Jan. 5, 1971 S. F. ROYKA ET AL 3,552,850

LUBRICATED BLADE CLEANING OF IMAGING PHOTOCONDUCTIVE MEMBERS

Filed Feb. 1, 1968 8 Sheets-Sheet 1

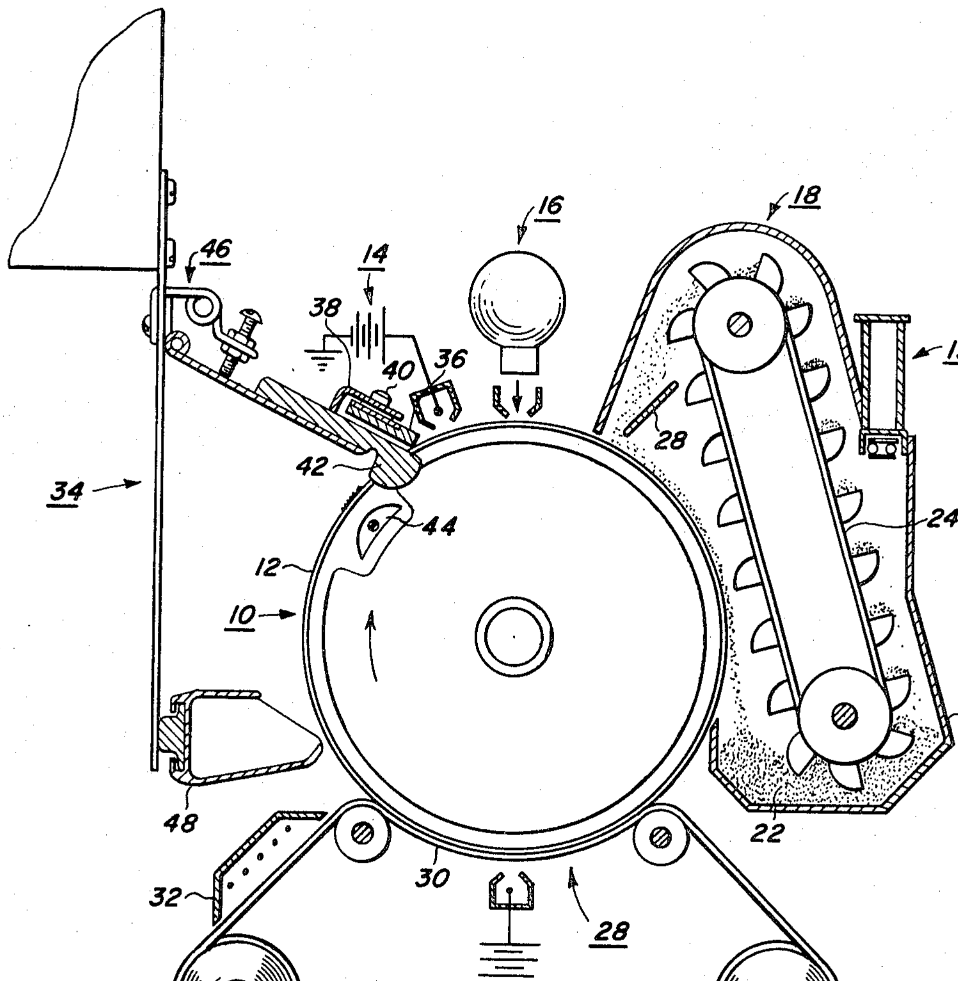

FIG. 1

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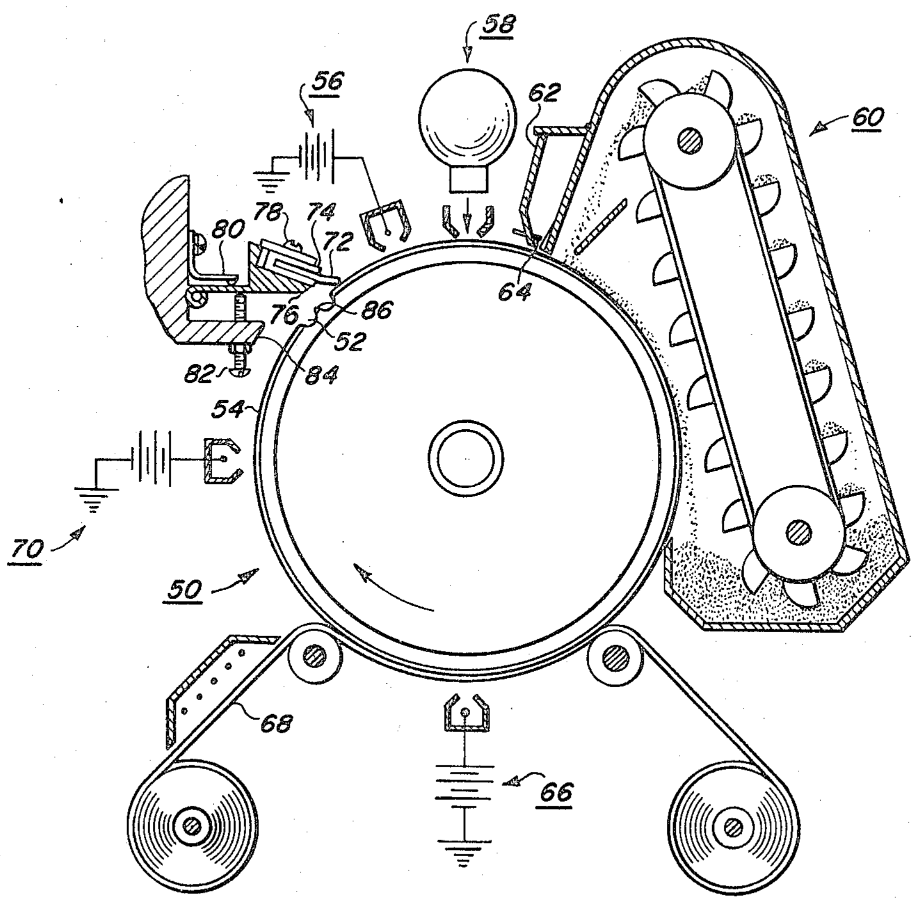

FIG. 2

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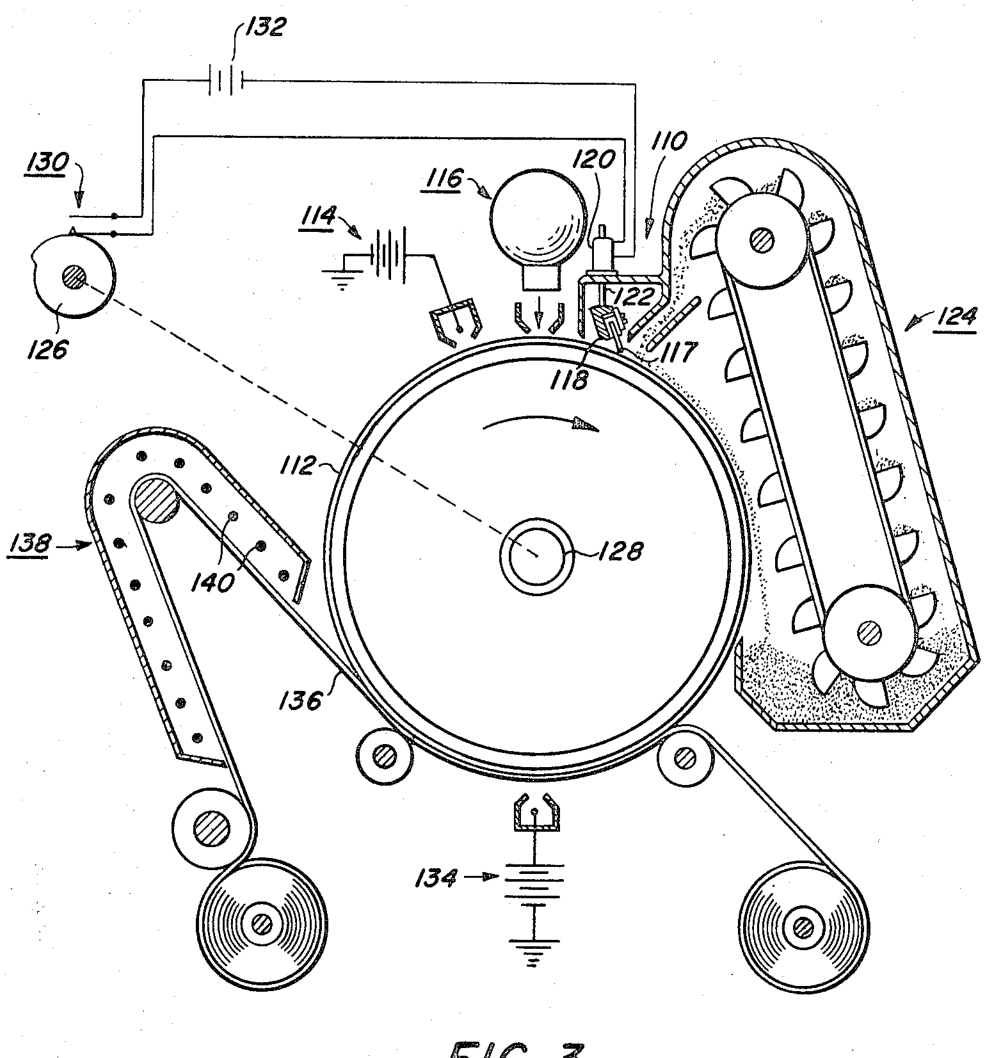

