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Egnaczak

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[54] CLEANING APPARATUS

[72] Inventor: Raymond K. Egnaczak, Williamson, N.Y.

[73] Assignee: Xerox Corporation, Rochester, N.Y.

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Primary Examiner—Leon G. Machlin

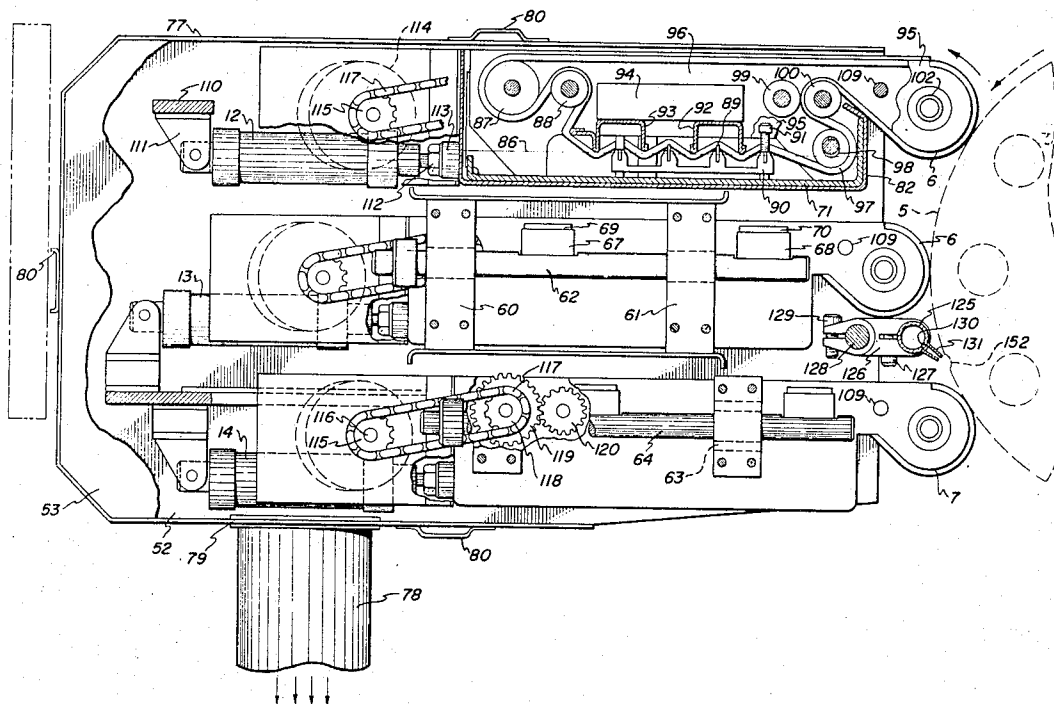
Attorney—James J. Ralabate, David C. Petre and Barry Jay Kesselman

[57]

ABSTRACT

A modular cleaning unit for cleaning relatively smooth surfaces of contaminants. The unit has one or more belts that contact the surface and scrub it. The belts contain fluids to help remove the particles and are electrically biased to attract the particles loosened from the surface. Optionally, lamps radiate the particles to ease removal from the surface. The continuous belts are driven through cleaning fluids and over belt cleaning and wringing devices before passing in contact with the surface to be cleaned.

