United States Patent [19]

Crawford

[11] **3,784,190**

[45] **Jan. 8, 1974**

[54] **SHEET REMOVING APPARATUS**

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[73] Assignee: **International Business Machines Corporation,** Armonk, N.Y.

[22] Filed: **Dec. 27, 1971**

[21] Appl. No.: **212,359**

[52] **U.S. Cl.** **271/80,** 271/51

[51] **Int. Cl.** **B65h 5/06**

[58] **Field of Search** ..... 271/51, 80, DIG. 2, 271/74 PG, 74 F

[56] **References Cited**

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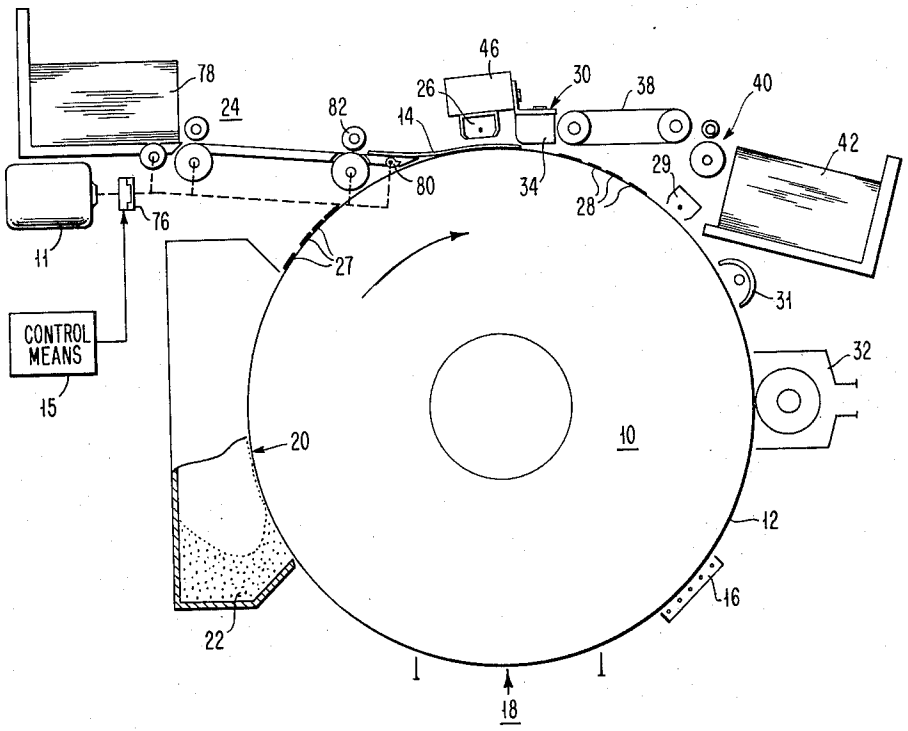
Primary Examiner—Richard E. Aegerter