FIG. 3

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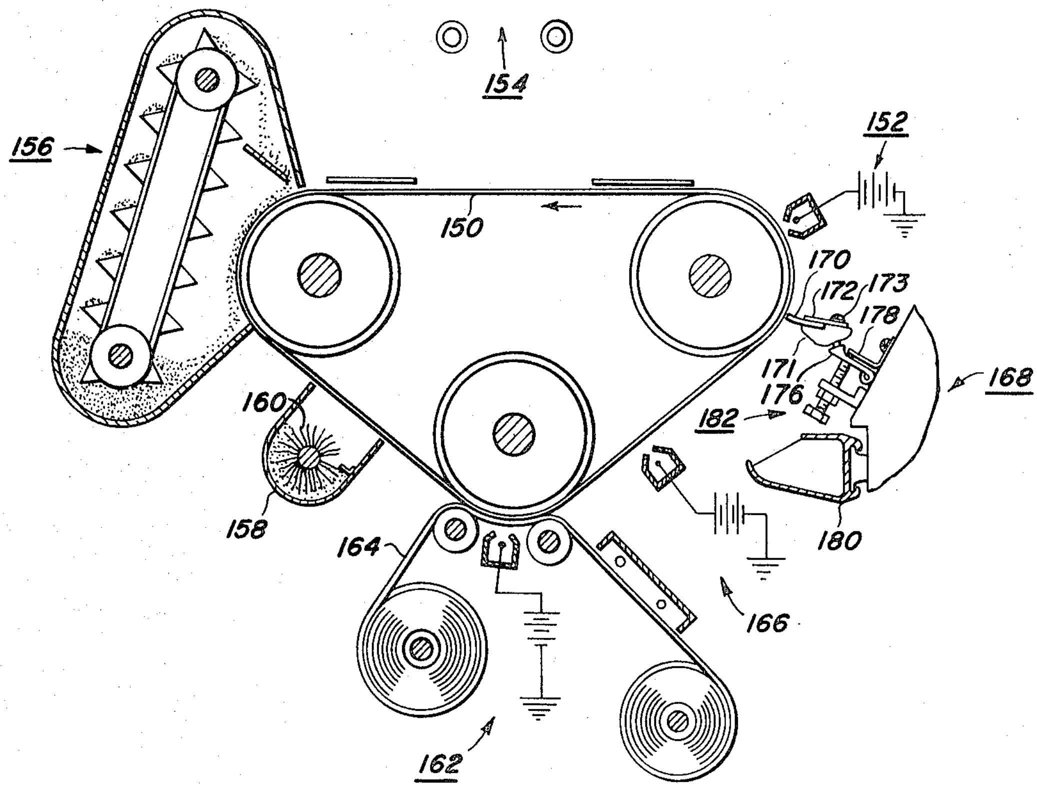

FIG. 4

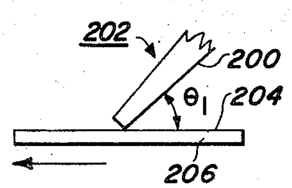

FIG. 5

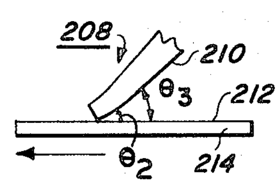

FIG. 6

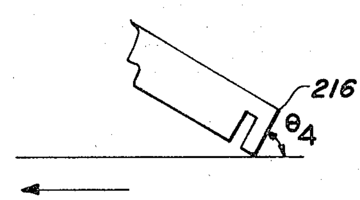

FIG. 7

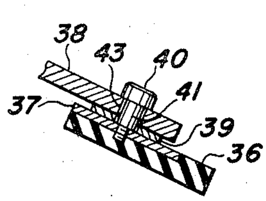

FIG. 8

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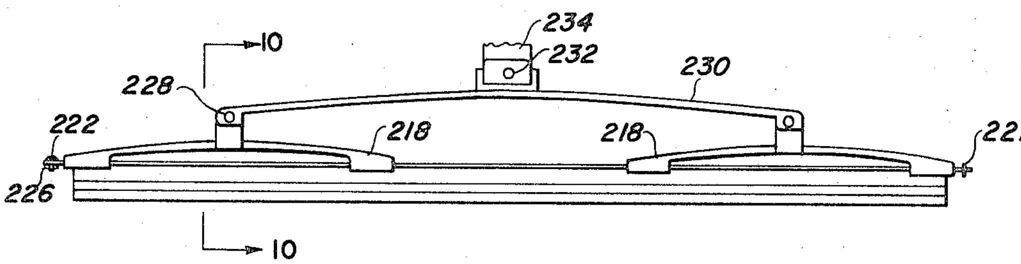

FIG. 9

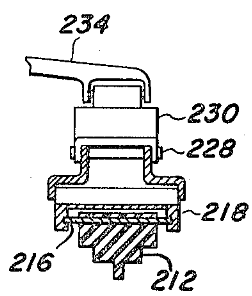

FIG. 10

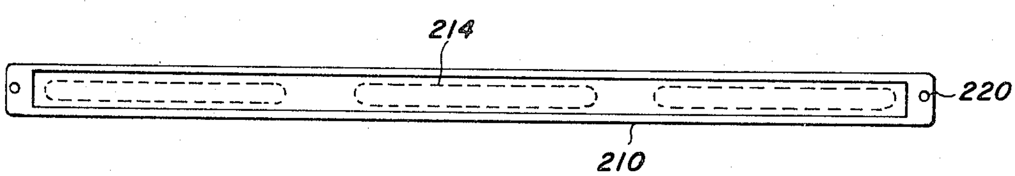

FIG. 11

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LUBRICATED BLADE CLEANING OF IMAGING PHOTOCONDUCTIVE MEMBERS

Filed Feb. 1, 1968 8 Sheets-Sheet 6

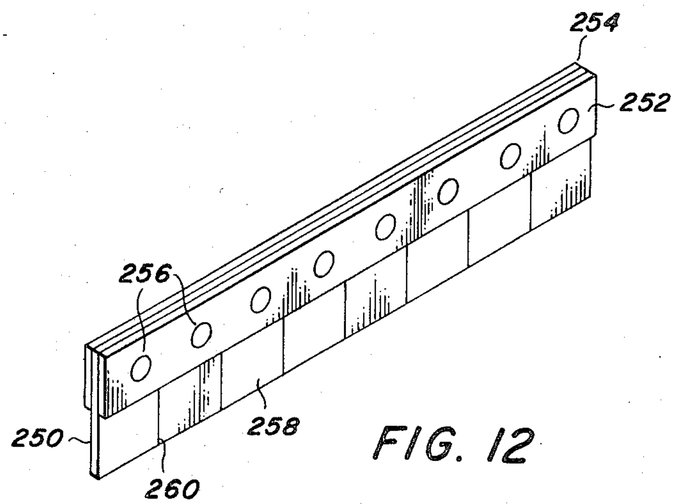

FIG. 12

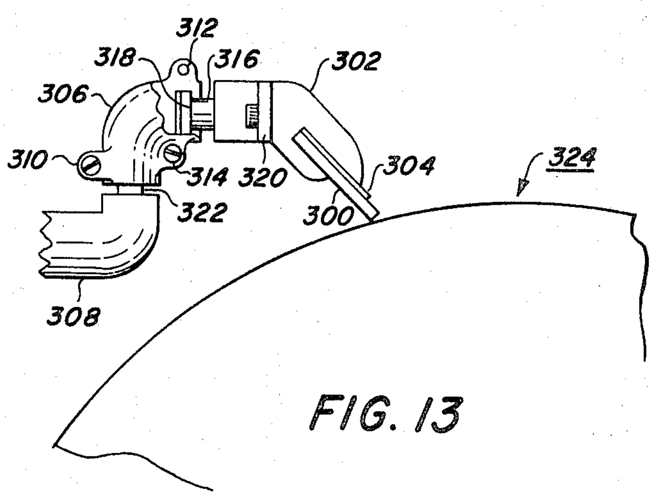

FIG. 13

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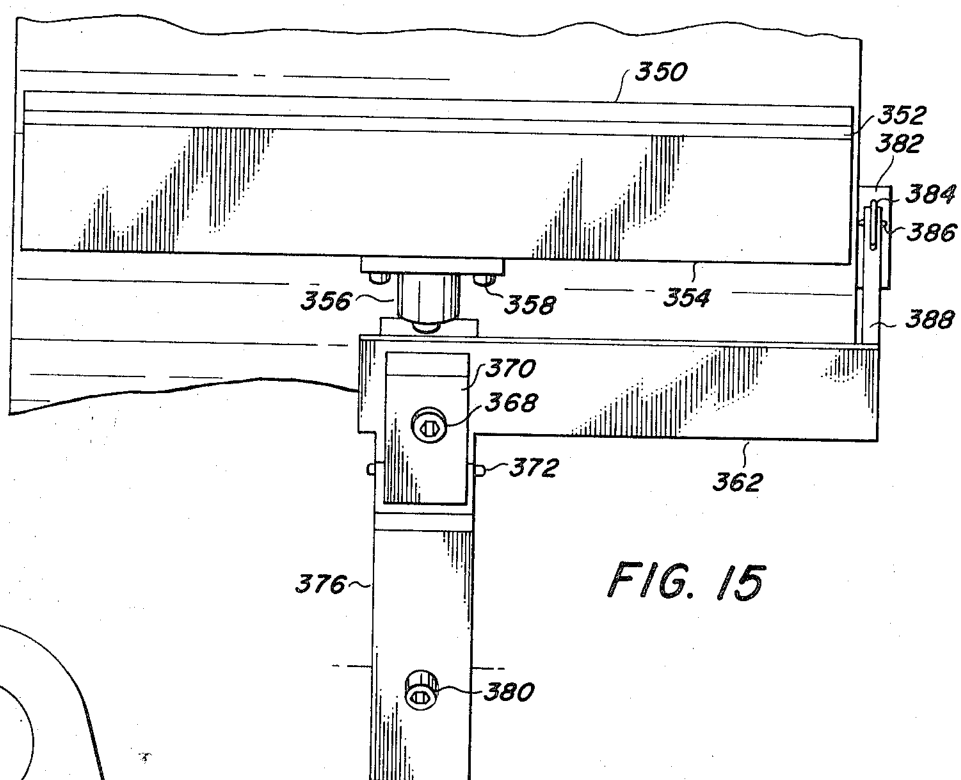