15 Claims, 3 Drawing Figures



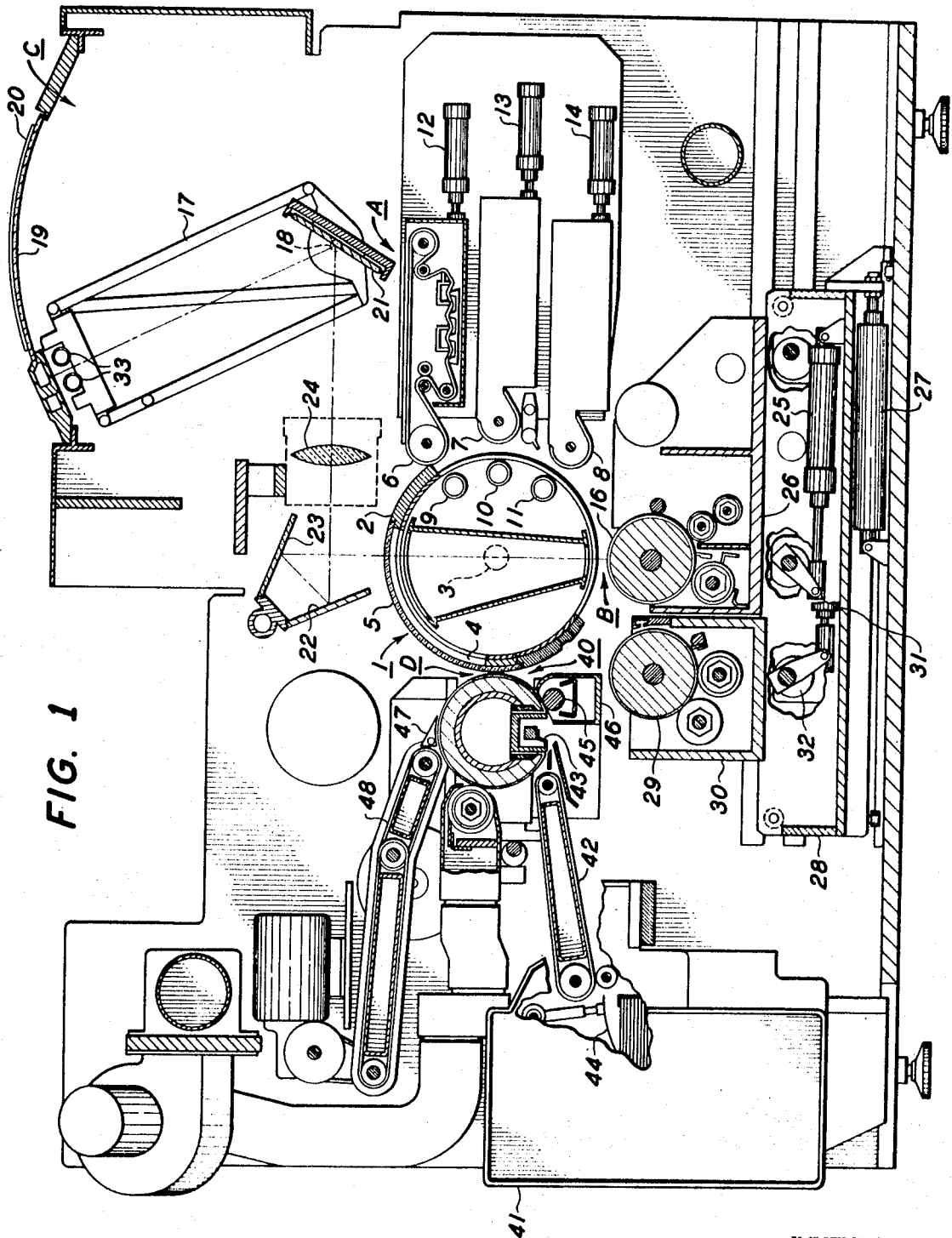