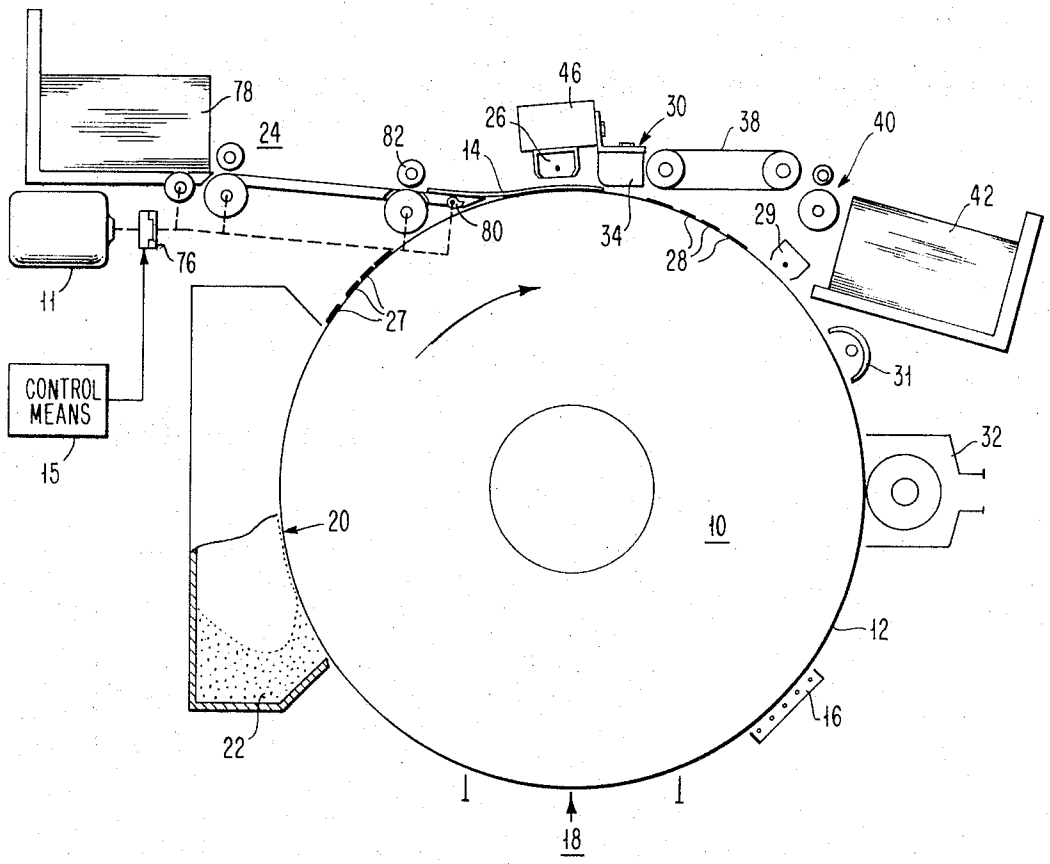
Attorney—Otto Schmid, Jr. et al.

[57] **ABSTRACT**

Apparatus is provided for separating a copy sheet bearing an unfused toner image from a moving electrophotographic surface to which the copy sheet is electrostatically attracted during the image transfer operation. The separating apparatus utilizes a nozzle assembly having a plurality of nozzles mounted near the electrophotographic surface. A high velocity flow of pressurized fluid from the nozzles for a predetermined time is sufficient to detact the leading edge of the sheet and a lower velocity flow of pressurized fluid from the nozzles is sufficient to hold the copy sheet closely adjacent to the nozzle assembly and permit movement of the copy sheet across the nozzle assembly to a sheet transport toward a fusing station.

9 Claims, 8 Drawing Figures




78
24
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CONTROL MEANS
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FIG. 1

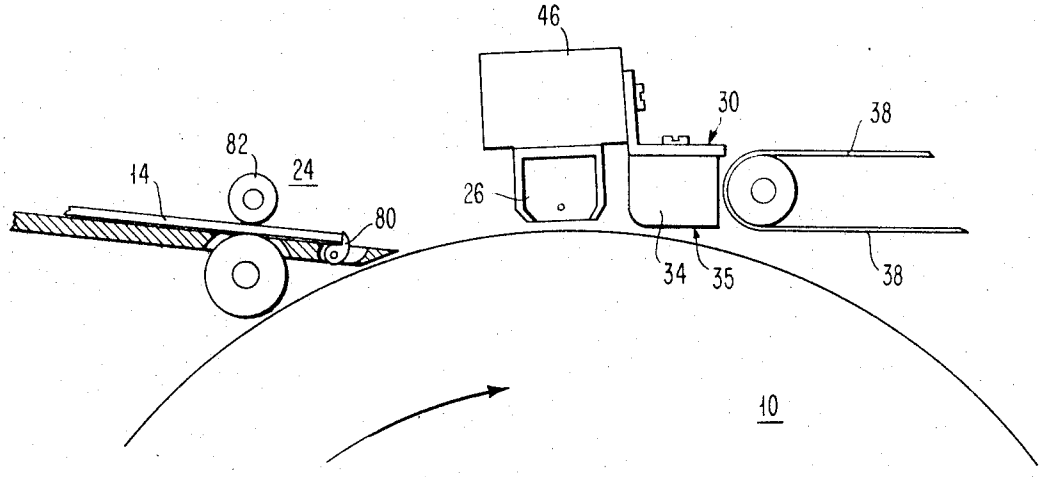
46
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FIG. 2

