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Jordan et al.

[11] **3,907,421**

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[54] **TRANSFER APPARATUS FOR ELECTROSTATIC REPRODUCING MACHINES**

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

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[21] Appl. No.: **444,996**

[52] **U.S. Cl.** ..... **355/3 R**

[51] **Int. Cl.²** **G03G 15/16**

[58] **Field of Search** 355/3, 15

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Primary Examiner—John M. Horan

[57] **ABSTRACT**

In an electrostatic reproducing machine, a latent electrostatic image is formed and developed on a photoreceptor belt and transferred to a copy sheet at a transfer station where a transfer roller is mounted to be in contact with the photoreceptor belt. Suitable means are provided for engaging the transfer roller into a position to be in contact with said photoreceptor belt when the machine is in operation and disengaging the transfer roller and moving it away from the photoreceptor belt so that the transfer roller does not touch the photoreceptor belt when the machine is not in operation. A brush roller may be provided for removing the residual toner particles remaining on the transfer roller and means may be provided for vacuuming the transfer roller and vicinity.

10 Claims, 7 Drawing Figures

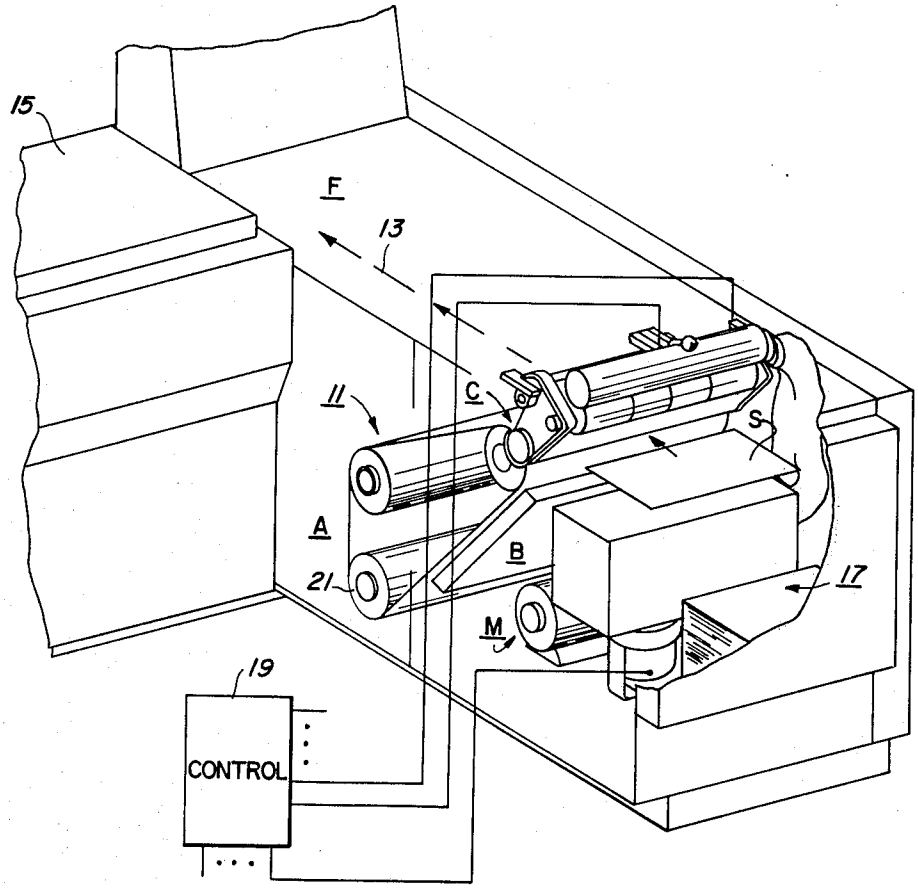


FIG. 1

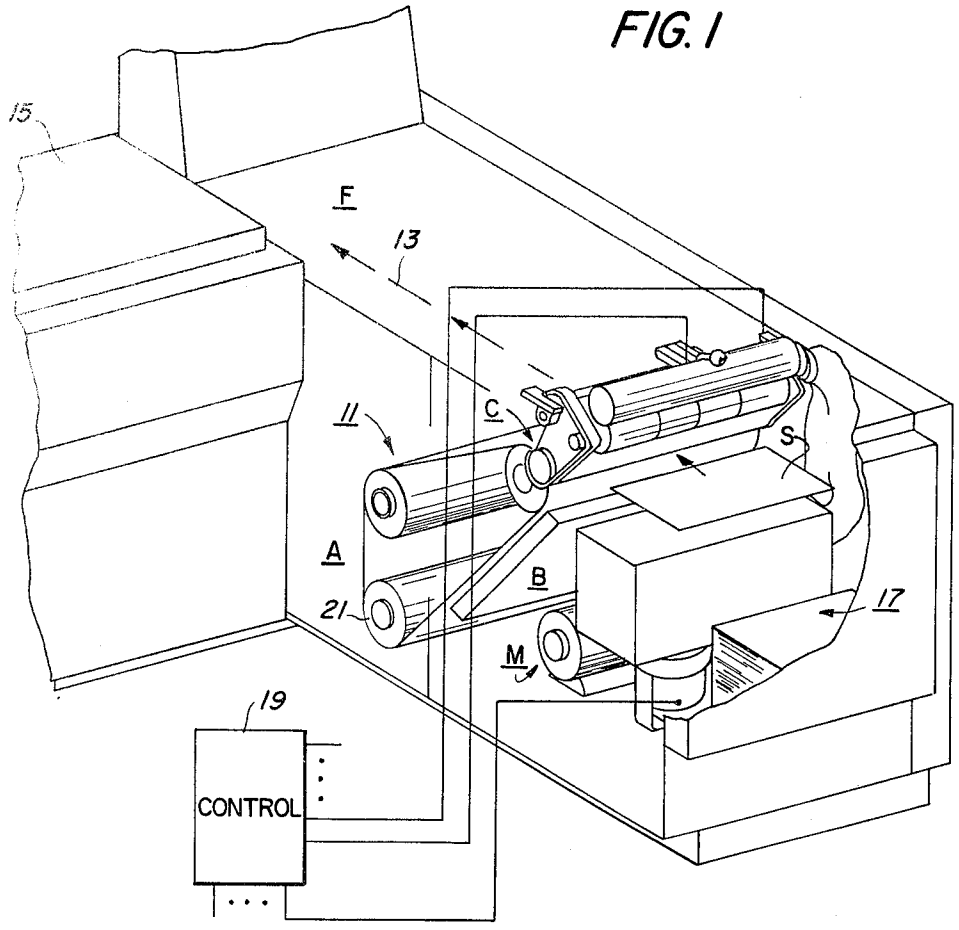