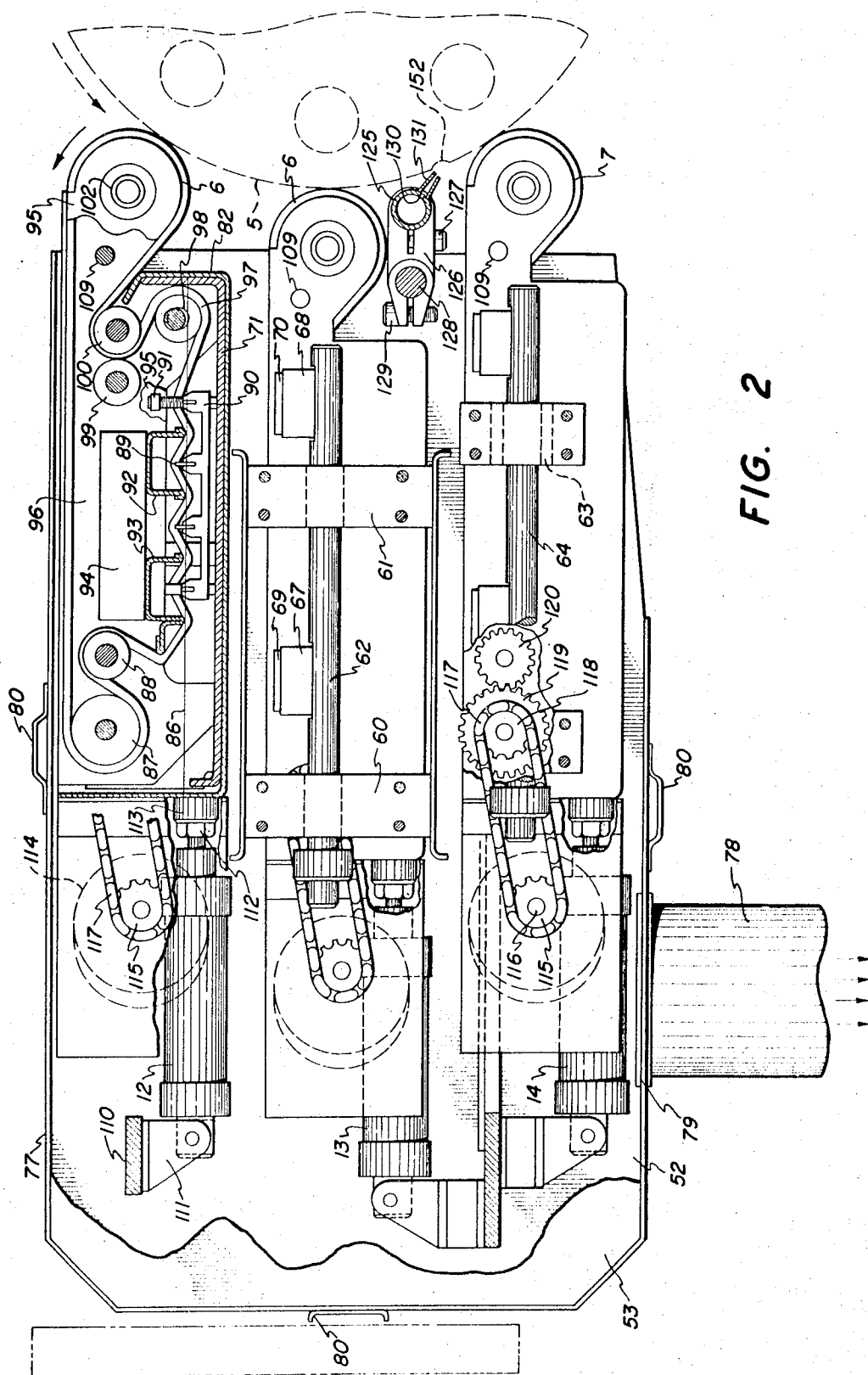
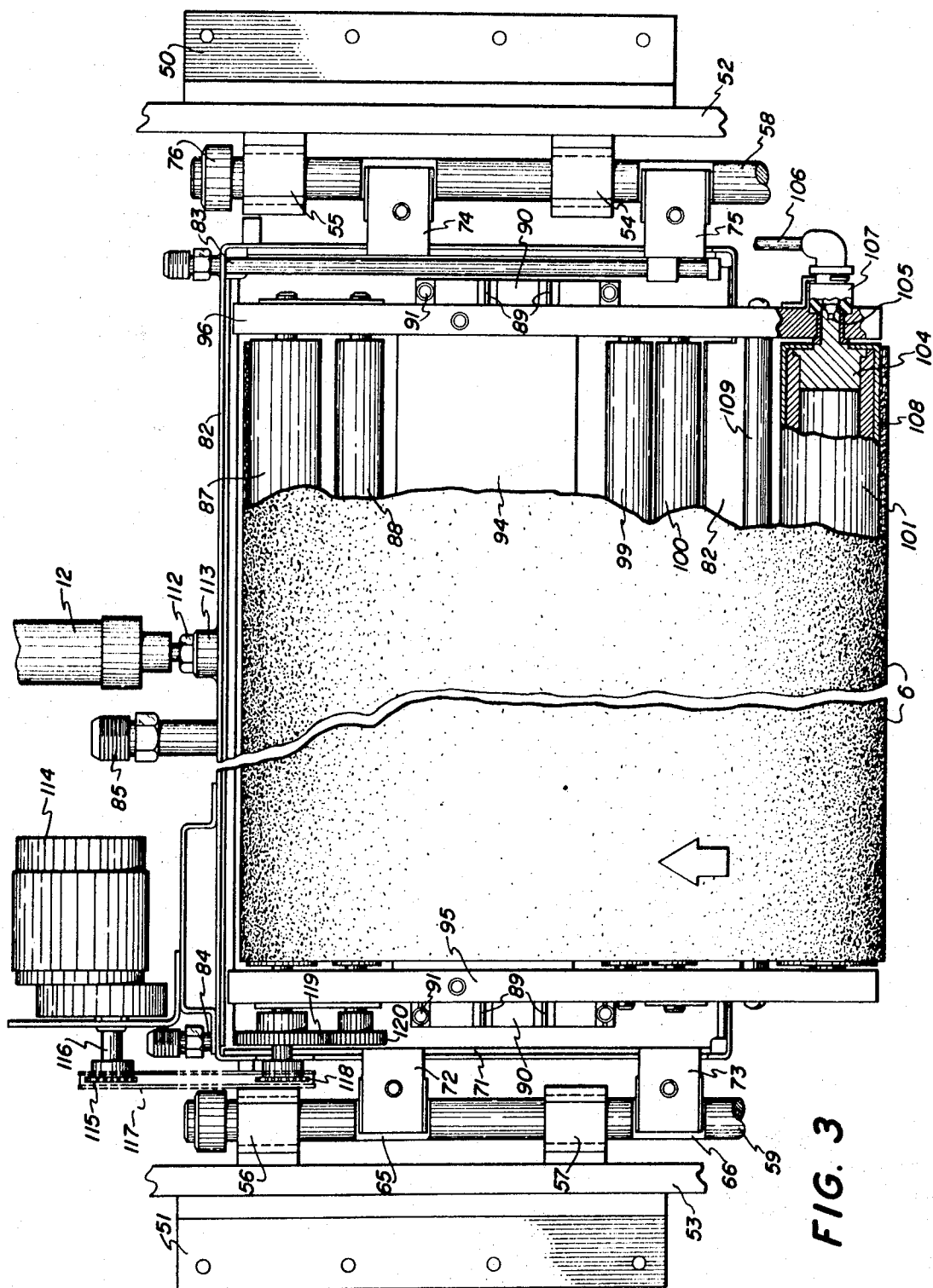