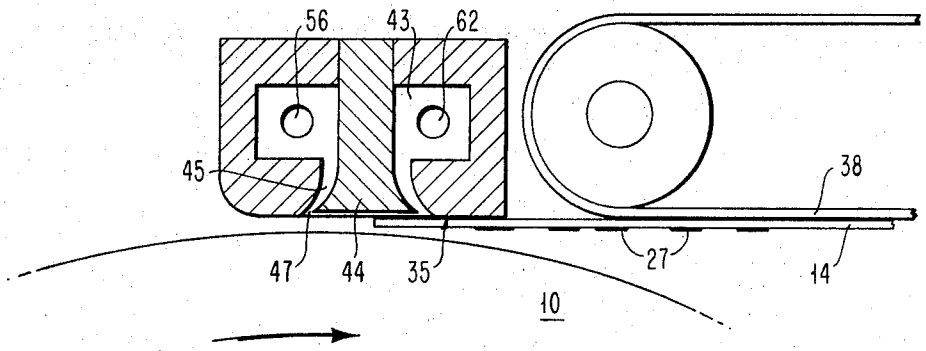

FIG. 3

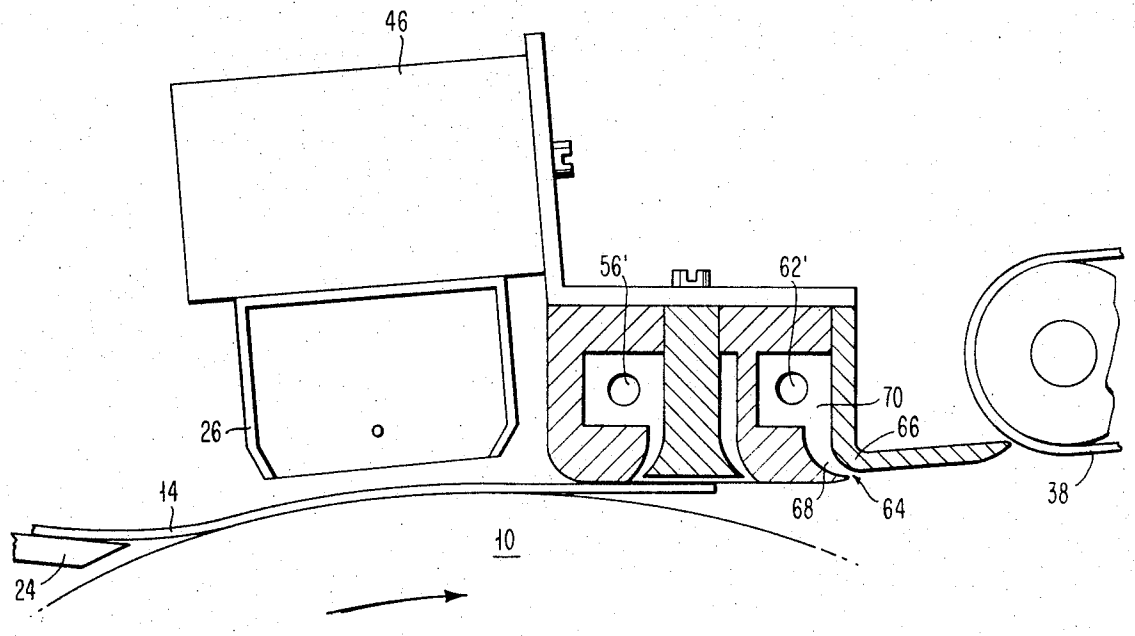

FIG. 4

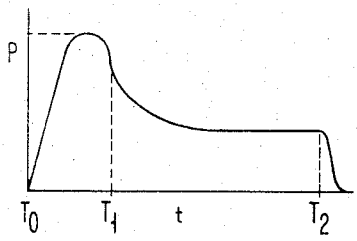

FIG. 5

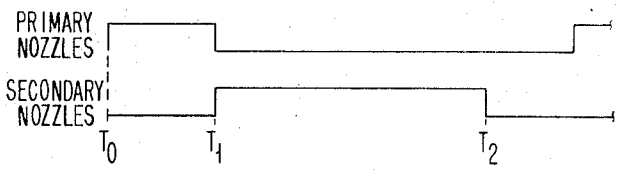

FIG. 7

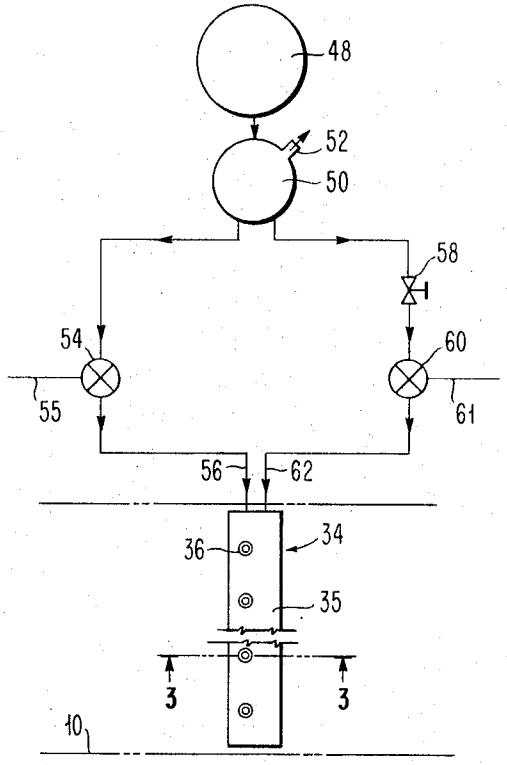

FIG. 6

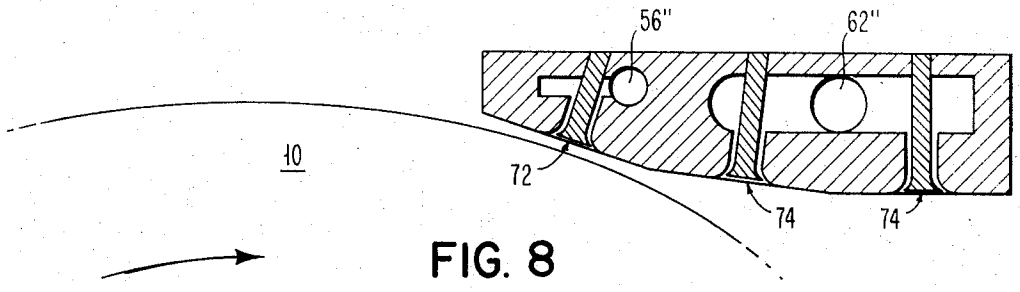

FIG. 8

SHEET REMOVING APPARATUS

BACKGROUND OF THE INVENTION

This invention relates to transfer of an electrophotographically developed image from an image-bearing member to a suitable transfer sheet and more particularly to apparatus for removing the transfer sheet from the image-bearing member.

DESCRIPTION OF THE PRIOR ART

One prior art apparatus for transferring a developed image to a copy sheet comprises a system wherein a corona discharge device is utilized to produce a charge on the back of the copy sheet to attract the image toner from the image-forming surface to the sheet. Due to the transfer charge, an electrostatic bond is produced between the image-forming surface and the sheet and this force must be overcome to separate the sheet bearing the toner image from the image-forming surface.

Mechanical devices such as gripper fingers, air puffers and combinations of these devices have been used in the past to effect separation. In some cases an electrostatic charge is produced to neutralize the electrostatic force which holds the copy sheet to the image-forming surface so that the copy sheet can be more easily separated from the image-forming surface.

These prior art systems have been effective to varying degrees in the past; however, as processing speeds have increased, these prior art methods are no longer effective to reliably separate the copy sheets from the image-forming surface without damaging the unfused images which are loosely adhered to the copy sheet.

It is therefore, a primary object of this invention to provide improved apparatus for separating an image-bearing copy sheet from an image-forming surface.

It is another object of this invention to provide apparatus for separating an image-bearing copy sheet from an image-forming surface without disturbing the image.