15
F
13
11
C
S
A
B
21
17
M
19
CONTROL

FIG. 2

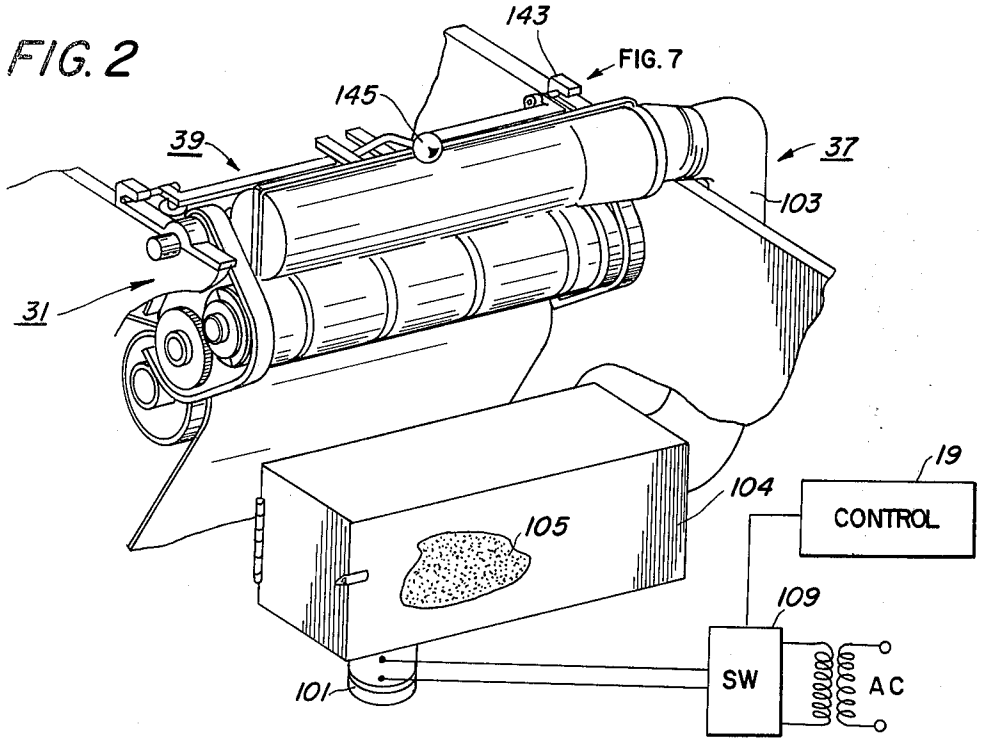

143
FIG. 7
145
39
37
103
31
104
19
CONTROL
105
109
SW
AC
101

FIG. 3

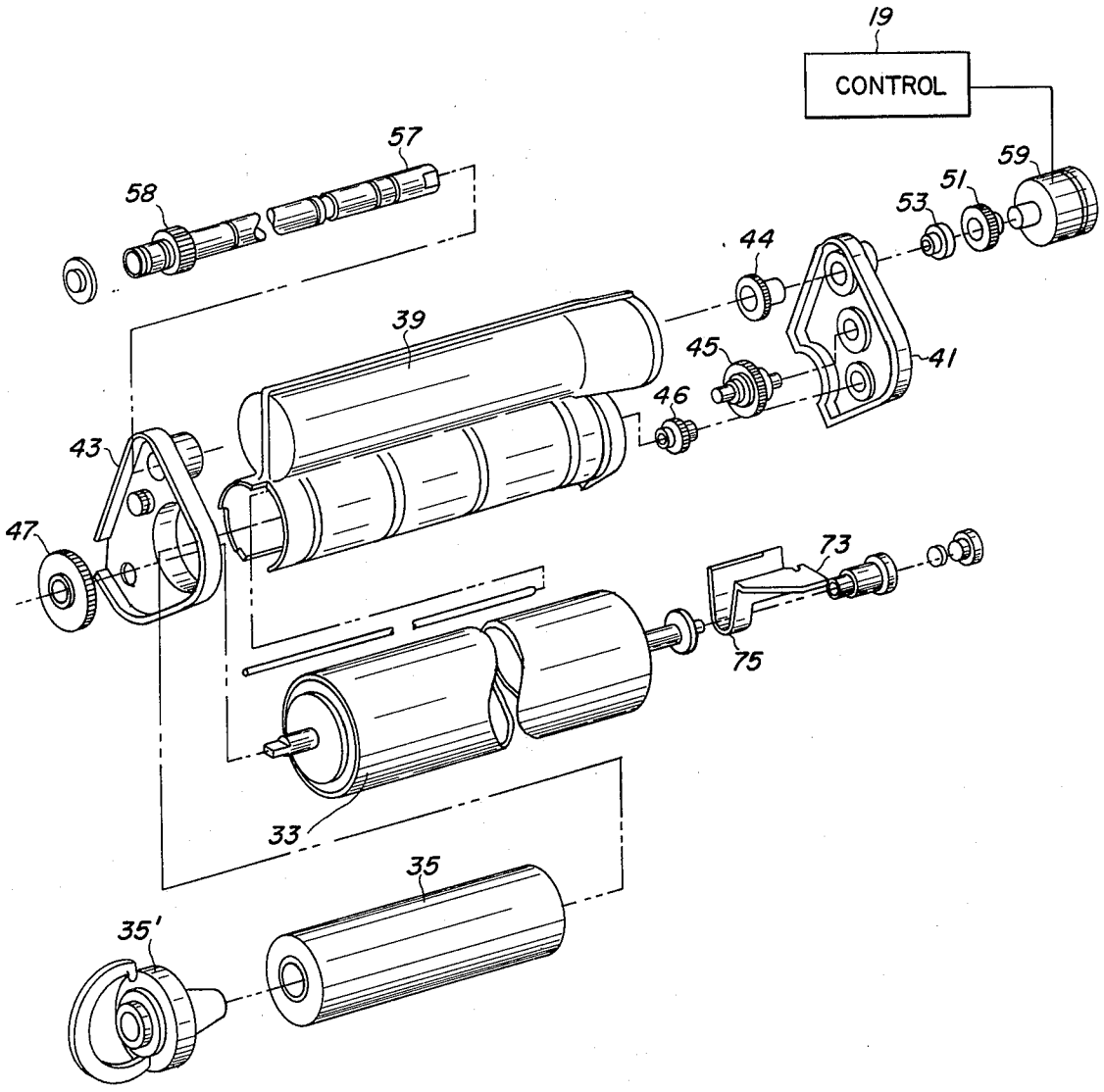


FIG. 4

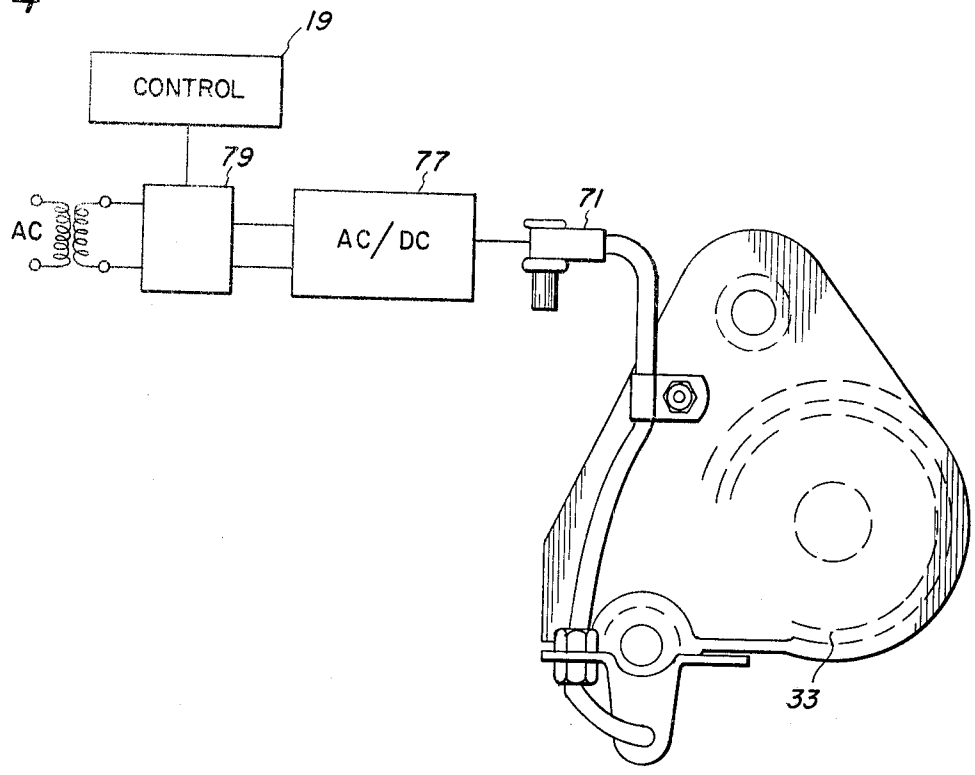


FIG. 7

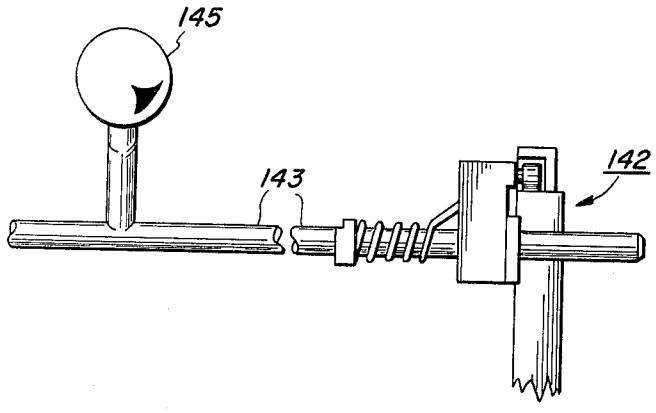
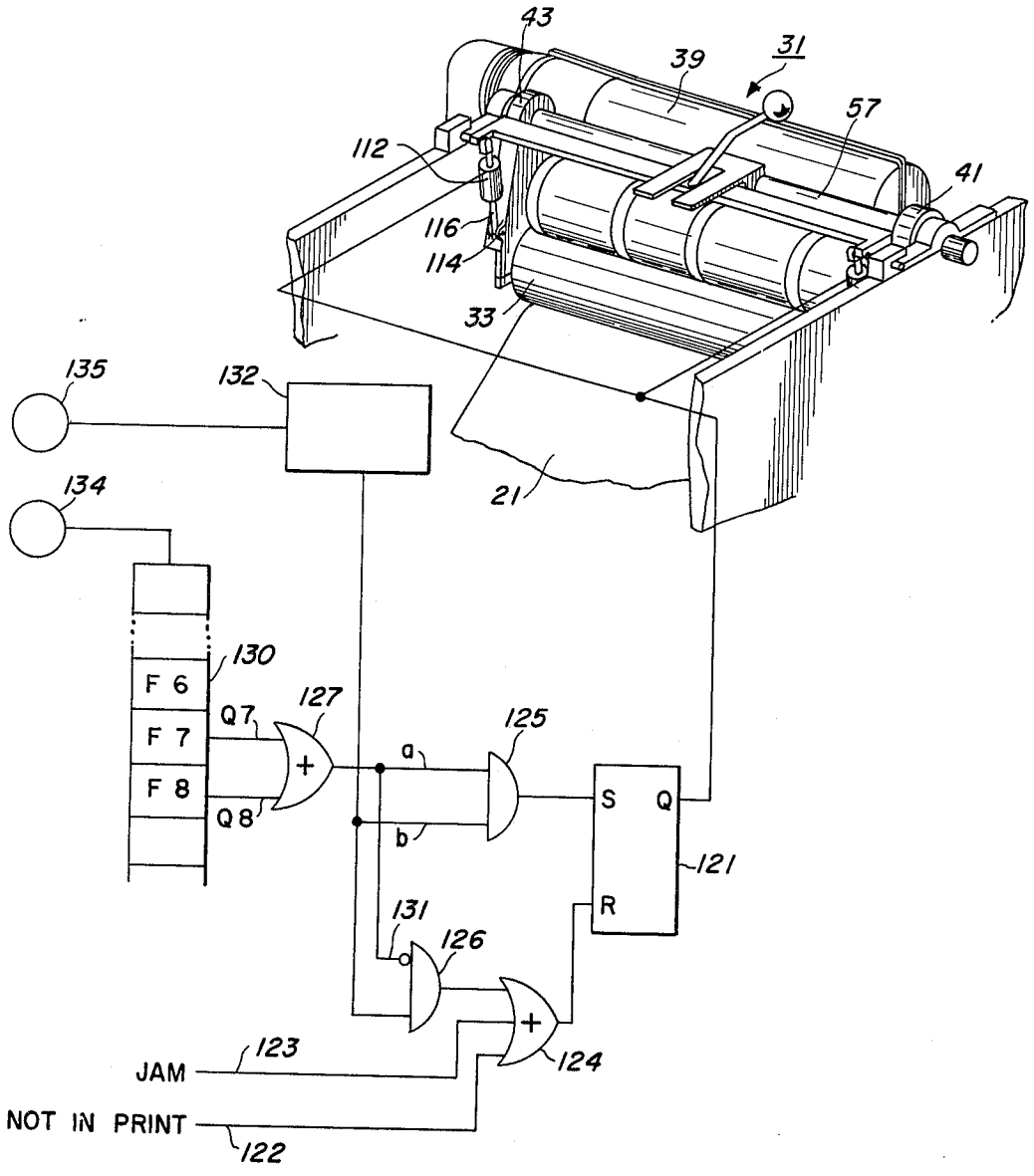


FIG. 5


43
39
31
57
41
112
116
114
33
135
132
134
21
130
F 6
F 7
F 8
Q7
Q8
127
125
a
b
S
Q
R
121
131
126
124
JAM
123
NOT IN PRINT
122

