the air hose 62, as will be pointed out more fully hereinafter. A hood 70′, which may be placed under reduced pressure by applying a suction hose to the duct 72′, surrounds the air knife assembly. Toner blown from the drum 2 by the air knife passes into the developing zone 20 to return to the system.

We have discovered that air velocity normal to the drum surface dries the surface much more effectively than air flowing in the direction tangentially to the drum. The rotation of the drum, in moving the web of paper at a rate of about 40 feet per minute, will coat a drum twelve inches in width with 320 grams of developer liquid per minute.

In using a light hydrocarbon diluent such as a hydrocarbon liquid sold under the trademark of "ISOPAR G" by Humble Oil & Refining Company, we require a volume of air of about seventeen and one-half cubic feet per minute through an air knife having a slot 6 inches long and 0.02 inches in width. The speed of the air jet to accomplish the evaporation of the ISOPAR G is about 240 miles per hour. ISOPAR G has a specific gravity of 0.75 at 60° F. It has a flash point of 105° F. and a kauributanol number of 27. Its initial boiling point is 157° C. Its final boiling point is 177° C. It is a substantially pure isoparaffin.

The toner is a solution of a high molecular weight resin substantially insoluble in the ISOPAR G suspended in or emulsified in the ISOPAR G. As the light hydrocarbon diluent evaporates, the film of residual toner liquid increases in thickness and in specific gravity. It collects on the drum adjacent the nozzle as shown in FIG. 4. This causes deflection of the air from the nozzle in a forward direction. Furthermore, drops of the thickened toner containing a high proportion of the high molecular weight resin may drop from the drum on the air knife and accumulations of resin thus formed tend to clog the air knife nozzle.

Since the drum moves in a clockwise direction and the nozzle of the air knife is stationary, the relative motion of the nozzle with respect to the drum is to the right as viewed in the drawings. Stated otherwise, the right-hand side of the nozzle is the relative leading edge

of the nozzle, considering its relative motion with respect to the drum. It will be observed in FIG. 2 that the relative leading edge of the nozzle has been extended and is wider than the trailing edge of the nozzle. We have found that we can correct the tendency of the high molecular weight resin components of the toner liquid which are not evaporated by the air knife to accumulate on the drum adjacent the air knife by increasing the clearance between the drum and the leading edge of the nozzle of the air knife. This is shown diagrammatically in FIG. 5. This entails removing a portion of the top surface of the member 42 of the air knife. An improved embodiment of the air knife is shown in FIG. 6. In this embodiment, a portion of the leading edge of the air knife, namely, the upper surface of the member 42 adjacent the drum 2, has been removed and capped with a sintered bronze plate 70. The trailing edge of the sintered bronze plate carries a baffle 72 extending into the air knife nozzle passage 48. This baffle directs air through the pores of the sintered bronze plate 70. The arrangement is such that the trailing member 40 of the nozzle, which extends above the upper surface of the sintered bronze plate 70 will direct air to the right as shown by the arrow in FIG. 5. The air directed by the baffle 72 through the pores of the sintered bronze plate 70 will ensure that there is no collection of toner resin on the leading edge 43 of the nozzle member 42.

We have found that we can also prevent the accumulation of resinous toner materials at the leading edge 43 of the nozzle member 42 by inserting a different baffle 74 as shown in FIG. 7. This baffle has a portion 76 extending in the direction of the leading edge of the nozzle to direct air over the surface 41 of nozzle member 42.

It will be observed that, in the nozzle shown in FIGS. 5, 6 and 7, a component of the air jet is directed to move toward the leading edge of the nozzle. This component smooths the toner layer upon the drum and eliminates turbulence introduced by the jetting of high velocity air against the drum in a direction normal to it. The spacing between the upper surface 41 of the leading member 42 of the nozzle assembly from the drum is about 0.125 inches. In FIG. 4, the accumulation is designated by the reference numeral 39. The smoother build-up shown in FIGS. 5 and 7 is designated by the reference numeral 37.