It is a further object of this invention to provide apparatus for reliably separating at high processing speed a copy sheet bearing an unfused toner image from an image-forming surface to which the copy sheet is electrostatically attracted.

SUMMARY OF THE INVENTION

Briefly, according to the invention, there is provided apparatus for separating a transfer sheet bearing loosely adhered image forming material from a moving image forming member to which the transfer sheet is electrostatically attracted comprising nozzle means mounted adjacent the image forming member for producing a high velocity flow of pressurized fluid from the nozzle means for a predetermined time for detaching the leading edge of the transfer sheet and for then producing a low velocity flow of pressurized fluid from the nozzle means to move the transfer sheet adjacent to the nozzle means to permit movement of the transfer sheet across the nozzle means to a utilization station.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a diagrammatic schematic view of electrophotographic imaging apparatus embodying the sheet removing apparatus of the present invention;

FIG. 2 is a partial side elevation of the sheet removing apparatus shown in FIG. 1;

FIG. 3 is a section view along the lines 3—3 of the nozzle assembly shown in FIG. 6;

FIG. 4 is a section view of an alternate embodiment of the nozzle assembly embodying the invention;

FIG. 5 is a plot of pressure applied to the nozzle assembly on a time scale;

FIG. 6 is a schematic diagram of the air control system for the nozzle assembly;

FIG. 7 is a plot of the control signals on a time basis applied to selectively control the sheet removing apparatus of the invention;

FIG. 8 is a section view of a further embodiment of the nozzle assembly according to the invention.

DESCRIPTION OF PREFERRED EMBODIMENTS

An example of a particular apparatus in which the subject invention is adapted for use is the electrophotographic imaging apparatus shown in FIG. 1. In this apparatus a rotatable drum 10 carries around its periphery an electrophotographic photoconductive member 12 on which is directed an image which is desired to be reproduced on a suitable insulating transfer member such as copy sheet 14. Drum 10 is driven by suitable belts or gears (not shown) from motor 11 and electrical signals to provide the required control and synchronization of the machine components are provided by control means 15 which may be a computer of an associated data processing system if desired. The surface of the photoconductor 12 is uniformly charged to a predetermined polarity by corona discharge device 16. The image to be reproduced is provided in a form so that a suitable exposure means is operable to direct the image to exposure station 18 onto the surface of the photoconductor 12. Relative motion may be provided during exposure of the image at a speed synchronized with the surface speed of drum 10 in a manner known in the art. Where the photoconductive surface is illuminated by the image, the surface is discharged leaving a charge pattern in the form of the image to be copied. Either the desired image or the background area may be discharged to produce the desired charge pattern, depending upon whether direct or reversal development is to be used.

Thereafter the drum passes a development station 20 at which a toner carrier mixture 22 is cascaded across or otherwise brought in contact with the electrostatic image on the surface of the photoconductor 12 as is known in the art. The toner having a charge opposite from the polarity of the electrostatic image charge is attracted to the drum surface to render the image visible.

Continuing the clockwise rotation of the drum 10, a copy sheet 14 is fed into contact with the developed eleectrostatic image by the transport means 24. A corona discharge device 26 is disposed above the copy sheet at the area of contact with the drum. Corona discharge device 26 produces ionization of a polarity opposite that of the toner sufficient to attract the toner forming the image to the copy sheet. After this transfer operation, the copy sheet 14 is separated from the drum by separator means 30 and fed by transport means 38 past a fusing station 40 which serves to fuse and permanently fix the image-forming toner to the copy sheet. The nature of the separating means 30 will be described in more detail later. Since transfer of all the image toner 27 is not usually accomplished, residual toner 28 remains on the drum surface after a transfer operation. The drum continues to rotate past a cleaning apparatus 32 which cleans the surface of the

photoconductor and removes any excess toner. If desired, a pre-clean corona **29** and an erase lamp **31** may be placed before cleaning station **32** to aid in cleaning the photoconductor. This operation completes the cycling of the drum for reproducing the desired image.