FIG. 1

INVENTOR.
RAYMOND K. EGNACZAK

BY *Barry Jay Kesselman*
ATTORNEY





CLEANING APPARATUS

This invention relates to cleaning systems and more particularly to apparatus for removing contaminants from a surface.

Recently, a new invention was disclosed for forming black and white or full color images through the use of photoelectrophoresis. The inventions described in U.S. Pat. Nos. 3,384,488; 3,384,565 and 3,383,993 all issued on May 21, 1968 disclose a system where photoelectrophoretic particles migrate in image configuration providing a visual image at one or both of two electrodes between which the particles are placed in suspension. The particles are photosensitive and apparently undergo a net change in charge polarity or a polarity alteration by interaction with one of the electrodes upon exposure to activating electromagnetic radiation. No other photosensitive elements or materials are required; hence, this provides a very simple and inexpensive imaging technique. Mixtures of two or more differently colored particles can secure various colors or images. Particles in these mixes may have overlapping or separate spectral response curves and are usable in subtractive color synthesis. The particles will migrate from one of the electrodes under the influence of an electric field when struck with energy of a wavelength within the spectral response of the colored particles.

Apparatus has been invented to better utilize the above process. U.S. Pat. No. 3,427,242 issued Feb. 11, 1969 describes a continuous apparatus embodiment of the above process. The apparatus requires that the injecting electrode surface used for supporting a transferable image be cleaned of residual pigment material remaining on its surface after the transfer to a suitable support of the major portion of the pigment forming the image that was formed on its surface.

Therefore, it is an object of this invention to improve the cleaning of surfaces. Another object of this invention is to improve the removal of electrophoretic particles from surfaces. Yet another object is to improve removal of photoelectrophoretic particles from a surface.

A further object of this invention is to improve cleaning of members of automated imaging machines. Still another object of this invention is to improve removal of photoelectrically sensitive particles from transparent members.

These and other objects are accomplished by providing one of more cleaning members for contacting the surface to be cleaned under the influence of an electric field and possibly electromagnetic radiation while moving the member through a fluid capable of dislodging material from the surface to be cleaned. The member is itself purged of contaminants by passage through cleaning and drying mechanisms acting directly on the member.

The unit is illustrated and described in a preferred environment operating in conjunction with other apparatus to automatically and continuously produce images of predetermined optical objects. Nevertheless, the invention need not be confined to such an embodiment and should be broadly construed within the limitations of the claims. It may be that other processes or apparatus will be invented having cleaning needs that can be satisfied by the apparatus described and claimed herein and it is the intention of this patent application to describe and claim an invention for use in many apparatus including some that may not yet be invented.

The invention herein is described and illustrated in a specific embodiment having specific components listed for carrying out the functions of the apparatus. Nevertheless the invention need not be thought of as being confined to such a specific showing and should be construed broadly within the scope of the claims. Any and all equivalent structures known to those skilled in the art can be substituted for specific apparatus disclosed as long as the substituted apparatus achieves a similar function. It may be that other processes or apparatus will be invented having similar needs to those fulfilled by the apparatus described and claimed herein and it is the intention herein to describe an invention for use in apparatus other than the embodiment shown.

These and other objects and advantages will become apparent to those skilled in the art after reading the following description taken in conjunction with the accompanying drawings wherein:

FIG. 1 schematically illustrates a preferred embodiment of a machine for forming photoelectrophoretic images;

FIG. 2 is a left-hand side view of the cleaning module partly sectioned with parts broken away to show hidden portions; and

FIG. 3 is a top view of the cleaning module with parts broken away.

OPERATION OF THE BASIC PHOTOELECTROPHORETIC IMAGING SYSTEM

A detailed description of the operation and theories relating to the actual imaging system automated by this invention and discussing the interaction of the photoelectrophoretic particles in the suspension used for image formation is found in the above cited patents. The imaging system therein described and which can be employed in the apparatus described herein operates by producing electromagnetic radiation in image configuration to which the individual photoelectrophoretic particles within the suspension are sensitive. The activating radiation and an electric field across the imaging suspension combine between two electrodes in the imaging area. An electrode referred to as the "transparent injecting electrode" is maintained electrically positive relative to "imaging electrodes" interfacing with it at the imaging area across the photosensitive suspension. Therefore, particles within the suspension that are negatively charged will be attracted to the relatively positive, transparent injecting electrode.