FIG. 15

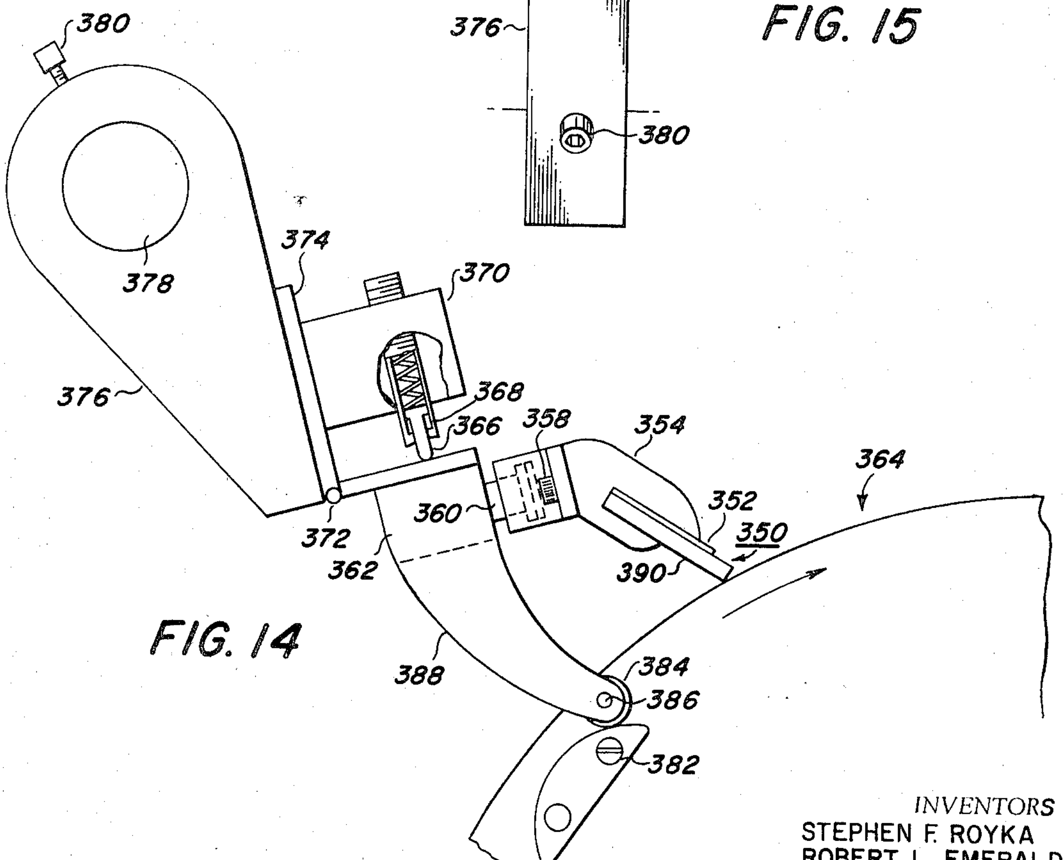

FIG. 14

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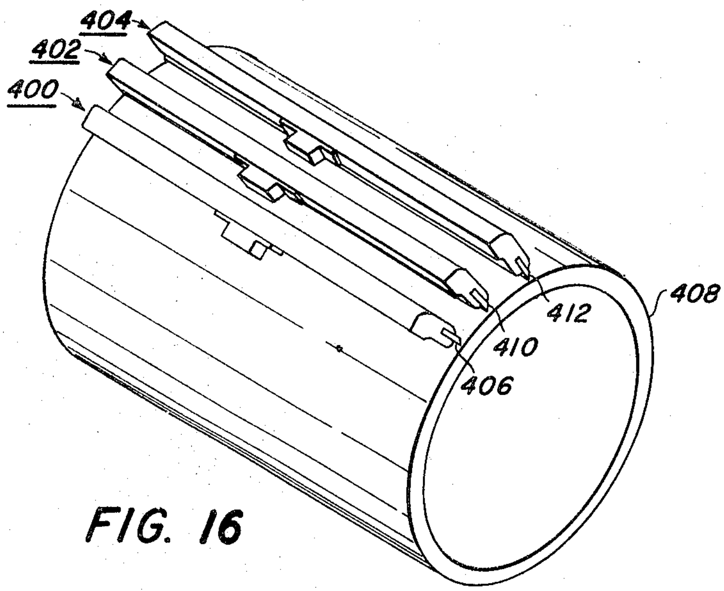

FIG. 16

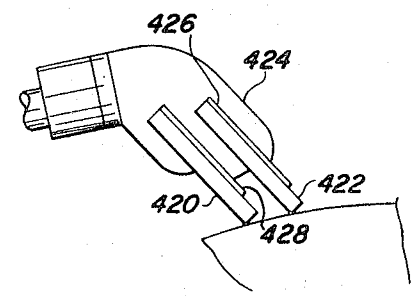

FIG. 17

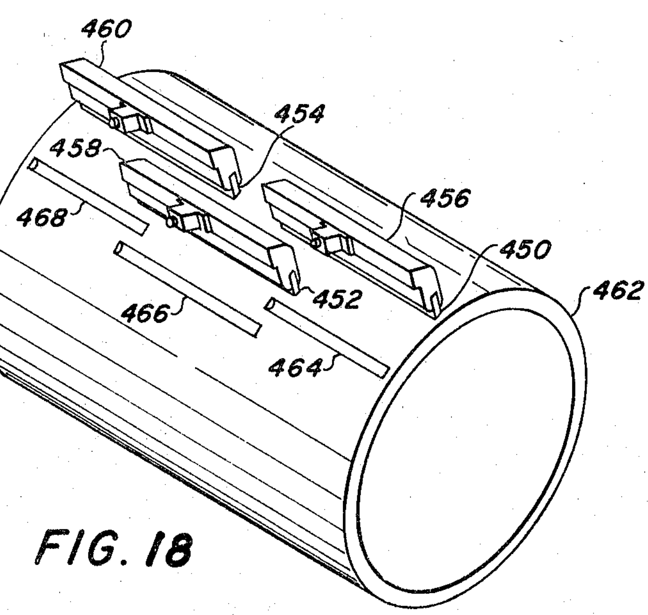

FIG. 18

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United States Patent Office

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3,552,850

LUBRICATED BLADE CLEANING OF IMAGING PHOTOCONDUCTIVE MEMBERS

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Int. Cl. G03g *13/08, 15/00*
U.S. Cl. 355—15 21 Claims

ABSTRACT OF THE DISCLOSURE

An imaging system employing a reusable electrostatographic imaging surface cleaning station comprising at least one self-adjusting flexible cleaning blade for pressure contact cleaning of the imaging surface and means to supply a dry solid lubricant to the imaging surface. The leading face of at least one cleaning blade is preferably positioned to form an acute angle of less than about 90° and greater than about 20° with the confronting portion of the imaging surface or plane tangent to the imaging surface at the line of blade contact.

BACKGROUND OF THE INVENTION

This invention relates to imaging systems, and more particularly, to an improved cleaning device.

The formation and development of images on the surface of photoconductor materials by electrosttic means is well known. The basic xerographic process, as taught by C. F. Carlson in U.S. Pat. 2,297,691, involves placing a uniform electrostatic charge on a photoconductive insulating layer, exposing the layer to a light-and-shadow image to dissipate the charge on the areas of the layer exposed to the light and developing the resulting latent electrostatic image by depositing on the image a finely-divided electroscopic material referred to in the art as "toner." The toner will normally be attracted to those areas of the layer which retain a charge, thereby forming a toner image corresponding to the latent electrostatic image. This powder image may then be transferred to a support surface such as paper. The transferred image may subsequently be permanently affixed to a support surface as by heat. Instead of latent image formation by uniformly charging the photoconductive layer and then exposing the layer to a light-and-shadow image, one may form the latent image by directly charging the layer in image configuration. The powder image may be fixed to the photoconductive layer if elimination of the powder image transfer step is desired. Other suitable fixing means such as solvent or overcoating treatment may be substituted for the foregoing heat fixing steps.

Several methods are known for applying the electroscopic particles to the latent electrostatic image to be developed. One development method, as disclosed by E. N. Wise in U.S. Pat. 2,618,552, is known as "cascade" development. In this method, a developer material comprising relatively large carrier particles having fine toner particles electrostatically coated thereon is conveyed and rolled or cascaded across the electrostatic image-bearing surface. The composition of the carrier particles is so chosen as to triboelectrically charge the toner particles to the desired polarity. As the mixture cascades or rolls across the image-bearing surface, the toner particles are electrostatically deposited and secured to the charged portion of the latent image and are not deposited on the uncharged or background portions of the image. Most of the toner particles accidentally deposited in the background areas are removed by the rolling carrier, due apparently, to the greater electrostatic attraction between the toner and the carrier than between the toner and the discharged background. The carrier and excess toner are then recycled. This technique is extremely good for the development of line copy images.

Another method of developing electrostatic images is the "imagnetic brush" process as disclosed, for example, in U.S. Pat. 2,874,063. In this method, a developer material containing toner and magnetic carrier particles is carried by a magnet. The magnetic field of the magnet causes alignment of the magnetic carriers into a brush-like configuration. This "magnetic brush" is engaged with the electrostatic image-bearing surface and the toner particles are drawn from the brush to the latent image by electrostatic attraction.

Still another technique for developing electrostatic latent images is the "power cloud" process disclosed by C. F. Carlson in U.S. Pat. 2,221,776. In this method, a developer material comprising electrically charged toner particles in a gaseous fluid is passed adjacent the surface bearing the latent electrostatic image. The toner particles are drawn by electrostatic attraction from the gas to the latent image. This process is particularly useful in continuous tone development.

Any other development method such as "touchdown" development as disclosed by R. W. Gundlach in U.S. Pat. 3,166,432 may be used were suitable.

In automatic xerographic equipment, it is conventional to employ a xerographic plate in the form of a cylindrical drum which is continuously rotated through a cycle of sequential operations including charging, exposing, developing, transfer and cleaning. The plate is usually charged with corona or positive polarity by means of a corona generating device of the type disclosed by L. E. Walkup in U.S. Pat. 2,777,957 which is connected to a suitable source of high potential. In forming a powder image on the electrostatic latent image during the development step, the powder image is electrostatically transferred to a support surface by means of a corona generating device such as the corona device mentioned above. In automatic equipment employing a rotating drum, a support surface to which a powder image is to be transferred is moved through the equipment at the same rate as the periphery of the drum and contacts the drum at the transfer position interposed between the drum surface and the corona generating device. Transfer is effected by the corona generating device which imparts an electrostatic charge to attract the powder image from the drum to the support surface. The polarity of charge required to effect image transfer is dependent upon the visual form of the original copy relative to the reproduction and the electroscopic characteristics of the developing materiel employed to effect development. For example, where a positive reproduction is to be made on the positive original, it is conventional to employ a positive polarity corona to effect transfer of a negatively charged toner image to its support surface. When a positive reproduction from a negative image is desired, it is conventional to employ a positively charged developing material which is repelled by the charged areas on the plate to the discharged areas thereon to form a positive image which may be transferred by negative polarity corona. In either case, a residual powder image usually remains on the plate after transfer. Before the plate may be reused for a subsequent cycle, it is necessary that the residul image be removed to prevent "ghost images" from forming on subsequent copies. In the positive-to-positive reproduction process described above, the residual developer powder is tightly retained on the plate surface by a phenomenon that is not fully understood but believed to be caused by an electrical charge that prevents complete transfer of the powder to the support surface, particularly in the image area. Discharge is substantially neutralized by means of a corona generating device prior to the contact of the residual powder image with a cleaning device. The neutralization of the charge enhances the cleaning efficiency of the cleaning device.