In the form of the nozzle shown in FIGS. 6 and 7, no gasket is employed. Instead, the nozzle assembly is completed by the end plates 50 and 52.

Referring now to FIG. 8, in some environments, it is desirable to employ somewhat higher boiling hydrocarbon diluents in the toner formulation. For example, ISOPAR L has an initial boiling point of 188° C. and a final point of 210° C.; while ISOPAR M has an initial boiling point of 240° C. and a final point of 249° C.

The specific gravity of ISOPAR M is 0.78 and it has a flash point of 180° F. Because of its higher distillation range, more energy is required to evaporate it from the photoconductive surface. This will require higher air pressure and a greater velocity in the air knife. This in turn requires a higher pressure output from the air blower. In order to reduce the amount of air required by the air knife, we have shown an arrangement in FIG. 8 for use with higher boiling isoparaffin diluents in the toner formulations. Adjacent the toning station casing 20, we provide a roller 100 driven by appropriate means (not shown) so the linear velocity of the surface of the roller **100** is equal to that linear velocity of the drum **2.** The roller is mounted for rotation about a shaft **102** and is spaced from the surface of the drum **2** by a distance of 0.005 inches. The film **35** formed by ISOPAR M on the surface of drum **2** has a thickness of 0.012 inches. This film is mechanically reduced in thickness by the roller **100** so that the balance of the film **37** can readily be removed by the air knife assembly **24** as shown in FIG. **8.** A wiper plate **104** maintains the roller **100** substantially free of a thick film of toner. The excess toner being wiped from the roller **104** passes back into the toner system.

Referring now to FIG. **9,** we have shown our air knife in combination with an anti-pollution system. The toning zone **20** and the air knife assembly **24** are mounted in a casing **200** which is spaced from the surface of the drum **2.** The centrifugal blower **202** takes suction from the duct **72'** communicating with the interior of the casing **200.** The blower discharges air through duct **204.** The main body of the air passes through pipe **208** controlled by valve **206** and is discharged through hose **62** to air knife distributor manifold **58** to the air knife **24.** A portion of the air passes through branch duct **210** controlled by valve **212** to a light hydrocarbon absorption unit **214.** The speed of the blower **202** is such that it will draw about 22 cubic feet per minute of air from inside the casing **200.** The valve **206** is so positioned that about eighteen cubic feet of air per minute will be furnished to the air knife. About four cubic feet of air per minute are drawn from the outside atmosphere, as shown by the arrows between the drum and the edges of the casing or hood **200.** Since 22 cubic feet per minute are being drawn from the hood and only 18 feet per minute bled to it, about four cubic feet of air will be drawn from the outside circumambient atmosphere into the hood. The light hydrocarbon vapors evaporated from the surface of the drum by the action of the air knife will pass into the centrifugal blower and be recirculated. The position of valve **212** is such that about four cubic feet of air per minute will pass through the absorption unit. The absorption unit is filled with activated charcoal **218** which is prepared by dry distillation of coconut shells followed by treatment with very high temperature steam. The charcoal will absorb the light hydrocarbon vapors so that the air passing to the atmosphere through discharge pipe **216** will be substantially free of pollution. About two and one-half cubic feet of activated charcoal will weigh about forty pounds and is capable of absorbing about a gallon of the light hydrocarbon diluent evaporated by the air knife. No air is discharged from the system except that which passes through the absorbent bed of activated charcoal. In this manner, our machine can be used in closed spaces for long periods of time without danger of contaminating the air by evaporation of the light hydrocarbon used as a diluent in the liquid toner.