The "injecting electrode" is so named because it is thought to inject electrical charges into activated photosensitive particles during imaging. The term "photosensitive" for the purposes of this invention refers to the property of a particle which, once attracted to the injecting electrode, will alter its polarity and migrate away from the electrode under the influence of an applied electric field when exposed to activating electromagnetic radiation. The term "suspension" may be defined as a system having solid particles dispersed in a solid, liquid or gas. Nevertheless, the suspension used in the embodiment of this invention described herein is of the general type having a solid suspended in a liquid carrier. The term "imaging electrode" is used to describe that electrode which interfaces with the injecting electrode through the suspension and which once contacted by activated photosensitive particles will not inject sufficient charge into them to cause them to migrate from the imaging electrode surface. The "imaging zone" or "imaging area" is that zone between two electrodes where photoelectrophoretic imaging occurs.

The particles within the suspension are generally insulating when not struck by activating radiation within their spectral response curve. The negative particles come into contact with or are closely adjacent to the injecting electrode and remain in that position under the influence of the applied electric field until they are exposed to activating electromagnetic radiation. The particles near the surface of the injecting electrode make up the potential imaging particles for the **final image to be reproduced thereon. When activating radiation strikes the particles, it makes them conductive "creating" an electrical junction of charge carriers which may be considered mobile in nature. The negative charge carriers of the electrical junction orient themselves toward the positive injecting electrode while the positive charge carriers move toward the imaging electrode. The negative charge carriers near the particle-electrode interface at the injecting electrode can move across the short distance between the particle and the surface of the electrode leaving the particle with a net positive charge. These polarity altered, net positively charged particles are now repelled away from the positive surface of the injecting electrode and are attracted to the negative surface of the imaging electrode. Accordingly, the particles struck by activating radiation of a

wavelength with which they are sensitive, i.e., a wavelength which will cause the formation of an electrical junction within the particles, move away from the injecting electrode to the imaging electrode leaving behind only particles which are not exposed to sufficient electromagnetic radiation in their responsive range to undergo this change.

Consequently, if all the particles in the system are sensitive to one wavelength of light or another and the system is exposed to an image with that wavelength of light, a positive image will be formed on the surface of the injecting electrode by the subtraction of bound particles from its surface leaving behind particles in the unexposed areas only. The polarities on the system can be reversed and imaging will occur. The system may be operated with dispersions of particles which initially take on a net positive charge or a net negative charge.

The imaging suspension may contain one, two, three or more different particles of various colors having various ranges of spectral response. In a monochromatic system the particles included in the suspension may be of any color and produce any color and the particle spectral response is relatively immaterial as long as there is a response in some region of the spectrum which can be matched by a convenient radiation exposure source. In polychromatic systems the particles may be selected so that particles of different colors respond to different wavelengths.

For photoelectrophoretic imaging to occur, these steps (not necessarily listed in the sequence that they occur) take place: (1) migration of the particles toward the injecting electrode due to the influence of the field, (2) the generation of charge carriers within the particles when struck with activating radiation, (3) particle deposition on or near the injecting electrode surface, (4) phenomena associated with the forming of an electrical junction between the particles and the injecting electrode, (5) particle charge exchange with the injecting electrode, (6) electrophoretic migration toward the imaging electrode, and (7) particle deposition on the imaging electrode. This leaves a positive image on the injecting electrode.

After the image is formed on the injecting electrode, the electrode may be brought into interface with a transfer member which has a charge polarity opposite to that of the imaging electrode. The injecting electrode is now maintained negative relative to the transfer member. The particles having a net negative charge will be attracted to the relatively positive transfer member. If a support material is interposed between the transfer member and the particle image, the particles will be attracted to the support material. Therefore, a photographically positive image can be formed on any support material.

The Machine Components

Referring now to FIG. 1, a preferred embodiment for an automated machine to produce images according to the aforementioned process is shown. An injecting electrode 1 forms a portion of a transparent cylinder member held in a housing 2 and is journaled for rotation in the direction indicated by the arrow about a shaft 3. The injecting electrode 1 is made up of a layer of optically transparent glass 4 overcoated with a thin optically transparent layer 5 of tin oxide or other electrically conducting material. A particular material suitable for this electrode is available under the name of NESA glass manufactured by Pittsburgh Plate Glass Company, Pittsburgh, Pa. The injecting electrode 1 is formed as a portion of a cylinder housed within the metal housing frame 2.