The residual toner image is removed by electrostatographic cleaning devices such as a "brush" type cleaning apparatus or "web" type cleaning apparatus. The typical brush cleaning apparatus is disclosed by L. E. Walkup et al. in U.S. Pat. 2,832,977. The brush-type cleaning means usually comprises one or more rotating brushes which brush residual powder from the plate into a stream of air which is exhausted through a filtering system. A typical web cleaning device is disclosed by W. P. Graff, Jr. et al. in U.S. Pat. 3,186,838. As disclosed by Graff, Jr. et al., removal of the residual powder on the plate is effected by passing a web of fibrous material over the plate surface.

While ordinarily capable of satisfactory cleaning electrostatographic plate surfaces, conventional electrostatographic plate cleaning devices suffer serious deficiencies in certain areas. Most of the known cleaning devices are complex and occupy a great deal of space in the electrostatographic copier or duplicator. Because of the space requirements of the cleaning system, compact machines operating at high speeds must be equipped with miniature high temperature fusers, thus presenting a heat dissipation problem and also presenting a fire hazard. Further, an additional power source or a complex mechanical linkage and drive system is required to operate the cleaning devices of the prior art. The cleaning devices employed in current commercial xerographic machines permanently remove residual toner particles from the developer system. Since toner material is an expensive consumable, permanent removal of the residual toner particles from the developer system during the cleaning step is undesirable because it adds to the cost of machine operation. Both the web-type and the brush cleaner systems normally do not return residual toner particles to the reusable developer mass after the cleaning operation. Since the web cleaner rapidly becomes loaded with toner particles during the cleaning process, it must frequently be replaced. Further, the web type cleaner is difficult to align with the surface of the electrostatographic plate and uneven contact between the web and the plate as well as uneven take-up of the web on a take-up roll is often encountered even with complex alignment apparatus. The brush-type cleaner must also be frequently replaced due to wear and accumulation of toner particles on the individual brush fibers. In addition, an elaborate and noisy vacuum and filtering system is necessary to collect the residual toner particles removed from the electrostatographic plate by the brush. The large amount of toner particles thrown into the air by the rapidly rotating brush cleaner often drift from the brush cleaning housing and form unwanted deposits on critical machine parts. Pressure contact between cleaning webs and imaging surfaces must be kept to a minimum to prevent rapid destruction of the imaging surface. Friction resulting from high web pressures are occasionally sufficient to cause the drum drive motor to fail due to overheating. Thus, there is a continuing need for a better system for cleaning reusable electrostatographic surfaces.

SUMMARY OF THE INVENTION

It is, therefore, an object of this invention to provide an electrostatographic imaging system which utilizes a cleaning means which overcomes the above-noted deficiencies.

It is another object of this invention to provide an improved reusable electrostatographic plate cleaning system occupying reduced space.

It is a further object of this invention to provide an improved reusable electrostatographic cleaning system adapted to reduce toner consumption in automatic electrostatographic imaging machines.

It is also an object of this invention to provide a plate cleaning system which does not require extensive alignment or adjustment.

It is still another object of this invention to provide a more durable longer lasting reusable electrostatographic plate cleaning system.

It is another object of this invention to provide a reusable electrostatographic plate cleaning system which does not require a power source.

It is a further object of this invention to provide a simple inexpensive reusable electrostatographic plate cleaning system.

It is a still further object of this invention to provide a reusable electrostatographic plate cleaning system which is more efficient than known electrostatographic plate cleaning systems.

The above objects and others are accomplished, generally speaking, by providing an imaging system employing an improved reusable electrostatographic imaging surface cleaning system comprising at least one self-adjusting flexible cleaning blade in pressure contact with the imaging surface. The leading edge or face of at least one cleaning blade preferably should be positioned to form an acute angle of less than about 90° and greater than about 20° with the confronting portion of the surface or plane tangent to the reusable imaging surface at the line of blade contact. Thus, the residual toner particles are preferably removed by a scraping rather than a chiseling action of the cleaning blade. As used herein, the expression "leading face" of the cleaning blade is intended to include that edge or face toward which the adjacent reusable electrostatographic imaging surface has relative movement. The reusable electrostatographic plate cleaning system of this invention includes means to supply a dry solid lubricant to the surface of the electrophotographic plate. Preferably, the cleaning system of this invention is adapted to rapidly and continuously or intermittently return the removed residual toner material to the developer sump for reuse without undue alteration of the toner concentration in the recycled developer.

The cleaning system of this invention is particularly effective in development systems employing two-component type developing materials. In carrying out the developing method of the present invention, any suitable conventional two-component type developing material comprising carrier and toner particles may be used. Representative patents in which these developer compositions are disclosed include U.S. Pat. 2,618,551 to Walkup, U.S. Pat. 2,618,552 to Wise, U.S. Pat. 2,633,415 to Walkup and Wise, U.S. Pat. 2,659,670 to Copley, U.S. Pat. 2,788,288 to Rheinfrank and Jones and U.S. Reissue Pat. 25,136 to Carlson. Generally, the toners have an average particle diameter between about 1 and about 30 microns, and the relatively larger carrier beads have an average particle diameter from about 50 to about 1,000 microns in diameter. Typical toner concentrations include a range from about 0.5 to about 10 percent by weight based on the total weight of the two-component developer composition.

Any suitable dry solid lubricant may be employed in the system of this invention. The dry solid lubricant may be supplied to the interface between the cleaning blade and the imaging surface by various techniques. For example, the dry solid lubricant may be in the form of a powder which is intimately mixed with the toner and supplied to the surface of the imaging surface during development of the latent electrostatic image. Alternatively, the dry solid lubricant may be dispersed throughout the photoconductive layer or suspended in a photoconductor overcoating. As the surface of the overcoating or treated photoconductor gradually wears away, additional dry lubricant which was originally distributed through the photoconductive or overcoating layer is exposed and made available at the interface of the cleaning blade and imaging surface. In another alternative embodiment, the dry solid lubricant may be sprinkled or smeared on the imaging surface at any point during the imaging cycle prior to the cleaning station. For example, a suitable dispenser such as a plurality of dispensers described in U.S. Pat. 3,013,703 may be positioned over a xerographic drum between the exposure and development stations and adapted to continuously or intermittently sprinkle dry solid lubricant particles on the imaging surface. Any suitable dry solid lubricant may be employed. Hydrophobic dry solid lubricants are preferred. Further, when the lubricant may ultimately transfer to the receiving sheet, the lubricant is preferably selected from the group of materials having a color which matches the color of the receiving sheet, e.g., white lubricant particles would be employed with white receiving sheets. Obviously, contrasting colors may be employed for novel effects if desired. Typical dry solid hydrophobic lubricants include metal salts of fatty acids such as zinc stearate, barium stearate, lead stearate, iron stearate, nickel stearate, cobalt stearate, copper stearate, strontium stearate, calcium stearate, cadmium stearate, magnesium stearate, zinc oleate, manganese oleate, iron oleate, cobalt oleate, copper oleate, lead oleate, magnesium oleate, zinc palmitate, cobalt palmitate, copper palmitate, magnesium palmitate, aluminum palmitate, calcium palmitate, lead caprylate, lead caproate, zinc linoleate, cobalt linoleate, calcium linoleate, zinc ricolinoleate and cadmium ricolinoleate; higher aliphatic acids such as stearic acid and palmitic acid; and colloidal pyrogenic silica particles such as Cab-O-Sil available from the Cabot Corporation and mixtures thereof.

Any suitable reusable electrostatographic imaging surface may be employed in the system of this invention. Well known electrostatographic imaging surfaces include photoconductive materials such as vitreous selenium, organic or inorganic photoconductors embedded in a nonphotoconductive matrix, organic or inorganic photoconductors embedded in a photoconductive matrix and the like. Representative patents in which photoconductive materials are disclosed include U.S. Pat. 2,803,542 to Ullrich, U.S. Pat. 2,970,906 to Bixby, U.S. Pat. 3,121,006 to Middleton, U.S. Pat. 3,121,007 to Middleton and U.S. Pat. 3,151,982 to Corrsin. Generally, photoconductive materials are supported by conductive substrates. Typical conductive substrates include brass, aluminum, gold, platinum, steel, glass coated with conductive oxides, metallized non-conductive substrates, laminated sheets of metal and plastic and the like. The conductive substrate may be in the form of a flat plate, cylinder, flexible sheet or other suitable configuration. Preferably, the photoconductive surface comprises vitreous selenium, selenium alloys or mixtures of selenium and other inorganic materials because superior copy quality is maintained for a greater number of copying or duplicating cycles.

BRIEF DESCRIPTION OF THE DRAWINGS

The advantages of the improved reusable electrostatographic plate cleaning system of this invention will become even further apparent upon consideration of the following disclosure of the invention, particularly when taken in conjunction with the accompanying drawings wherein:

FIG. 1 is a schematic sectional view of a xerographic reproducing apparatus employing a preferred embodiment of the cleaning blade apparatus of the invention.

FIG. 2 is a schematic sectional view of an alternative form of the apparatus shown in FIG. 1.

FIG. 3 is a schematic sectional view of another alternative form of the apparatus shown in FIG. 1.

FIG. 4 is a schematic sectional view of still another alternative form of the apparatus shown in FIG. 1.

FIG. 5 is a schematic fragmentary sectional view of one type of cleaning blade and photoreceptor configuration according to this invention.

FIG. 6 is a schematic sectional view of an alternative form of the blade and photoreceptor configuration shown in FIG. 5.

FIG. 7 is a schematic sectional view of another alternative form of the blade and photoreceptor configuration shown in FIG. 5.

FIG. 8 is an enlarged fragmentary sectional view of the cleaning blade assembly shown in FIG. 1.

FIG. 9 is a schematic elevation of an alternative form of the cleaning blade assembly of this invention.

FIG. 10 is an end elevation taken on line **10—10** of FIG. 9.

FIG. 11 is a plan view of only the cleaning blade component of the cleaning blade assembly illustrated in FIG. 9.

FIG. 12 is a view in perspective of an alternative embodiment of the cleaning blade of the present invention.

FIG. 13 is a side view in elevation of another alternative embodiment of the blade assembly of the present invention.

FIG. 14 is a side view in elevation of still another alternative embodiment of the blade assembly of this invention.

FIG. 15 is a plan view of the blade assembly and at a right angle with respect to the view of FIG. 14.

FIG. 16 is a view in perpsective of a plurality of cleaning blade holding members and blades according to another embodiment of this invention.