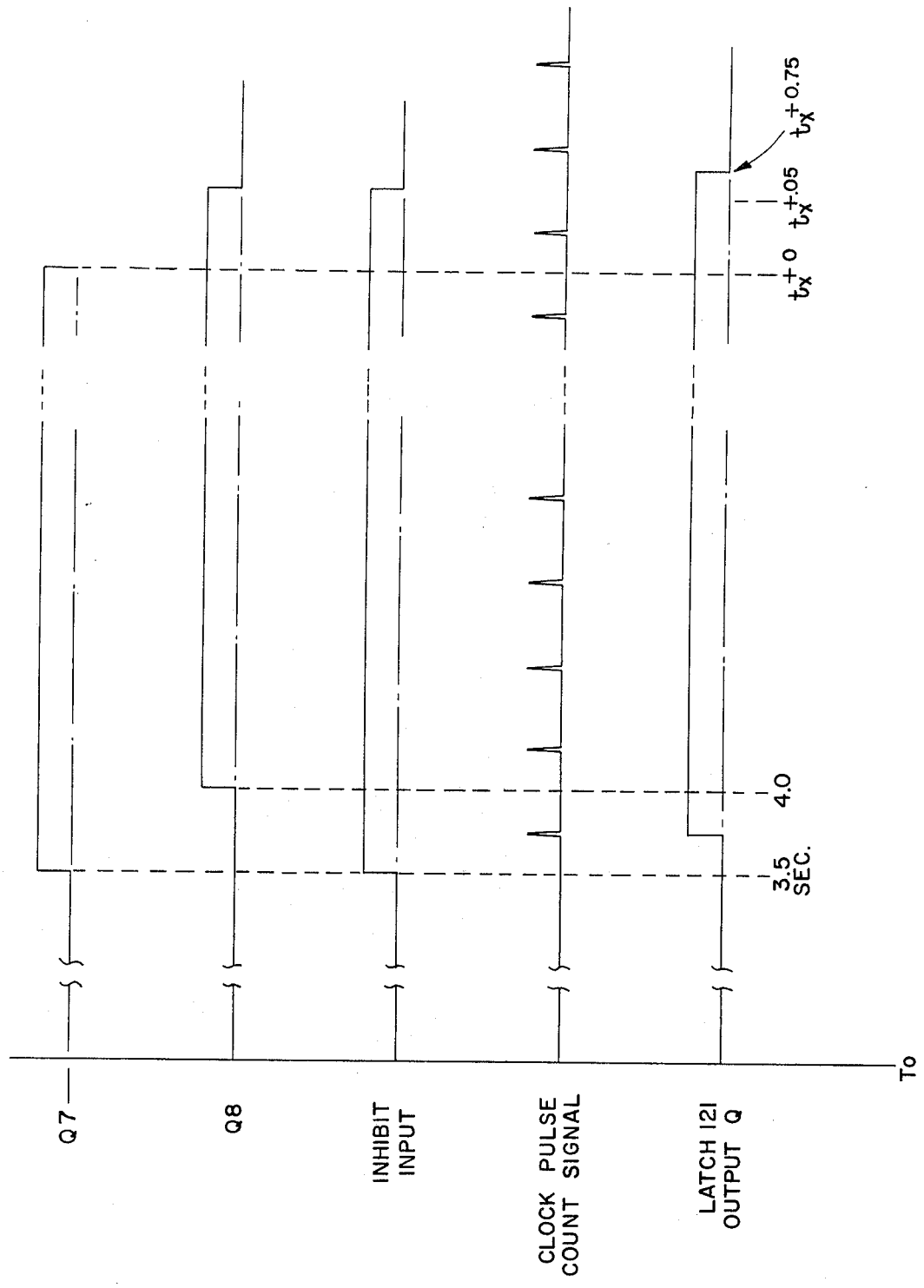

Q7
Q8
INHIBIT INPUT
CLOCK PULSE COUNT SIGNAL
LATCH 121 OUTPUT Q
To
3.5 SEC.
4.0
t_x+0
$t_x+.05$
$t_x+0.75$

FIG. 6

TRANSFER APPARATUS FOR ELECTROSTATIC REPRODUCING MACHINES

This invention relates to a reproducing machine and, more particularly, to an improved apparatus for transferring an electrostatic image formed on a photoreceptor belt of electrostatic reproducing machines to a copy sheet.

Ever increasing demands for high quality, reliability and speed of copier/duplicator machines in recent years have placed a great challenge to improve overall and various subsidiary aspects of the reproducing machines. Of the different types of reproducing machines, the electrostatic or, more commonly known as xerographic copier/duplicator machines evolved from the basic discovery of xerography by Chester F. Carlson have met this difficult challenge quite successfully. More recently there has evolved high speed copier/duplicator machines utilizing xerographic technology that are designed to operate just about twice as fast as the fastest machines known heretofore. In increasing the speed of the machines, many of their subfeatures had to be redesigned and improved. Such a high speed machine may comprise a photoreceptor belt on which latent electrostatic images are formed, developed, transferred to copy sheets and then in succession.

Heretofore, in such machines, generally, the transfer roller is positioned so that its peripheral surface is held in contact with the photoreceptor surface and left in that position. The drive means such as a motor used to drive the photoreceptor belt was driven at a speed such that peripheral surface of the transfer roller moved at the same speed as the photoreceptor belt.

It is an object of the present invention to improve the high speed electrostatic copier/duplicator machines in general and, more particularly, to provide an improved image transfer apparatus.

Another object of the present invention is to provide an improved transfer apparatus for the copy quality of the copies made by the copier/duplicator machines.

The aforementioned and other objects of the present invention is obtained, according to the present invention, by providing suitable means for engaging the transfer roller into contact with the photoreceptor surface only when the machine is in operation and disengaging the transfer roller when the machine is not in operation.

It is another feature of the present invention to provide cleaning means for cleaning the transfer roller to remove any residual toners or image forming particles remaining on the transfer roller after the image transfer to the copy sheet takes place.

It is further feature of the present invention to provide suitable cleaning means, such as vacuuming means, for removing any residual toner particles remaining on the transfer roller and vicinity thereof to maintain high copy quality of the copy sheets.

The foregoing and other objects and features of the present invention will become clearer from the detailed description of illustrative embodiments in conjunction with the accompanying drawings, in which:

FIG. 1 shows a perspective schematic view of a portion of a high-speed electrostatic machine in the transfer apparatus according to the present invention may be incorporated;

FIG. 2 shows an enlarged perspective view of the transfer apparatus shown in FIG. 1;

FIG. 3 shows an exploded view of the transfer apparatus shown in FIG. 2 to show various component parts of the apparatus more clearly;

FIG. 4 shows the means for connecting an electrical bias voltage to the transfer roller;

FIG. 5 shows a schematic drawing including control means for engaging and disengaging the transfer roller into and away from the photoreceptor surface; and

FIG. 6 shows timing diagram helpful to explain the timed operation of the control means shown in FIG. 5.

FIG. 7 shows a manually operable arrangement for lifting the transfer apparatus to make room to clear transfer contact area.

DETAILED DESCRIPTION

High speed copier/duplicator machines of the type based on electrostatographic principles and more particularly on the xerographic principle will now be briefly described to set forth the environment in which the improved transfer apparatus of the present invention may be utilized. Referring to FIG. 1, an electrostatographic high speed copier/duplicator machine comprises a xerographic image forming area 11, a paper path 13, image creating station 15, paper sheet feeding station 17, and a suitable control means 19 for controlling the operation of the machine process stations.

Typically, the image creating station 15 receives a document original to be copied and the document original is flashed to form a latent electrostatic image on a moving photoreceptor belt 21 at the imaging station A. The belt 21 has a photosensitive surface where the latent electrostatic image of the document original is formed. There is provided a suitable machine drive means or a motor M which drives the photoconductor belt 21 in a given direction, e. g. at a constant speed during the copying operation. As the belt passes a developing station B the latent electrostatic image is developed with triboelectrically charged toner particles. As the belt is driven further, the image made of the charged toner particles is brought to a transfer station C where it is transferred to a copy sheet S.