The machine shown schematically in FIG. 1 is positioned where the injecting electrode cylinder portion is about to be rotated in a predetermined path to a cleaning station labeled A whereat a plurality of cleaning members such as belts 6, 7 and 8 contact the conductive surface 5 of the injecting electrode. On the opposite side of the injecting electrode held stationary within the machine frame are lamps 9, 10 and 11 juxtaposed to the belts 6, 7 and 8 respectively. When activated, the lamps send flood light illumination through the trans-

parent injecting electrode at the contact areas between the electrode and the cleaning belts. Each of the belts are activated by one of the cylinders 12, 13 and 14 to contact the injecting electrode 1. These cylinders operate to press the belts against the conductive surface of the injecting electrode in order to clean it.

The next station in the path of movement of the injecting electrode is the imaging station B. Here, on the first pass of the injecting electrode 1 through station B the first imaging member, the imaging electrode 16 interfaces with the conductive surface 5 of the injecting electrode 1.

The optical system at station C projects an image to the imaging zone between the electrodes 1 and 16 at station B. The optical system has a lamp carriage 17 journaled at an axis 18 to oscillate in a path indicated by the arrows. A document 20 is positioned at the platen 19. The lamps are shown at the start of scan position and as the injecting electrode 1 passes through the imaging area at station B the lamps move across the platen 19 projecting an image at station B through suitable mirrors 21-23, a lens 24 and the transparent electrode 1.

The imaging electrode roller 16 moves in rolling interface relation with the conductive surface 5 of the injecting electrode 1 and functions both to supply suspension to the injecting electrode and to image that suspension between the injecting electrode surface 5 and the surface of the electrode 16.

The injecting electrode continues to rotate at a constant velocity through a complete rotation of the predetermined path. It travels without interacting with any elements located around the periphery of the path until it again reaches station B at the imaging zone. Now, however, the injecting electrode 16 has been moved out of its interfacing position by operation of a cylinder 25 which lowers the electrode 16 and the housing 26 supporting it. Further, a cylinder 27 moves a carriage 28 along a horizontal path carrying with it the housing 26 which supports the imaging electrode 16. Also moved in the carriage 28 is a second imaging member, the imaging electrode 29 within a housing 30 maintaining it. A cylinder 31 operates through an eccentric 32 to raise the housing 30 and the second imaging electrode 29 at the imaging zone at the imaging station B of the machine. The second imaging electrode 29 moves in rolling interface with the injecting electrode surface 5 as that surface passes through the imaging station B. At this time the original 20 on the platen 19 is again illuminated by the scanning lamps 33 at the optical system station C. The scan is synchronized with the movement of the injecting electrode to project a flowing image in registration with the first projection and moving at the same rate as is the surface 5 at the imaging zone.

The injecting electrode 1 then passes into the transfer station D. At station D is a transfer roller 40. A sheet of support material held in the supply tray 41 is lifted therefrom and is carried through a vacuum transport 42 to the transfer roller 40. It is gripped by a gripper mechanism 43 on the transfer roller 40 and rotated to the injecting electrode 1 passing at station D. Before the sheet 44 contacts the surface 5 of the injecting electrode 1 it is moistened with a liquid that will aid in transferring the particles of the suspension on the surface 5. The wetting is accomplished by a wetting bar 45 rotated in a pool of suitable wetting material held within a tank 46. The transfer member 40 rotates the support material 44 in rolling contact with the surface 5 of the injecting electrode 1 under the influence of a suitable electric field causing the particles forming the image on the injecting electrode to be transferred to the support material. The support material is removed from the transfer member by picker fingers 47 and a release mechanism on the grippers. Next it is carried on a vacuum transport 48 to a suitable receptacle.

Injecting Electrode Cleaning Mechanism

At the start of the imaging cycle, the injecting electrode 1 moves past the cleaning mechanism at station A in FIG. 1. There are three individual cleaning belts, 6, 7 and 8, in-

dividually housed and individually adjustable to contact the surface 5 of the injecting electrode 1 by action of the hydraulic cylinders 12, 13 and 14 respectively. The cylinder, of course, can be pneumatic or hydraulic or other substitute means such as cams, solenoids, or mechanical linkage or the like could be used to shuttle the cleaning members into contact with the injecting electrode surface 5.

The cleaning mechanism is a modular unit that mounts onto the main frames of the machine via brackets 50 and 51. These brackets attach respectively to the main modular side plates 52 and 53 which support the entire mechanism including the three separate cleaning belts and their supporting equipment. Fastened to the side plates for each belt assembly are four Oilite bushings, for example the bushings 54-57. Each set of two bushings maintains a slide rod such as rods 58 and 59 of the topmost belt assembly. Identical systems are maintained for each of the other cleaning belt assemblies. For example, in FIG. 21, bushings 60 and 61 are shown on a second belt assembly for supporting the slide rod 62 while bushing 63 is shown supporting the slide rod 64 on the bottommost cleaning belt structure. Each of the slide rods have two flat portions thereon such as portion 65 and 66 of the slide rod 59. Onto the flats on each of the slide rods are fastened spacers such as 67 and 68 shown on the flats of slide rod 62.