FIG. 17 is a side view in elevation of an alternative embodiment of the multiple blade system of FIG. 16.

FIG. 18 is a view in perspective of another modified form of the multiple blade embodiment of FIG. 16.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. 1, reference character **10** designates a rotatable xerographic drum having an outer layer **12** of photoconductive insulating material such as vitreous selenium. The drum **10** is mounted to move in the direction indicated by the arrow. The surface of photoconductive insulating layer **12** is uniformly charged by conventional corona charging device **14** and exposed to a pattern of activating electromagnetic radiation at **16**. The latent electrostatic image formed by the exposure means **16** is developed by rotating drum **10** by means of a conventional driving means, not shown, through a developing apparatus **18** including a developer housing **20** having a lower reservoir or sump portion for accumulating toner, carrier and dry lubricant particles **22**. Mounted within the developer housing **20** is a driven bucket-type conveyor **24** used to carry the developer material from the sump to the upper portion of the developer housing **20** from where the developer material is cascaded over a hopper chute **28** onto the surface of the photoconductive layer **12**.

As the developer material cascades over the drum, toner particles in the developer material adhere electrostatically to the previously formed electrostatic latent image areas on the surface of the photoconductive layer **12** to form a visible xerographic power image; the remaining developer material falling off the peripheral surface of the drum into the sump of the developer housing **20**. Toner particles consumed during the developing operation to form the xerographic powder images are replenished by a toner dispenser **19** such as the dispenser described in U.S. Pat 3,013,703 to Hunt. In the embodiment illustrated in FIG. 1, the dry solid hydrophobic lubricant is employed in finely-divided form and admixed with the toner particles. Thus, the dry solid lubricant particles are introduced into the machine simultaneously with the toner particles by means of dispenser **19**.

The developed images emerging from the developing apparatus may be transferred at a transfer station **28** to a moving paper web **30**. The transferred power image may be permanently fixed to the web **30** by any conventional means such as by heat fuser **32**. The surface of the photoconductor **12** is then cleaned of residual toner particles by the cleaning apparatus **34** thus completing the entire charging, exposing, developing, transferring and cleaning cycle.

The cleaning apparatus illustrated in FIG. 1 comprises a substantially rectangular cleaning blade member **36** pivotally secured to a hinged blade holder **38** by means of a shouldered screw **40**. The cleaning blade **36** normally rests in pressure contact with the surface of photoconductive layer **12** due to the combined weight of the blade itself, the blade holder **38**, and cam follower **42** which is secured to blade holder **38** by suitable means not shown. The cam follower **42** is located to one side of the drum **10** and extends sufficiently below an extension of the plane of the outer surface of photoconductive layer **12** for engagement with cam **44** during rotation of drum **10**. If desired, the downward pressure exerted by the combined weight of cleaning blade **36**, blade holder **38** and cam follower **42** may be supplemented by spring biasing means **46**. Cam **44** is securely attached to an end of and rotates with drum **10**. As the cam **44** engages cam follower **42**, the cam follower rides upon and follows the curved surface of cam **44** thereby causing blade holder **38** and blade **36** to be lifted away form the surface of photoconductive layer **12**. The raising of the blade **36** permits the ridge of residual toner particles accumulated by blade **36** to be transported on the moving surface of photoconductive layer **12** into the developing apparatus **18** where it is removed from the surface of photoconductive layer **12** by the cascading developer. Pivotal blade movement should be limited to avoid contact between the blade and the imaging surface while the blade is in the retracted position. This is accomplished in this embodiment by contact between the blade **36** and blade holder **38**. Thus, residual toner particles which are normally wasted by permanent removal from the xerographic machine by conventional cleaning apparatus is immediately reclaimed each cycle for reuse in the embodiment illustrated in FIG. 1. A removable trough **48** may be positioned subadjacent the nine o'clock position of the outer periphery of drum **10** to collect any toner particles which may gravitate away form blade **36** along the outer surface of drum **10**.

In FIG. 2, another embodiment of the invention is shown wherein the outer surface of xerographic drum **50** contains at least one groove which extends longitudinally across the drum surface parallel to the drum axis. The development cycle illustrated in this embodiment is similar to the system described with reference to FIG. 1. However, instead of introducing the dry lubricant with the toner as shown in FIG. 1, lubricant is supplied to the surface of photoconductive insulating layer **54** after the photoconductive insulating layer **54** is charged by means of corona charging device **56** and exposed at **58** but prior ot development in the developing apparatus **60**. The dry lubricant, in particular form, is stored in dispenser **62** and controllably released by means of gate **64**.

The developed images emerging from the developing apparatus **60** may be transferred at a transfer station **66** to a moving paper web **68**. The residual untransferred toner particles adhering to the surface of photoconductive insulating layer **54** may then be optionally charged by means of a conventional corona discharge device **70** such as the device described by L. E. Walkup in U.S. Pat. 2,777,957. The polarity of charge imparted to the residual toner particles by corona charging device **70** depends upon the particular results desired. Where it is desired to eliminate the inconvenience of removing and discharging the contents of a catch trough such as trough **48** illustrated in FIG. 1, the corona discharge device should be capable of imparting a charge polarity which increases the electrostatic charge adhesion between the residual toner particles and the surface of photoconductive insulatign layer **54** to prevent the possibility of residual toner gravitating away from the surface of drum **50**. Elimination of the trough also permits maximum recovery of residual toner particles for reuse in the developing apparatus. If desired, the corona discharge device **70** may be used to impart a charge polarity which reduces the electrostatic attraction between the residual toner particles and the surface of photoconductive insulating **54**. The reduced attraction reduces the wiper blade pressure required to remove the residual toner particles and therefore extends the life of the photoconductor and cleaning blade. Optionally, a light source, not shown, may be employed in conjunction with or substituted for corona discharge device **70** to reduce toner particle adhesion to the photoconductor surface.

The cleaning apparatus illustrated in FIG. 2 comprises a substantially rectangular cleaning blade member **72** reinforced by a U-shaped channel member **74** and pivotally secured to a hinged blade holder **76** by means of a shouldered screw **78**. The cleaning blade **72** is biased by means of leaf spring **80** to bear yieldingly against the surface of photoconductive insulating layer **54**. As the drum **50** rotates, the residual toner on the surface of photoconductive insulating layer **54** is dislodged and transported by cleaning blade **72** along the drum surface toward and finally into grooves **52**. A screw **82** mounted in a lug **84** serves to limit the lowest position to which the cleaning blade **72** can be biased by the leaf spring **80**. By properly adjusting screw **82**, the cleaning blade **72** can be positioned to bear yieldingly against the surface of photoconductive insulating layer **54** and yet be prevented from removing accumulated toner from the grooves **52**. In addition to serving as a temporary reservoir to accumulate residual toner particles, grooves **52** also are adapted to remove any residual toner particles adhering to the leading face of cleaning blade **72**. Removal of the residual toner particles from the leading face of cleaning blade **72** is effected by a wiping action between the leading face of the cleaning blade **72** and faces **86** of grooves **52**. As the drum **50** continues to rotate, the residual toner particles collected in grooves **52** are transported into the developing apparatus **60** where the collected toner particles are removed by the cascading developer.

A xerographic imaging system incorporating another cleaning embodiment of this invention is illustrated in FIG. 3. In this imaging system, the cleaning apparatus **110** is positioned in the development cycle to act on photoconductive insulating layer **112** after charging with corona charging device **114** and exposure at **116**. The cleaning apparatus **110** comprises a cleaning blade **117** pivotally mounted in blade holder **118** which is securely attached to solenoid **120** by shaft **122**. The solenoid **120** is activated periodically, for example, once every cycle, to permit displacement of the blade holder **118** and blade **117** away from the surface of photoconductive insulating layer **112**. The raising of blade **117** permits the ridge of residual toner particles accumulated by blade **117** to be transported on the moving surface of photoconductive insulating layer **112** into the developing apparatus **124** where it is removed from the surface of the photoconductive layer by the cascading developer. Surprisingly good images are obtained even though a coating of residual toner particles is carried on the surface of photoconductive insulating layer **112** during the charging and exposure steps. The solenoid **120** may be energized by any suitable means. For example, in FIG. 3, cam **126** may be driven by drum shaft **128** through a direct drive linkage to close micro-switch **130** once every imaging cycle. Obviously, other suitable electrically hydraulically or pneumatically activated means may be substituted for the solenoid **120**. The closing of micro-switch **130** completes the illustrated circuit and permits solenoid **120** to receive electrical energy from a suitable source **132**.

The developed images emerging from the developing apparatus **124** may be transferred at a transfer station **134** to a moving paper web **136**. The transferred powdered image is permanently fixed to the web **136** by a large high capacity heat fuser **138**. Since conventional bulky cleaning systems are eliminated by the employment of the cleaning blade of this invention, and since the toner fusing unit is usually the principal factor in limiting the speed of a xerographic imaging machine, the additional space gained by employment of the cleaning blade of this invention permits the employment of enlarged heat fusers such as the heat fuser **138**. Increased exposure time of toner images to heat energy emanating from heater elements **140** permits increased fusing speed without increasing the danger of fire when conventional inflammable receiving webs such as paper web **136** are employed. The dry solid lubricant for effecting toner removal with the cleaning blade of this invention may be supplied to the interface between cleaning blade **117** and surface of photoconductive insulating layer **112** by a component of photoconductive insulating layer **112** itself. For example, the photoconductive insulating layer may be formed by co-evaporation of a dry solid lubricant such as zinc stearate and selenium onto the drum surface during manufacture. Xerographic plates containing dry solid lubricant dispersed throughout the photoconductive insulating layer are known and described, for example, in copending application Ser. No. 594,074, filed Nov. 14, 1966, by R. J. Joseph.

Referring now to FIG. 4, reference character **150** designates a xerographic belt mounted to move in the direction indicated by the arrow. The surface of the xerographic belt **150** is uniformly charged by conventional corona charging device **152** and exposed to a pattern of activating electromagnetic radiation at full frame exposure station **154**. The latent electromstatic image formed at the full frame exposure station **154** is developed by passing xerographic belt **150** through a developing apparatus **156**. The developed surface of xerographic belt **150** is then passed through a powder cloud of dry solid lubricant in dusting chamber **158**. The powder cloud of dry solid lubricant is maintained by a suitable means such as rotating brush **160** positioned within dusting chamber **158**. The developed images emerging from dusting chamber **158** are then transferred at a transfer station **162** to a moving receiving sheet or web **164**. The residual untransferred toner particles adhering to the surface of xerographic belt **150** may, if desired, then be charged by corona discharged device **166** to neutralize the electrostatic charge attraction between the residual toner particles and the surface of xerographic belt **150**. The charge neutralization treatment permits a reduction of the wiper blade pressure required to remove the residual toner particles. The surface of xerographic belt **150** is finally cleaned of residual toner particles by the cleaning apparatus **168** thus completing the entire charging, exposing, developing, lubricant treating and cleaning cycle.