The copy sheet S which has the image on its bottom is then advanced forward along the paper path 13 (FIG. 1) to a fusing station F where the image is fused on the sheet for permanent retention. Subsequently it is advanced toward a collection means where the successive copy sheets are stacked or collated. In the meantime, the photoreceptor belt continues to travel and is cleaned and uniformly charged again and then exposed again to form a subsequent latent electrostatic image for a succeeding copy.

A suitable means 19 is typically provided for providing control signals to run the machine. Generally the control means is designed to enable the operator to program the machine to copy the number of copies she desires to make of the originals, start drive means, energize various auxiliary means such as vacuum means and heater for the fuser etc., so that the machine is ready to operate and then run it automatically to run off the copies. For a detailed description of such a machine written from the systems control point of view, one may refer to U.S. application, Ser. No. 445,014, filed Feb. 22, 1974, concurrently with the present application and assigned to the same assignee.

Now generally referring to FIG. 2, at the transfer station 31, generally a transfer roller 33 (of FIG. 3) is used in transferring the image formed of the toner particles

on the photoconductor belt to the copy sheet. As it is well known, the roller is generally biased by a DC voltage of a suitable amplitude, for example 2000 – 3000 volts, so that the toner particles charged in one polarity at the developing station B are now subjected to the attracting force of the electric field created by the oppositely charged biased roller. Consequently, the toner particles are attracted toward the transfer roller as they pass by the roller. By feeding a copy sheet such as a plain paper through the nip between the transfer roller and the belt the image formed of the toner particles is electrostatically attracted and transferred to the copy sheet. The copy sheet is then advanced forward by a suitable vacuum transport means (not shown) to the fusing station F.

Heretofore, generally the transfer apparatus was made of a simple transfer roller which was held at a stationary position in contact with the photoreceptor belt and was usually left in that position on a permanent basis. The applicants have found that when left in contact any extended period of time, for example, overnight the roller seemed to have deleterious effect upon the quality of the photoreceptor belt. It seems that the portion of the belt where the roller is left in contact tends to deform or dent the flat photoreceptor surface. Apparently, a form of cold flow takes place; that is, a constituent element such as selenium that makes up the belt, tends to flow or migrate in the portion of the receptor subjected to pressure for an extended period of time. Also the pressure roller tends to leave a dent in the photoreceptor belt when it is left for any stretch of time under pressure. The resulting deformation seems to cause inconsistency and non-uniformity to the toner images formed in the affected area, thereby making the resulting copies to have poor and non-uniform quality.

To resolve the aforementioned shortcomings, applicants have devised an improved transfer apparatus having a transfer roller that is engaged or cammed into the photo-receptor belt to form an effective contact therewith only when the machine is actually in operation to make the copies and disengaged or decammed away from the belt when the machine is not in operation so that the roller does not apply any pressure to the belt when the machine is not in operation.

Now more specifically referring to FIGS. **2** and **3**, transfer apparatus **31**, according to the present invention, includes a transfer roller **33**, a cleaning brush roller **35**, and vacuum means **37**. These elements are housed within a suitable housing means **39** and are operatively interconnected by suitable means. Worn out or dirty brush roller **35** may be replaced with clean roller by using any suitable mounting means **35'** as illustrated.

Thus, as shown in FIG. **3**, the apparatus includes suitable mounting means including a rear **41** and a front frame **43**, a drive shaft **57** mounted rotatably on the front and rear frames, gear members **44–47** and **58** for coupling the transfer and brush rollers to the drive shaft. Hence, when driven by a suitable means, for example, a motor M, the drive shaft drives the transfer roller and the brush roller. This enables the brush roller to clean or brush away any residual toner particles that may remain on the surface of the transfer roller subsequent to image transfer operation. The motor itself is energized by the control means when the machine enters into copy mode, i. e. it starts to make copies.

As illustrated schematically in FIGS. **3** and **4**, there is provided suitable means for electrically biasing the transfer roller **33** in a given polarity. As is generally known, such bias potential is maintained at a high DC electrostatic potential. A suitable high voltage lead **71** is used to apply the potential from a high voltage source **77** to the transfer roller **33** via a suitable coupling members **73** including busing member **75.** The high voltage DC comes from an AC line power supply which is converted into a high voltage DC by a suitable conventional AC to DC conversion means **77.** The control means **19** provides a suitable control signal to a switch **79** interposed between the line AC live power source and the AC to DC converting means **77.** The control means **19** provides a timed switching signal to the switch **79** to turn on and apply the high DC voltage to the transfer roller only when the machine operates to make the copy. For the switch **79,** any suitable conventional means, such as light emitting diode and photo-darlington arrangement that provides photo-optical isolation and detection may be used to minimize static and provide better isolation.

Referring to FIG. **2,** the vacuum means includes a blower motor **101** for applying a vacuum to the transfer roller, cleaning roller and areas that are enclosed within the housing member **39.** The cleaning arrangement includes a duct **103** linked to a housing assembly **104** for retaining a filter bag **105.** The blower motor **101** is driven by the AC line power. Any suitable AC switch **109** interposed between the line power and the motor **101** may be used to operate the blower and the vacuuming operation under the command of the control means **19.**

As shown in FIG. **5,** there is provided a suitable means for lifting the transfer apparatus **31** and lift the transfer roller **33** away from the photoreceptor belt **21.** The mechanism used for moving the apparatus may be of any suitable means such as a clutch mechanism which can be clutched or declutched by actuation and deactuation of suitable solenoid means **111** and **112.** The solenoids are operatively linked via their actuating arms **116** and **117** to the suitable places of the frame such as the corners **116** and **117** of rear and front frames **41** and **43** of the transfer apparatus so that under the normal deactuated state, the arms **116** and **117** are extended to rotate the frames **41** and **43** counter clockwise about the shaft **57.** The solenoid mechanisms themselves are mounted on the frame of the machine to provide reference positions for the solenoid arm movement.