Flanged portions 69 and 70 are mounted on these spacers. The support member 71 is stamped or otherwise formed to have four flanges 72 through 75 for connection to the slide rods. On each of the slide rods is a collar such as collar 76 on slide rod 58. The collar acts as a positive stop against one of the bushings 55 and is preset to move the belt assembly which it supports into proper pressure contact with the injecting electrode surface 5 during cleaning thereof. The entire cleaning module including the plurality of belt assemblies is maintained within a shroud 77. This aids in the removal of vapors, should any be present, through a vapor removal hose 78 entering the shroud through an opening 79 specifically adapted for that purpose. The shroud is formed of thin metal and to add stiffness to it and to prevent its buckling, stiffeners 80 are spot welded or otherwise formed on the shroud.

Reference to only one of the cleaning belt assemblies will be made to describe the cleaning system. All of the belt assemblies are structured and operated in the same basic manner. Each belt cleaning member has a fluid holding tray such as tray 82. The tray is given stiffness and support by a metal stamped support member 71. Liquid is brought into the tray through an inlet pipe 83 and is removed from the tray by an outlet pipe 84 where the contaminated liquid is circulated through a filter such as that described in copending application Ser. No. 806,637 filed on Mar. 12, 1969 in the name of Terence Davies and entitled "Electrostatic Pigment Filter." An overflow port 85 is provided to ensure that any excess liquid accumulated within the tray 82 is removed without spilling over the edges thereof. Suitable fittings are provided on each of these pipes to connect with hosing for pumping the liquid through the tray 82 and the filter.

The belt 6 runs through the fluid 86 in the bottom of the tray picking it up for contact with the injecting electrode surface 5 as it passes and skids against that surface. The liquid level is indicated by the reference numeral 86. The belt can be formed of any generally known cleaning material such as a tufted cotton fabric, felt or bush-like material of any other material that will function to help clean the surface of the injecting electrode. The belt is wrapped around a pair of driving rollers 87 and 88 which, by friction, pull the belt in the direction shown. The belt is cleaned of contaminating material picked up from the injecting electrode by passage over a series of scraper blades such as the blade 89 made of nylon, rubber or any material that will be unaffected by the pigment particles or the cleaning fluids used in the process. The blades are maintained in an aluminum extrusion 90 which, with the blades, is leveled by four leveling screws such as screw 91. The proper tension for the belt passing over the blades held within the extrusion is maintained by belt shaping members 92 and

93 held on a phenolic block support 94. The support 94 extends across the belt member from the frame 95 to the frame 96 both of which support all of the rollers and drive mechanism for the belt. The shaping members can be metal stampings, plastic moldings or any material stiff enough to form a belt path tight against the scraper blades.

The belt is further wrapped around an idler roller 97 mounted eccentrically on shaft 98. It is through this roller that belt tracking is maintained by shifting ends of the roller on the eccentric shaft. A wringer assembly composed of rollers 99 and 100 pinch and squeeze the belt as it passes therebetween in order to wring out the excess cleaning fluid that may have been absorbed by the belt material. The belt rolls over the pressure roller 101 which maintains the belt against the injecting electrode surface 5 when the cleaning assembly is in contact therewith. The roller is support by the frames 95 and 96 through bearing 102.

The end cap 104 of the pressure roller 101 is metallic and is contacted by a contact brush 105 capable of presenting an electrical bias of between 0-10 KV across the suspension residue to the end cap and therethrough to the metallic pressure roller 101. The metal roller is covered with a sleeve 108 of urethane rubber which gives good pressure qualities during cleaning. The electrical potential is supplied through an electrical source. The electrical housing 107 is suitably fastened to the frame 96 of the cleaning assembly. The entire cleaning assembly is securely braced by the frames 95 and 96 and the various rollers plus a supporting tie bar 109.

Each of the cleaning assemblies is moved into contact at a predetermined time in the machine operation cycle. The three stations are moved in simultaneously with each other by the operation of the cylinders 12-14 operating on each of the cleaning assemblies. The cylinder 12 is fastened to the frame structure of the cleaning assembly module A by a tie plate 110 and is attached through a clevis mount 111 thereto. The piston of the cylinder is attached to the cleaning assembly tray 82 through a lock nut 112 and a second nut 113 which is spot welded to the tank 82. When actuated, the cylinder pushes the tray toward the drum until the collar stop 76 strikes the bushing 75 positively stopping the movement of the cleaning assembly against the drum at a predetermined interference position.