The cleaning apparatus illustrated in FIG. 4 includes a cleaning blade assembly comprising a substantially rectangular cleaning blade member **170** clamped to a pivoting head **171** by means of plate **172** and a plurality of screws **173**. Head **171** is pivotally mounted on a single shaft **174** by suitable means not shown. Shaft **174** is in turn secured to a hinged blade holder **176** by a press fit. The cleaning blade **170** is indirectly biased by means of leaf spring **178** to bear yieldingly against the surface of xerographic belt **150**. As the surface of xerographic belt **150** travels past cleaning blade member **170**, the residual toner particles on the surface of the belt are dislodged and permitted to fall into the trough **180**. The position of the cleaning blade **170** relative to the surface of xerographic belt **150** may be regulated by a screw and lug assembly **182**.

As discussed above, the leading edge or face of at least one cleaning blade is preferably positioned to form an acute angle of less than about 90° and greater than about 20° with the surface or plane tangent to the surface of the electrostatographic imaging layer at the line of blade contact. The acute angle, designated by the symbol θ_1 in FIG. 5, is normally the angle between the leading edge or face **200** of cleaning blade **202** and the confronting surface **204** of a reusable electrostatographic imaging layer **206**. However, when relatively flexible cleaning blades such as the cleaning blade **208** illustrated in FIG. 6 are employed, the acute angle between the leading edge or face **210** and electrostatographic imaging surface **212** of electrostatographic imaging layer **214** should be the angle measured θ_2 measured as close as possible to the line of contact between the cleaning blade and the confronting electrostatographic imaging surface or tangent to the imaging surface to avoid an erroneous reading such as θ_3 taken at a substantial distance from the line of blade contact. In the embodiments illustrated in FIG. 5 and FIG. 6, the cleaning blades are inclined toward the ridge of collected toner material. It is apparent, however, that in the preferred embodiment the overall blade inclination need not be toward the ridge collected toner particles, but may in fact be inclined away from the collected toner particles as long as there is a leading edge or face **216** even at a microscopic level to form an acute angle θ_4 as illustrated in FIG. 7. When the blade angle θ exceeds about 90° with angular knife edged blades, uneven removal of toner particles from the surface of the imaging layer often occurs. Uneven toner removal frequently may be alleviated by increasing blade pressure. However, increased blade pressure tends to increase wear of the contacting surfaces. The configuration of the cleaning blade at the point of contact need not be a sharp corner as illustrated in FIGS. 5, 6 and 7, but may be a knife edge or even slightly rounded due to wear or as originally installed. Where a rounded or curved contacting surface of a cleaning blade surface is employed, the radius of curvature should preferably be less than about .035 inch because toner will become trapped and impacted at the shallow angle caused by the rounded edge and the drum interface. The area enclosed by the angle increases as the radius increases. It is apparent, however, that even the blades of this invention having slightly rounded contacting surfaces are characterized by an overall angular appearance.

It is evident from the embodiment illustrated in the drawings described above that the principles of the present invention include the use of at least one self-adjusting or aligning flexible cleaning blade yieldingly bearing against a reusable electrostatographic imaging surface and a means to directly or indirectly supply dry solid lubricant material to the interface between the cleaning blade and the imaging surface. In the absence of a means to provide a dry lubricant, repeated exposure of a reusable electrostatographic imaging surface to the abrasive action of a cleaning blade bearing yieldingly on the moving imaging surface for the large number of cycles required in commercial machines causes rapid degradation of both the cleaning blade and imaging surface to the extent that the cost of equipment replacement and degradation of imaging quality renders the system economically unfeasible. It is further apparent from the embodiment depicted in the drawings described above, that cleaning blades adapted to rapidly and continuously or intermittently permit the return of the removed residual toner material to the developer sump for reuse are preferred because greater efficiency and economy of operation are achieved. Because of the necessity for uniform and efficient removal of residual toner particles from the surface of reusable electrostatographic imaging surfaces in precision high-speed, high-volume copying or duplicating machines, the self-adjusting feature of the cleaning blade is critical. Non-uniform and incomplete removal of residual toner particles contributes to the formation of a toner film on the imaging surface with an attendant degradation of image quality during subsequent imaging cycles.

An enlarged fragmentary sectional view of the cleaning blade shown in FIG. 1 is illustrated in FIG. 8. In this embodiment, the flexible rectangular cleaning blade member **36** is adhesively united to a metal plate **37** which is in turn spaced from blade holder member **38** by a washer **39**. Rectangular blade member **36** is pivotally secured to blade holder **38** by a single shouldered screw **40** which is received by a centered threaded hole in metal plate **37.** Since the diameter of the unthreaded portion **41** of shouldered screw **40** is less than the diameter of the opening **43** of blade holder **38**, the flexible cleaning blade **36** is free to pivot around the axis of shouldered screw **40.** The ability to freely pivot around the axis of shouldered screw **40** allows the pressure exerted by the cleaning blade **36** along the line of contact with the reusable imaging surface to equalize itself thereby uniformly removing residual toner particles from the imaging surface without danger of toner build up and film formation.

Another embodiment of the self-adjusting cleaning blade of this invention is illustrated in FIGS. 9, 10 and 11. This cleaning blade unit includes a flexible metal reinforcing plate **210** molded into a rubber cleaning blade **212**. The metal reinforcing plate contains a plurality of punched out sections **214** which permit the portions of the rubber cleaning blade **212** above and below the metal reinforcing plate to adhere to each other during the cleaning blade molding operation. The flexible metal reinforcing plate **210** is slidably mounted in grooves **216** in the lower support arms **218**. Holes **220** are located at each end of flexible metal reinforcing plate **210** to receive a pin **221** or a machine screw **222** and a nut **226**. The pin **221** or machine screw **222** and nut **226** are positioned at the ends of flexible reinforcing plate **210** to limit the distance of travel of flexible metal reinforcing plate **210** in grooves **216** during the reusable imaging surface cleaning operation. Lower support arms **218** are pivotally mounted with the aid of pins **228** at the ends of upper support arm **230**. The upper suport arm **230** is pivotally secured by a pin **232** to blade holder **234**. Suitable means, not shown, may be attached to the blade holder **234** to bias the cleaning blade **212** toward the reusable imaging surface. The biasing pressure applied to the blade holder **234** is transmitted to the flexible metal reinforcing plate **210** through upper support arm **230** and lower support arms **218**. Since the flexible metal reinforcing plate **210** is flexible in a direction perpendicular to its punched surface, the biasing pressure imparted to the flexible metal reinforcing plate **210** by lower support arms **218** is substantially uniformly conveyed to the entire length of rubber cleaning blade **212**. If desired, the number of intermediate support arms may be increased or decreased depending upon the length of the cleaning blade employed. It is apparent from the foregoing discussion that the cleaning blade of this embodiment is also self-adjusting and would uniformly remove residual toner particles from the reusable imaging surface.

FIG. **12** shows another modification of the self-dajusting cleaning blade of this invention. In this embodiment, the flexible cleaning blade **250** is sandwiched between metal plate **252** and metal plate **254**. The assembly of plates and wiper blade are secured together by a plurality of rivets **256**. The flexible cleaning blade **250** is divided up into a number of independent blade segments **258** by a plurality of slits **260**. Each of the blade segments **258** may ride over any slight imperfection on the surface of the reusable imaging layer without adversely affecting the position of the adjacent independent blade segments in relation to the reusable imaging surface.

Another alternative embodiment of the self-adjusting cleaning blade assembly is illustrated in FIG. 13. A flexible cleaning blade **300** is clamped in the jaws of a blade holder **302**. The jaws extend along the entire length of the cleaning blade **300** to prevent undue flexing of the cleaning blade along the direction of photoreceptor surface travel. An adjustable plate **304** is sandwiched between the upper jaw of blade holder **302** and cleaning blade **300**. When highly flexible cleaning blade materials are employed, the adjustable plate **304** should be selected from relatively stiff materials such as metal to provide additional support for the cleaning blade. Conversely, where stiff cleaning blades are employed, the adjustable plate may comprise a soft resilient material such as polyurethane sponge. The blade holder is pivotally mounted in elbow **306** which is in turn pivotally connected to a second elbow **308**. The second elbow **308** is attached to a suitable support by a hinged means, not shown, which is similar to the hinged support illustrated in FIGS. 1, 2 and 4. Elbow **306** comprises two half shells which may be secured together by screws inserted through flanges **310**, **312**, and **314**. As shown in the partial cut-away view of elbow **306**, the split halves of elbow **306** are either molded or machined to form a cavity in each shell which conforms to the configuration of the enlarged head **318** of shaft **316**. The cavity formed in the elbow **306** should be slightly larger than the enlarged portion of shaft **316** to permit the shaft **316** to freely rotate within the cavity. The other end of the shaft **316** may be rigidly secured by a press-fit to a T-shaped member **320** which is in turn secured by machine screws to blade holder **302**. An identical arrangement is employed to permit shaft **322** to axially rotate in elbow **306**. The other end of shaft **322** is permanently secured to elbow **308** by a press fit. The two pivot points employed in the cleaning blade shown in FIG. 13 permit automatic alignment of the cleaning blade **300** relative to the axis of drum **324** as well as automatic equalization of pressure along the line of contact between the cleaning blade **300** and the reusable surface of electrostatographic drum **324**.