The control means **19** may include a suitable logic circuitry as illustrated in FIG. **5** which is designed to actuate the solenoids **111** and **112** to cam the transfer roller so that it establishes the necessary contact with the photoreceptor belt when the image transfer takes place and deactuate the solenoids to decam the roller to lift it away from the belt surface when the image transfer no longer takes place. As is generally known a latch circuit provides a two state output signal, one state being logical 1 and the other state being logical 0. In the present situation the latch circuit **121** is provided with suitable input means for keeping it reset so that its output *a* is logical 0 while the machine is not in operation or when the machine enters into some sort of malfunction such as jam condition or when the machine is energized but is actually not running, i.e., belt **21** is not moving and sheets are not fed. The reset lead R representing

these conditions are fed from path **122** and path **123** to the latch via an OR gate **124** at the input thereby and causes its output Q to be logical 0. This keeps the solenoids in deactuated state. To actuate the solenoids then the latch is set by applying a logical 1 signal to the set lead S. When this happens the Q output changes to logical 1 and thereby actuates the solenoids.

According to an aspect of the present invention, the setting and resetting of the latch **121**, that is the actuation and deactuation of the solenoids, are so precisely timed that they occur just prior to the arrival of the first copy sheet and entry of its leading edge into the nip between the transfer roller and the belt and deactuate the solenoids just after the exiting of the lagging edge of the last sheet of the copy sheets in a copy run of the reproducing machine. To provide this precise timing means a suitable control circuitry such as the ones described in the U.S. Pat. No. 3,796,486, issued on Mar. 12, 1974 and U.S. application Ser. No. 445,014 filed Feb. 22, 1974 concurrently with the present publication and assigned to the present assignee may be utilized. Both applications are expressly incorporated by reference into the present application. Referring to parts of the control means pertinent to the understanding of the present apparatus, the means includes gates **125–127** and a shift register **130** having a number, say 25 of shift flip-flops connected in series and a matrix decoder **132**, all operatively connected as shall be explained. The shift register responds to a series train of pitch pulses, the rhythm rate of which, say two pitches per second establishing the copying speed of the machine. The pitch pulses start as the machine begins to move and occur once each time, in effect per imaging cycle or exposure. The pitch pulse comes from a suitable pitch pulse generating means **134**. Clock pulses from a clock source **135** come from a given number of pulses per period say 1000 pulses. The control means includes decode matrix **132** which derives precisely timed control pulses within each pitch interval.

Because of the distance it takes sometimes for the path between the paper supply and the transfer station: The control means is designed to be able to keep track of the precise time interval it takes for the sheet to travel from the time it is fed to the time it reaches the nip between the roller **33** and the belt. Suppose it takes 3.80 seconds at the earliest for the sheet to reach the nip. Suppose further that it takes 0.4 second for a sheet to travel through the nip. Going back the shift register, the flip-flops start shifting as soon as the first sheet is fed starting with the first flip-flop. When 7th flip-flop F7 shifts it means, therefore 3.5 seconds have elapsed assuming two pitches per second and a sheet is fed in every half a second. The sheet is almost there in that, as stated above; it will be there 3.80 seconds. Flip-flop 7 generates Q7 signal of logical 1 at this point to input a pair of AND gate **125**. At this point, the decode matrix **132**, which is reset by each pitch pulse starts counting and as it counts 500 pulses, supposing there are 1000 pulses per pitch period or time interval. The decode matrix is set up so that it generates a control pulse at the 500 pulse count, and applies it to the second input *b* of the AND gate **125**. In response the AND **125** provides a logical 1 pulse signal and sets the latch. In turn the latch provides a logical 1 or actuating signal to the solenoid actuating means to cam in the transfer roller. Note at this point that the time is 3.75 sec. from the start. The paper comes at 3.80 sec. So the camming is 0.05 sec ahead of the arrival of the paper. In other words the camming takes place 0.05 sec before the lead edge hits the nip. 0.05 second is allowed here to take into account the fact that the mechanical tolerances typically encountered in machines of the sort in which the present logic is incorporated. Now 500 pulse count signal continues to appear in every pitch and is applied to the first input *a* of the inhibit gate **126**. Q7 changes from logical 0 to 1 at the 3.5 second point, Q8 at 4.0 seconds. So the inhibit input X goes to logical 1 at Q7 or 3.5 seconds and stays until Q8 goes to 0. While to inhibit input is logical 1, the gate **126** is disabled from passing **500** clock pulse count signals from the matrix **132**. So it is evident that when last sheet enters Q7 goes to logical 1 and then Q8 output. After Q8 output the inhibit signal is removed and the response the next 500 Q clock pulse goes through the OR gate **124** and resets the latch **121** and turns the cam off. Here note that the last sheet is allowed about 0.75 second, from the time its lead edge enters and the lagging edgedeparts the nip. This is more than adequate to assure that the last has left the transfer station.