A sheet separating operation is initiated by a signal FEED SHEET which is generated by control means **15.** The signal is generated in synchronism with the position of the image on drum **10** so that a sheet **14** is fed to merge with the toned image on drum **10.** The FEED SHEET signal is coupled to actuate single revolution clutch **76** for one cycle of operation of the feed components connected by dashed lines. A cycle of operation results in a sheet being fed from the position shown in FIG. **2** to the drum to receive the toned image from drum **10** while a second sheet is being fed from hopper **78** to be registered at stop **80.** The motion of pressure roll **82** to an operative position is coordinated with the position of stop **80** so that stop **80** is moved out of the path of the sheet before the pressure roll **82** is lowered to drive sheet **14.** Stop **80** is then moved to the operative position prior to the arrival of the second sheet so that the second sheet is properly registered at stop **80.**

Sheet **14** is fed to coincide with the toned image on the drum. The transfer corona is energized to produce ions of the proper polarity which are sprayed on the back of sheet **14** to electrostatically attract the image toner to sheet **14.** Sheet **14** with the toned image loosely adhering to the surface is then separated from drum **10** by separator means **30.**

Separator means **30** comprises a nozzle assembly **34** which is mounted in a fixed position near the surface of drum **10.** Nozzle assembly **34** comprises a plurality of individual nozzles **36** through each of which a relatively high velocity stream of pressurized fluid is ejected as the leading edge of copy sheet **14** approaches the nozzle assembly. The individual nozzles are designed to produce a blast of fluid directed substantially tangentially to the surface of the drum. Due to copy sheet **14** being wrapped around curved drum **10,** a small portion of the leading edge of the paper may not follow the contour of the drum, thereby making easier the sheet separation operation. However, even if the leading edge of the sheet is completely tacked down by electrostatic attraction, my invention reliably separates the sheet from the drum without damage to the toner image. The blast of fluid raises the leading edge of the sheet as the leading edge approaches the nozzle exit point. When the leading edge of the sheet is positioned approximately opposite the nozzle exit, a relatively lower volume of fluid is introduced through the individual nozzles so that the movement of the fluid between the individual nozzles **36** and copy sheet **14** creates a partial vacuum, thereby pulling (by Bernoulli's principle) the copy sheet leading edge to a position closely approaching, but not touching the nozzle assembly. The electrostatic attachment of copy sheet **14** to drum **10** continues to drive the leading edge of copy sheet **14** and the low volume of fluid is effective to guide the sheet in a substantially friction-free manner to sheet transport means **38.** Sheet transport means **38** comprises a suitable transport such as a vacuum belt transport or electrostatic belt transport, which is effective to convey copy sheet **14** by contacting only the non-image side of sheet **14** through a suitable fusing station **40** in an output means such as stacker **42.**

Thus, it can be seem that the apparatus comprising the invention is operable to remove the copy sheet from the image-forming drum at high speed with little chance of damaging the unfused toner image, since the separator means is in position to blow fluid on the image side of the sheet only during the passage of the first fraction of an inch of the leading edge of the sheet. Once this fraction of an inch of the leading edge passes the nozzle **36,** the sheet itself is effective to prevent the flow of fluid from reaching the image side of the sheet and all further processing of the sheet prior to the fusing of the image is accomplished entirely by contacting the non-image side of copy sheet **14.**

One embodiment of nozzle assembly **34** is shown in greater detail in FIGS. **2** and **3.** The nozzle assembly extends across the surface of drum **10** and is mounted by suitable support means **46** in a fixed position with surface **35** spaced a relatively small distance from the drum surface. An enclosure which extends across assembly **34** is provided to form a manifold **43** in the nozzle assembly for introducing pressurized fluid such as compressed air into each of the nozzles **36.** A plurality of individual nozzles **36** are formed by a contoured opening **45** in the manifold and a shaped diffuser member **44.** The nozzle opening **47** formed by fixedly mounting a diffuser member **44** in each contoured opening **45** is preferably designed to form an annular converging nozzle since this design produces greater efficiency for reliably removing a sheet bearing an unfused toner image from drum **10.** The number of individual nozzles used to cover the drum width is a matter of design choice which depends on the air pressure utilized, the rotational speed of the drum, the weight of the paper and the design characteristics of the nozzles.