In FIGS. 14 and 15, a self-adjusting cleaning blade assembly having one pivot point instead of the two pivot points of the FIG. 13 self-adjusting cleaning blade assembly is shown. A flexible cleaning blade **350** and adjustable stiffener plate **352** are clamped in the jaws of a blade holder **354**. The jaws of the blade holder **354** extend along the entire length of the cleaning blade **350** to provide sufficient support for the cleaning blade. The blade holder **354** is secured to a T-shaped connecting member **356** by machine screws **358**. The T-shaped member **356** is pivotally mounted on one end of a shaft **360** in a manner similar to that illustrated in FIG. 13. The other end of shaft **360** is permanently secured to a hinged member **362**. The hinged member **362** is biased toward the reusable electrostatographic drum surface **364** by spring loaded pin **366** which is slidably mounted in hollow sleeve **368**. The pressure exerted by pin **366** may be adjusted by rotation of the threaded sleeve **368** within a threaded hole in support block **370**. The hinged member **362** is hinged at point **372**. The support block **370** and hinge half **374** are secured by suitable means, not shown, to a support arm **376** which is mounted on a shaft **378**. Shaft **378** is permanently secured to the frame of the imaging machine by means not shown. A set screw **380** is threadably received in the arm **376** to secure and prevent rotation of arm **376** on shaft **378**. By loosening the set screw **380**, the cleaning blade assembly may be slidably removed from shaft **378** for repairs or adjustment of the cleaning blade assembly or electrostatographic drum. The set screw **380** may also be used to position the arm **367** on shaft **378** thereby permitting adjustment of the cleaning blade angle relative to the surface of the electrostatographic drum. Cam **382** is securely attached to an end of and rotates with drum **364**. As the drum **364** rotates in the direction shown by the arrow, cam **382** engages a roller cam follower **384** which rotates on a supporting pin **386** which is secured to the lower bifurcated portion of arm **388** which extends downwardly from one end of hinged member **362**. As the cam **382** engages roller cam follower **384**, the roller cam follower rides upon and follows the curved surface of cam **382** thereby causing arm **388** as well as the cleaning blade **350** to be lifted away from the surface of the electrostatographic drum **364**. The raising of the blade **350** permits the ridge of residual toner particles accumulated by blade **350** to be transported on the moving surface of electrostatographic drum **364** into the developing apparatus, not shown, where it is removed from the surface by the cascading developer. Since the blade holder **354** positions the leading face **390** of cleaning blade **350** at an angle of about 135° with respect to the axis of shaft **360**, the function of the two pivot points employed in the cleaning blade assembly of FIG. 13 is accomplished with a single pivot point, thereby permitting automatic alignment of the cleaning blade **350** relative to the axis of drum **364** as well as automatic equalization of pressure between the cleaning blade **350** and the reusable surface of electrostatographic drum **364** along the line of blade-drum contact. In other words, the blade **350** has two adaptations to the imaging surface, one transversely or generally circumferentially of the imaging surface and one axially across the width thereof.

If desired, a plurality of cleaning blades may be employed to clean the residual toner particles from the surface of the reusable imaging surface. In the embodiment depicted in FIG. 16, each of the cleaning blade assemblies **400, 402** and **404** extend across the entire axial length of the electrostatographic imaging drum. The blade material employed in each of the cleaning blade assemblies need not be identical to the materials employed in the other cleaning blades. For example, cleaning blade **406** may comprise a flexible but relatively stiff material such as polyurethane which removes the bulk of the residual toner particles on the surface of electrostatographic drum **408** whereas the cleaning blades **410** and **412** of cleaning blade assemblies **402** and **404**, respectively, may comprise relatively soft material which removes the residual toner particles, if any, not removed by cleaning blade **406.** Where a highly compact multiple cleaning blade system is desired, the cleaning blade assembly shown in FIG. 17 may be substituted for the plurality of cleaning blade assemblies of FIG. 16. The cleaning blade assembly illustrated in FIG. 17 comprises two cleaning blades **420** and **422** clamped in the jaws of a single blade holder **424.** The jaws extend along the entire length of the cleaning blades **420** and **422** to prevent undue flexing of the cleaning blade. Adjustable stiffener plates **426** and **428** may be sandwiched between the upper surface of each blade and the jaws of the blade holder. As discussed above, the stiffening blades provide additional support for the cleaning blades, particularly when highly flexible cleaning blade materials are employed.

An alternative multiple cleaning blade system is shown in the isometric view in FIG. 18. Each of the cleaning blades **450, 452** and **454** carried by the cleaning blade holders **456, 458** and **460**, respectively, extends across a portion of the axial length of reusable electrostatographic drum **462.** The cleaning blades are staggered and overlapped to insure that the entire imaging surface of the reusable electrostatographic drum **462** are contacted by the blades. The reusable electrostatographic drum **462** contains staggered grooves or depressions **464, 466** and **468.** These grooves or depressions are positioned to permit each of the cleaning blades to ride over the grooves rather than into the grooves. For example, cleaning blade **452** is prevented from riding down into the grooves **464** and **468** by the undepressed surface of reusable electrostatographic drum **462** located between grooves **464** and **468.** Similarily, since the groove **466** is shorter than the length of cleaning blade **452,** the undepressed surface of reusable electrostatographic imaging drum **462** located at each end of groove **466** prevents the cleaning blade **452** from riding down into groove **466.** The groove arrangement shown in FIG. 18 eliminates the need of a means to limit the lowest position of cleaning blade travel since the undepressed portions of the surface of reusable electrostatographic drum **462** prevent the cleaning blades from entering the grooves and removing accumulated toner. As the electrostatographic drum **462** continues to rotate, the residual toner particles collected in the grooves **464, 466** and **468** are transported into the developing apparatus, not shown, where the collected toner particles are removed by the cascading developer.

Although most of the illustrations discussed above are directed to electrostatographic imaging systems employing a cascade development station, it is apparent that other development techniques such as the magnetic brush, fiber brush, powder cloud and touchdown development systems described above may be used where suitable. However, the cascade type development system is preferred because of the rapid return of residual toner particles to the main body of developer and uniform mixing of the main body of developer with the recovered toner for reuse. The carrier bead trapping and attendant electrostatographic imaging surface bead scratching problems encountered with the prior art cleaning web systems are completely obviated by the cleaning blade systems of the present invention. Permanent removal of residual toner by conventional web and brush cleaning systems is also eliminated by employing the preferred cleaning system of this invention.

Any suitable non-metallic flexible cleaning blade material may be employed in the cleaning system of this invention. Typical non-metallic flexible materials include: polysiloxane rubber, polyurethane rubber, polytetrafluoroethylene resin, polytrifluorochloroethylene resin, styrene-butadiene rubber, nitrile rubber, nitrile-silicone rubber, flexible polyurethane foam, polyethylene resin and blends, mixtures and copolymers thereof. The blade should be sufficiently soft to minimize abrasion of reusable imaging surfaces, particularly selenium type imaging surfaces. Preferably, the blade material should have a Shore hardness of less than about D65. Considerable latitude in blade thickness is permissible. However, the blade should be sufficiently thick to avoid collapse of the blade on the imaging surface under the blade pressure conditions employed. Obviously, greater latitude in flexibility of the blade material is available when the stiffening members described above are employed in the blade holder. The cleaning blade pressure upon the surface of the reusable imaging surface can vary considerably. Generally, the minimum pressure necessary for effective removal of the toner particles from the reusable imaging surface is preferred because undue wear of the reusable imaging surface is avoided. Satisfactory results have been obtained when the weight of a three pound cleaning blade assembly, such as the cleaning blade assembly illustrated in FIG. 1, was the only source of pressure exerted on the cleaning blade. The corner between the leading face of the cleaning blade and the blade end or edge must be sufficiently abrupt to perform an effective scraping action as opposed to a smearing action. However, satisfactory results are obtained when the angular imaging surface engaging edge of the cleaning blade is slightly rounded due to wear as described above. Thus, effective toner removal is maximized when the surface area of the portion of the blade in contact with the imaging surface is minimized. A surprisingly large latitude of operating speeds is permissible with the cleaning blade of this invention. Extremely high cleaning efficiency is achieved with cleaning blade to reusable imaging surface relative speeds of up to about 5 feet per second.

The following examples further specifically define and describe the imaging system of the present invention for deveoping electrostatic latent images with toner, transferring the resulting toner images to a receiving surface and thereafter cleaning the reusable imaging surface with a flexible self-adjusting cleaning blade. Parts and percentages are by weight unless otherwise indicated. These examples, other than the control examples, are intended to illustrate the various preferred embodiments of the present invention.

In the following Examples I through IV, are carried out in a copying machine described in detail in U.S. Pat. 3,099,856. A standard Xerox 813 cleaning web is employed in the control example and a self-aligning polyurethane elastomer. Disogrin, cleaning blade is substituted for the cleaning web in the examples illustrating the preferred embodiments of this invention.

EXAMPLE I

The vitreous selenium drum of a copying machine is corona charged to a voltage of about 800 volts and exposed to a light-and-shadow image to form an electrostatic latent image. The selenium drum is then rotated through a cascade development station. A developer comprising a toner comprising a styrene-butyl methacrylate copolymer, polyvinyl butyral, and carbon black prepared by the method disclosed in Example I of U.S. Pat. 3,079,-342 and carrier beads prepared by the process disclosed in U.S. Pat. 2,618,551 is employed in the developer station. After the electrostatic latent images are developed in the developing station, the resulting toner images are transferred to a sheet of paper at a transfer station. The residual toner powder remaining on the selenium drum after passage through the transfer station is removed by a conventional Xerox 813 cleaning web at a cleaning station. A detailed description of this type of imaging system is set forth in U.S. Pat. 3,099,856. The drum is rotated at a constant linear surface speed of approximately 3 inches per second during the imaging cycle. The imaging cycle is repeated for 10,000 cycles. This test serves as a control. Microscopic examination of the selenium surface after 10,000 cycles, reveals considerable wear with a large number of deep scratches apparently caused by carrier beads trapped between the cleaning web and the selenium drum surface. The quantity of toner lost with this cleaning system is found to be about 87 grams.

EXAMPLE II

The test described in Example I is repeated with a fresh selenium drum, zinc stearate powder in the developer and a self-aligning cleaning blade assembly substituted for the cleaning web. The zinc stearate is incorporated into the developer by simply tumbling about 99 parts toner particles with about 1 part by weight, based on the total weight of the toner, of powdered zinc stearate in a sealed horizontal rotating cylinder. The cleaning blade assembly employed is similar to the cleaning blade assembly illustrated in FIG. 1 except for the elimination of spring biasing means **46**. The blade material is a rectangular strip of polyurethane elastomer, Disorgrin, (available from Disorgrin Industries) having a thickness of about 3/32 inch. The leading face of the cleaning blade is positioned to form an acute angle of about 60° with the confronting portion of the selenium drum surface at the line of blade contact. Although the spring biasing means shown in FIG. 1 is not employed, sufficient pressure is applied to the blade by the weight of the blade assembly to effectively remove residual toner particles from the drum surface. The total weight of the blade assembly is found to be about 3 pounds. A cam is securely attached to one end of the selenium drum for contact with a cam follower attached to the blade assembly. Since the cam is securely attached to the selenium drum, the cam causes the blade to lift away from the selenium surface once every imaging cycle to permit the toner collected by the blade to be transported by the drum surface into the developing housing where it is picked up by the cascading developer. The modified machine is operated for 10,000 cycles and the drum is then removed for examination. Microscopic studies of the selenium surface indicate only slight wear of the surface. No deep scratches can be found anywhere on the selenium surface. The quantity of toner lost with this cleaning system is found to be about 3.5 grams. Thus, the toner lost in this modified machine is about 24 times less than the loss in the machine described in Example I.