In short, then, the latch output is logical 0 when machine is started but not yet in the print mode because of the Not In Print signal applied to the reset lead via the OR gate **123**. This stays in this condition. The clock count pulses from the decode matrix **132** start to come in from the very first pitch interval via the input *a* of the inhibit gate **126**. At this point, however, the gate **126** is not disabled or not inhibited from passing this pulse since Q7 and Q8 are still in the logical 0 state. So the clock count signal pulse goes through the gate inhibit **127** and the OR gate **123** and applies to reset lead. But because of the inherent nature of the latch circuit, this will not change its Q output. Now the time period for the first sheet to travel from the copy sheet feeding station to the transfer station is about to expire and this corresponds to the Q7 pitch pulse signal. At this point, Q7 goes to logical 1 and when the next succeeding **500** clock count pulse signals come in and are applied to the AND gate **125**, the AND gate **125** provides logical signal 1 and this in turn causes the latch **121** to change its output from logical 0 to logical 1 and causes the solenoids to be actuated and cam the transfer roller into the contact relationship with the photoreceptor belt. Now the latch Q7 and the latch Q8 continue to remain to be in the logical 1 state so long as the copy sheets continue to traverse and in the paper path. The output of the OR gate **129** is logical 1 from the time Q7 goes to logical 1 and thus inhibits the gate **127** from passing the clock count signals from the matrix decoder **132** to the reset lead of the latch **121** via the OR gate **123**. Thus, the latch **121** remains in the set state, that is, its Q output remains logical 1 while the copy sheets remain in the paper path. Now when the last of the paper sheets is fed the shift register keeps track of the last sheet, that is, the flip-flops of the shift registers start to change its Q outputs from logical 1 to logical 0 in succession. When Q7 goes to logical 0, that alone will not remove the inhibit signal from the inhibit input **131**. But when Q8 goes to logical 0 then the output of the OR gate **127** will go to logical 0 and this will remove the inhibiting signal from the inhibit gate **127**. Thus the next clock count signal comes from the decode matrix **132** and it will provide the necessary signal to reset lead R of the latch **121** via the OR gate **123** and the reset latch. This causes the output Q of the latch **121** to go to logical 0

and thus deactuate cam and thereby disengage the transfer roller from the belt. Upon deactuation, the arms **113** and **114** retract and lift the roller **33** away from the belt **21** so that the roller **33** does not apply any pressure to the belt. Any suitable distance such as a fraction of an inch spacing is enough to remove the pressure and thus eliminate the aforementioned cold flow or dent problem. It is noted that while it is shown here to use two solenoid means, obviously one solenoid could function just as well with some obvious changes.

Thus, in summary then in accordance with an aspect of the present invention, suitable control means is provided to engage or cam the transfer roller into contact with the photoreceptor belt only when the machine is ready and begins to operate and disengage it away from the belt when the machine completes the copy run or enters into interrupt mode due to jam or other machine malfunctions.

FIG. **7** illustrates another aspect of the present invention in that the transfer apparatus may further include a suitable pressure actuable manual camming means **142.** The camming means **142** includes a shaft **143** and pressure coupling means operably coupled to a handle **145** so that when the operator rotates the handle, he can lift the entire transfer apparatus away from the photoconductor belt **21** high enough so that he can reach in and clear any jammed copy sheets. In such situations there must be a very substantial clearance between the photoconductor belt **21** and the rest of the apparatus so that the operator or the service attendant is given working space in the transfer roller area.

While the invention has been particularly shown and described with respect to illustrative embodiments thereof, it will be obvious to those of ordinary skill in the art to make various changes and modifications without departing from the spirit and scope of the invention. It is therefore intended that all such changes and modifications are encompassed within the ambit of the appended claims.

What is claimed is:

1. In an electrostatic reproducing machine wherein a latent image is formed and developed by image forming particles on a moving photoreceptor surface and a transfer roller is used to transfer the image onto a copy sheet, the improvement which comprises means for engaging said transfer roller into contact with the photosensitive surface to effect the image transfer when the machine is in operation and disengaging said transfer roller away from said photosensitive surface so that the transfer roller surface is not in contact with the photosensitive surface when the machine is not in operation; and

control means for generating an enabling control signal when said machine is conditioned to be ready to actuate a copy operation and for generating a disabling control signal when said machine completes a copy run or the machine operation enters into an interrupt mode due to jam or other malfunction conditions, said engaging and disengaging means responsive to said enabling control signal for engaging said roller in contact with said photoreceptor surface and responsive to said disabling control signal for disengaging said roller away from said photoreceptor surface.

2. The combination according to claim **1,** including means for cleaning said transfer roller to remove the image forming particles adhering thereto after the image transfer operation.

3. The combination according to claim **2,** said cleaning means includes a brush roller, means for driving said brush roller to brush the surface of said transfer roller and means for vacuuming the particles from the transfer roller and vicinity.

4. The combination according to claim **1,** including means for vacuuming image forming particles remaining on said transfer roller and vicinity after the image transfer.

5. An electrostatic reproducing machine comprising:

movable photoreceptor means, having photosensitive surface,

means for forming and developing images on said photosensitive surface using toner particles,

a copy sheet medium,

a transfer roller,

means for engaging said transfer roller in contact with said photoreceptor and driving them while they are in contact,

means for feeding said copy sheet medium through the nip between said photosensitive surface and transfer roller,

means for disengaging said transfer roller from said photosensitive surface to remove pressure applied by the roller against said surface,

means for sensing a status of said machine, said sensing means producing a first signal when said machine is ready to make electrostatic copies, said sensing means producing a second signal when an operation is complete or when said machine is in a status resulting from a jam condition or other malfunction, and

control means for actuating said engaging and said disengaging means to form the contact to make copies in response to said first signal and deactuating said engaging and said disengaging means for moving said transfer roller away from the photosensitive surface to break the contact so that said roller does not touch the photosensitive surface in response to said second signal.

6. The machine according to claim **5,** including vacuum cleaning means for cleaning said transfer roller and vicinity.

7. The machine according to claim **5,** including a cleaning roller for brushing the transfer roller.

8. The machine according to claim **7,** including vacuum means for cleaning the transfer roller and the cleaning roller and vicinity thereof.

9. The machine according to claim **8,** including means for manually lifting the transfer and cleaning rollers to provide working space between the transfer roller and the photosensitive surface for enabling an operator to remove matters such as a jammed copy sheet between the rollers and the surface.

10. The machine according to claim **9,** including means for driving said transfer roller and said cleaning roller, and a unitary housing means for confining said rollers within an area.

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