The absorption unit **214** is so positioned that it can be easily removed and replaced by a new absorption unit when the activated charcoal **218** becomes saturated with hydrocarbons. The bolts **220** which attach the lower flange **222** to the duct **211** and the bolts **224** which attach the flange **223** to the upper flange of the unit **214** may be easily removed for quick replacement of a fresh absorption unit. The diluent collected by the absorption unit can be recovered, if desired, by stripping the absorbed ISOPAR from the activated charcoal by steam. The steam containing the ISOPAR vapor can then be condensed and passed to a separating zone where the water is drawn off and the ISOPAR recovered.

It will be seen that we have accomplished the objects of our invention. We have provided a novel pneumatic assembly for removing excess developer liquid from photoconductive surfaces. We have provided an improved air knife for accomplishing this in an efficient manner. The construction of the air knife is such that it can be used for long periods of time without having its nozzle become clogged by the residue or the heavy components in the liquid toner formulation. The arrangement is such that the circumambient air is not polluted.

It will be understood that certain features and subcombinations are of utility and may be employed without reference to other features and subcombinations. This is contemplated by and is within the scope of our claims. It is further obvious that various changes may be made in details within the scope of our claims without departing from the spirit of our invention. It is, therefore, to be understood that our invention is not to be limited to the specific details shown and described.

Having thus described our invention, what we claim is:

1. In an electrophotographic machine, a member having a photoconductive surface, means for producing a latent electrostatic image on said surface, means for applying liquid developer to said surface, an air knife for removing excess developer from said surface, means for moving said member in a direction to carry said image sequentially past said developer applying means and said air knife, said air knife being formed with an elongated air nozzle slot defining a pair of side walls, means for positioning said air knife normal to said photoconductive surface, one of said walls terminating in an outwardly extending lip adjacent to the edge of said nozzle outlet which is leading with respect to said direction of movement, said lip being positioned below the terminus of the other nozzle side wall.

2. An electrophotographic machine as in claim **1** in which said lip carries a porous metal overlay.

3. In an electrophotographic machine as in claim **2,** a baffle carried by said overlay and extending into said nozzle slot.

4. In an electrophotographic machine as in claim **1,** a baffle, and means for positioning said baffle in said nozzle slot, said baffle being provided with a portion spaced from and extending in the direction of said lip.

5. In an electrophotographic machine, a member having a photoconductive surface, means for producing an electrostatic latent image upon said surface, a liquid developing station for developing said image, an air knife for removing excess developer liquid from said surface, means for moving said image first past said developing station and then past said air knife, a metering roller positioned between said developing station and said air knife closely adjacent said photoconductive surface, means for rotating said roller, and means for wiping developing liquid from the surface of the roller.

6. An electrostatic photographic machine as in claim **5** in which said air knife is positioned to direct a sheet of air normal to said photoconductive surface.

7. An electrostatic photographic machine including in combination a member having a photoconductive surface, means for producing an electrostatic latent image upon said surface, a developing station for developing said latent image, an air knife for removing excess developer from said surface, means for moving said image first past said developing station and then past said air knife, a hood surrounding said air knife and said developing station, a blower, a first duct taking suction from inside said hood communicating with the inlet of said blower, and a second duct providing communication between the outlet of said blower and said air knife.

8. A machine as in claim **7** in which said hood is spaced from said photoconductive surface and a bleeder duct providing communication between the atmosphere and said second duct, the construction being such that some circumambient air is drawn into the hood by the blower and some air drawn from the hood is discharged to the atmosphere.

9. A machine as in claim **8** including means for controlling the flow of air through said second duct and through said bleeder duct.

10. A machine as in claim **8** including absorption means positioned to absorb vaporized liquid passing through the atmosphere through said bleeder duct.

11. An electrostatic photographic machine including in combination a member having a photoconductive surface, means for producing an electrostatic latent image upon said surface, a liquid developing station for developing said latent image, an air knife, means for moving said image first past said developing station and then past said air knife, means for positioning said air knife normal to said photoconductive surface to cause said air knife to remove excess developer from said surface, a hood, means for positioning said hood about said air knife, and means for reducing the air pressure within the hood to remove vaporized developer.

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