EXAMPLE III

The procedure described in Example II is repeated with a fresh drum and fresh developer. In addition, a powder dispenser is positioned between the cleaning blade assembly and the exposure station. The dispenser is regulated to sprinkle a thin powder film of zinc stearate on the selenium surface during the imaging cycle. After 10,000 cycles, a microscopic examination of the imaging surface reveals substantially the same degree of wear observed on the imaging surface described in Example II.

EXAMPLE IV

The test described in Example I is repeated with a modified selenium drum, zinc stearate powder in the developer and a self-aligning cleaning blade assembly substituted for the cleaning web. The zinc stearate is incorporated into the developer by simply tumbling about 100 parts toner particles with about 1 part by weight, based on the total weight of the toner, of zinc stearate in a sealed horizontal rotating cylinder. The cleaning blade assembly employed is similar to the cleaning blade assembly illustrated in FIG. 2. The selenium drum is modified to provide two adjacent and parallel depressions extending axially along the length of the drum. These depressions have a semi-circular cross section with a radius of curvature of about .062 inch. The blade material is a rectangular strip of natural rubber having a thickness of about 1/16 inch. The leading face of the cleaning blade is positioned to form an acute angle of about 80° with the confronting portion of the selenium drum surface at the line of blade contact. The total pressure exerted upon the blade in a direction parallel to the drum radius at the line of contact is about 3 pounds as determined by a spring scale. A corona discharge electrode is positioned between the transfer station and the cleaning station to neutralize electric charge carrier by residual toner particles. This neutralization is accomplished by operating the corona discharge electrode at a high voltage alternating potential of about 60 cycles AC and 6,000 peak volts. The voltage is biased at a slightly negative current, such that the positive current is about 10 microamps and the negative current is about 12 microamps. A limit is provided to permit the cleaning blade to pass over the grooves without substantial penetration, thereby preventing the cleaning blade from scooping out toner particles from the grooves. The toner particles collected in the grooves are picked up by the cascading developer in the developing housing. The modified drum is operated for 10,000 cycles and the drum is then removed for examination. Microscopic studies of the selenium surface indicate substantially the same degree of wear observed on the imaging surface described in Example II. The quantity of toner loss in this cleaning system is considerably less than the loss in the machine described in Example I.

While the invention has been particularly shown and described with reference to preferred embodiments thereof, other modifications and ramifications of the present invention will appear to those skilled in the art upon a reading of the disclosure. These are intended to be included within the scope of this invention.

What is claimed is:

1. An electrostatographic imaging apparatus comprising:

an annular recyclicable layer having an electrostatographic imaging surface and a plurality of processing stations;

means to support said recyclicable layer and to effect relative movement between said electrostatographic imaging surface and said stations;

a first of said stations comprising means for forming an electrostatic latent image on said imaging surface;

a second of said stations comprising means for applying toner particles to said imaging surface to develop said electrostatic latent image;

a third of said stations comprising for transferring said developed toner image from said imaging surface to a receiving surface;

a fourth of said stations comprising at least one cleaning blade assembly for removing residual particles from at least a portion of said imaging surface, said cleaning blade assembly comprising at least one flexible cleaning blade and cleaning blade aligning means, said cleaning blade having a substantially angular imaging surface engaging edge and being elongated axially along the width of said imaging layer and said cleaning blade aligning means being adapted to permit said cleaning blade to align itself substantially parallel to said imaging surface and axially along the width of said imaging layer when said cleaning blade is engaged with said imaging surface;

means for periodically displacing said cleaning blade toward and away from said imaging surface thereby permitting residual particles accumulated by said cleaning blade to be transported on said imaging surface past said cleaning blade; and

means to supply a dry solid lubricant to said electrostatographic imaging surface.

2. An electrostatographic imaging apparatus according to claim **1** in which said means for supporting said cleaning blade assembly is adapted to position the leading face of said cleaning blade at an angle between about 20° and about 90° with a tangential plane to said imaging surface at the line of cleaning blade contact when said cleaning blade is engaged with said imaging surface.

3. An electrostatographic imaging apparatus according to claim **1** in which said means for periodically displacing said cleaning blade comprising a cam secured to said means to support said annular recyclicable layer and a cam follower secured to said cleaning blade assembly and positioned to permit a sufficient degree of engagement of said cam following with said cam to displace said cleaning blade away from said imaging surface.

4. An electrostatographic imaging apparatus comprising:

an annular recyclicable layer having an electrostatographic imaging surface and at least one groove extending axially along said imaging surface and a plurality of processing stations;

means to effect relative movement between said electrostatographic imaging surface and said stations;

a first of said stations comprising means for forming an electrostatic latent image on said imaging surface;

a second of said stations comprising means for applying toner particles to said imaging surface to develop said electrostatic image;

a third of said stations comprising means for transferring said developed toner image from said imaging surface to a receiving surface;

a fourth of said stations comprising at least one cleaning blade assembly for removing residual particles from at least a portion of said imaging surface, said cleaning blade assembly comprising at least one flexible cleaning blade, cleaning blade aligning means and cleaning blade limiting means, said cleaning blade having substantially angular imaging surface engaging edge and being elongated axially along the width of said imaging layer when said cleaning blade is engaged with said imaging surface and said cleaning blade limiting means being adapted to limit penetration of said cleaning blade into said groove; and

means to supply a dry solid lubricant to said electrostatographic imaging surface.

5. An electrostatographic imaging apparatus according to claim **4** in which said means for supporting said cleaning blade assembly is adapted to position the leading face of said cleaning blade at an angle between about 20° and about 90° with a tangential plane to said imaging surface at the line of cleaning blade contact when said cleaning blade is engaged with said imaging surface.

6. An electrostatographic imaging apparatus according to claim **4** in which a plurality of parallel grooves extend axially along said imaging surface.

7. An electrostatographic imaging apparatus according to claim **6** in which the length of each of said plurality of grooves is less than the width of said electrostatographic imaging surface.

8. An electrostatographic imaging apparatus according to claim **7** in which the plurality of said flexible cleaning blades are located at said fourth of said stations.

9. An electrostatographic imaging apparatus according to claim **8** in which the length of each of said cleaning blades is less than the width of said electrostatographic imaging surface.

10. An electrostatographic imaging apparatus according to claim **9** in which the length of each of said grooves is less than the length of each of said flexible cleaning blades.

11. A photoconductive imaging apparatus comprising:

a recyclicable layer having a dry photoconductive imaging-surface and a plurality of processing stations;

means to effect relative movement between said photoconductive imaging-surface and said stations;

a first of said stations comprising means for forming an electrostatic latent image on said photoconductive imaging-surface;

a second of said stations comprising means for applying dry toner particles to said photoconductive imaging-surface to develop said electrostatic latent image whereby a developed toner image is formed;

a third of said stations comprising means for transferring said developed toner image from said photoconductive imaging-surface to a receiving surface;

a fourth of such stations comprising a cleaning assembly for removing dry residual particles from said dry photoconductive imaging-surface, said cleaning assembly comprising a pressure applying means and at least one flexible cleaning blade having a substantially angular imaging-surface engaging edge aligned parallel to and in pressure contact with said photoconductive imaging-surface, said pressure applying means being adapted to apply sufficient pressure to said flexible cleaning blade to remove substantially all of said residual particles on the portion of said photoconductive imaging-surface in contact with said flexible cleaning blade; and

means to supply a dry solid lubricant to said photoconductive imaging-surface.

12. A photoconductive imaging apparatus comprising:

an annular recyclicable layer having a dry photoconductive imaging-surface and a plurality of processing stations;

means to effect relative movement between said photoconductive imaging-surface and said stations;

a first of said stations comprising means for forming an electrostatic latent image on said photoconductive imaging-surface.

a second of said stations comprising means for applying dry toner particles to said photoconductive imaging-surface to develop said electrostatic latent image whereby a developed toner image is formed;

a third of said stations comprising means for transferring said developed toner image from said photoconductive imaging-surface to a receiving surface;

a fourth of said stations comprising a cleaning assembly for removing dry residual particles from said dry photoconductive imaging surface, said cleaning assembly comprising a pressure applying means and at least one flexible cleaning blade having a substantially angular imaging-surface engaging edge aligned parallel to and in pressure contact with said photoconductive imaging-surface, said angular imaging-surface engaging edge being elongated axially along the width of said annular recyclicable layer, said pressure applying means being adapted to apply sufficient pressure to said cleaning blade to remove substantially all of said residual particles on the portion of said photoconductive imaging-surface in contact with said flexible cleaning blade; and

means to supply a dry solid lubricant to said photoconductive imaging-surface.

13. A photoconductive imaging apparatus according to claim **12** in which said cleaning blade assembly is adapted to position the leading face of said cleaning blade at an angle between about 20° and about 90° with a tangential plane to said photoconductive imaging-surface at the line of cleaning blade contact when said cleaning blade is engaged with said photoconductive imaging-surface.

14. A photoconductive imaging apparatus according to claim **12** in which said annular recyclicable layer is a belt.

15. A photoconductive imaging apparatus according to claim **12** in which said annular recyclicable layer is a cylinder.

16. A photoconductive imaging apparatus according to claim **12** further including a corona discharge electrode positioned and disposed to apply electrostatic charge to said photoconductive imaging-surface prior to removal of residual particles from said photoconductive imaging-surface by said cleaning blade.

17. A photoconductive imaging apparatus according to claim **12** in which said fourth of said stations is positioned adjacent to the said photoconductive imaging-surface between said first of said stations and said second of said stations.

18. A photoconductive imaging apparatus according to claim **12** in which said fourth of said stations is positioned

adjacent to the said photoconductive imaging-surface between said third of said stations and said first of said stations.

19. A photoconductive imaging apparatus according to claim **12** in which a toner catch-tray is positioned subadjacent said fourth of said stations to catch any residual particles falling away from said fourth of said stations.

20. A photoconductive imaging apparatus according to claim **12** in which said cleaning blade comprises a row of blade segments.

21. A photoconductive imaging apparatus according to claim **12** in which said means for applied dry toner particles is adapted to cascade said toner particles and carrier particles over a portion of said photoconductive imaging surface.

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