Each of the belts of the cleaning assemblies are driven by individual motors such as motor 114. The motors move the belts in the direction indicated via a sprocket 115 attached to the shaft 116 of the motor driving it. The power is transmitted through a chain drive 117 to the driven sprocket 118 and then to the gearing 119 and 120 attached to the shafts of the driving member rollers comparable to rollers 87 and 88.

Operating as part of the drum cleaning module is a puffer tube 125 which extends across the length of the module and the drum between the second and third cleaning assemblies along the direction of movement of the drum. The puffer tube is held by a puffer mount 126 and securely fastened to the mount by a clamping screw 127. The mount is held on a tie rod 128 by a clamping screw 129 ensuring non-slip attachment between the mount and the tie rod. The puffer tube 125 has a slot 130 across the length thereof and a nozzle 131 welded across the slot 130. The puffer is aimed in a predetermined direction to affect the removal of residual particles and cleaning fluid from the injecting electrode drum housing at a notch 152 specially designed to cooperate with the puffer tube for removal of accumulated materials. The removal is affected by the venturi tube principle by blowing against the entrance to the nip of the notch and thereby puffing all of the fluid out of the notch where it is contacted by the last cleaning belt assembly for removal from the area.

The lamps 9-11 aid in the electrophoretic cleaning process because the particles are photosensitive. When struck by the broad spectral output of the lamps under the influence of the grounded injecting electrode and the negatively charged pressure roller 101 behind the cleaning belt, the particles migrate photoelectrophoretically from the injecting electrode to the cleaning belt.

Although a specific preferred embodiment of the invention and its environment are shown, the scope of the invention should not be assumed to be limited by illustration. By way of example only, although cylinders are illustrated as moving the cleaning belt, electrical or mechanical means such as solenoids or cams could also serve the equivalent function. Although a continuous belt is shown for contacting the contaminated surface, other shapes of types of members could serve the same function and fall within the inventive scope of the appended claims. Likewise, other environments different from the one illustrated could be used to accommodate the invention and be improved by the invention.

While this invention has been described with reference to the structures disclosed herein and while certain theories have been expressed to explain the experimentally obtainable results obtained, it is not confined to the details set forth; and this application is intended to cover such modifications or changes as may come within the purposes of the improvements or the scope of the following claims.

What is claimed is:

1. Apparatus for cleaning a contaminatable surface of a movable part of a machine including
 - a. a surface contacting member;
 - b. a frame for holding said member;
 - c. means to move said member into contact with the said surface attached to said frame;
 - d. deformable cylindrical roller means backing said member for supporting said member against the surface;
 - e. means for applying cleaning fluids to said member;
 - f. means to remove contaminants from said member;
 - g. means to drive said member in slipping relative movement about an axis parallel to the movement of the surface.
2. Apparatus for cleaning a surface including
 - a surface contacting member;
 - a frame for holding said member;
 - means to move said member into contact with the said surface attached to said frame;
 - means backing said member for supporting said member against the surface;
 - means for applying cleaning fluids to said member;
 - means to remove contaminants from said member;
 - means to drive said member in slipping relative movement with the surface, and
 - means for coupling the backing means of said member to an electrical source.

3. The apparatus of claim 2 further including
 - a housing for maintaining a plurality of frames and members and including a plurality of members for contacting the surface.
4. The apparatus of claim 2 including a light source opposite said member at the contact position with said surface and adapted for lighting during cleaning by said member.
5. The apparatus of claim 1 further including puffer means directed toward the surface.
6. The apparatus of claim 5 wherein said puffer means includes a tube and having a slot therein,
 - a gas coupling means for bringing gases into said tube; and
 - a nozzle attached to said tube at the slot therein for guiding the gases exiting from said tube toward the surface.
7. The apparatus of claim 2 wherein said member is cylindrical in shape.
8. The apparatus of claim 2 wherein said member comprises a continuous belt.
9. The apparatus of claim 2 wherein said means to move said member into contact with said surface includes a fluid driven means.
10. The apparatus of claim 2 wherein said backing means includes an electrically conductive rubber roller.
11. The apparatus of claim 1 wherein said means for applying fluids include a sump portion within said frame such that said member is positioned for contact therewith.
12. The apparatus of claim 2 wherein said means to remove deposits includes
 - pinch roller means for contacting said member at said means backing said member and for squeezing portions of said member passing between portions of said pinch roller means.
13. The apparatus of claim 8 wherein said means to remove deposits from said member includes
 - belt shapers for contacting the side of said belt opposite the side for contacting the surface,
 - blades spaced on the opposite side of the belt between shapers for removing contaminants from the contact side of the belt.
14. The apparatus of claim 13 further including
 - leveling means for aligning said blades with said shapers for a predetermined interference with said belt.
15. The apparatus of claim 5 including a notch in the surface to be cleaned, said notch capable of being positioned opposite said puffer means in operative association therewith.

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