The pressurized air or other suitable fluid may be provided from any suitable source which produces a sufficient quantity and pressure of air to overcome the force produced by the electrostatic bond between the image forming surface and the copy sheet. One embodiment for producing the desired pressure is shown in FIG. **6.** A suitable pump **48** is provided to compress the air for storage in storage tank **50** to which a suitable relief valve **52** is attached to provide a predetermined maximum pressure. A first solenoid valve **54** is placed in an output line from tank **50** to provide the pressure to input line **56** for separating the leading edge of copy sheet **14** from the image-forming surface when valve **54** is energized with a suitable electrical signal generated by control means **15** such as the PRIMARY NOZZLES signal shown in FIG. **7.** A second air path from tank **50** is provided with a pressure regulator **58** and a second solenoid valve **60** to produce the lower level of pressure suitable for holding the copy sheet to the nozzle assembly. Pressure regulator **58** is set so that the required pressure is provided to input line **62** of nozzle assembly **34** when valve **60** is selectively actuated by a suitable electrical signal generated by control means **15** such as the signal SECONDARY NOZZLES shown in FIG. **7.**

Each of the solenoid valves **54, 60** may be selectively actuated to provide the pressure to the manifold of nozzle assembly **34.** For example, the valves may be actuated at times shown in FIG. **7** to produce the gas pressure as shown in FIG. **5.** At time T_0 the sheet is in the approximate position shown in FIG. **1** approaching the nozzle assembly and valve **54** is energized to direct the high pressure gas to the nozzle assembly. At time T_1 the sheet is located at the approximate position shown in

FIG. 4 and the lower pressure air is directed to the nozzle assembly by turning off valve **54** and turning on valve **60.** This level of pressure is maintained until time T_2 when the sheet is at the approximate position shown in FIG. **3.** In some cases the lower pressure gas may be left on at all times and obtain reliable operation in which case valve **60** would not be necessary.

In some cases the valves **54, 60** may be actuated mechanically by means of suitable cams which are timed to coincide with the position of the leading edge of the sheet **14** on drum member **10.** However, the position of the sheet on the drum may not be located accurately enough for reliable operation of the separating apparatus, particularly in machines which operate at high process speeds. In other machines the sheet is accurately located on the drum but at a random position on the drum. It is, therefore, preferable to have valves that are selectively operable according to an electric signal which is generated in synchronism with the position of the sheet on the drum. In these cases sufficiently accurate signals PRIMARY NOZZLES and SECONDARY NOZZLES are generated from the logic control circuits **15** in the machine to actuate the valves **54, 60** by applying the signal to lines **55, 61** respectively at the proper time in the machine cycle to produce reliable separation of the copy sheet without damage to the image on the sheet.

In some cases such as very high speed or synchronous machine operation, it may be necessary to provide apparatus for sensing the position of the leading edge of a copy sheet so that a sufficiently accurate signal can be generated for actuation of valves **54, 60** to separate the sheet without damaging the toner image on the sheet. One suitable apparatus (not shown) for sensing the position of the leading edge of a sheet comprises a light source mounted to produce a beam of light which impinges on the surface of drum **10.** A suitable sensing apparatus such as a photocell is positioned near the surface of the drum at the point of impingement of the light beam on the surface of the drum. During operation when no sheet is present, the surface of drum **10** reflects the light so that substantially no light reaches the photocell; however, when a sheet is present the light is diffused so that sufficient light reaches the photocell to produce a detectable signal from the photocell output. This signal indicates that the leading edge of a sheet is present and the signal is sent to control means **15** and utilized to generate the signal PRIMARY NOZZLES to actuate the solenoid valve **54** for a sufficient time to separate the leading edge of the sheet. Upon termination of the signal PRIMARY NOZZLES for the separating pressure, a second signal SECONDARY NOZZLES is generated which actuates solenoid valve **60** to produce the holding level of air for a time sufficient for the leading edge of sheet **14** to reach sheet transport **38.** Thus, it can be seen that the sheet is under positive control at all times from the separation of the sheet until the image is fused to copy sheet **14.**

For higher process speeds the alternate embodiment of nozzle assembly **34** shown in FIG. **4** may produce more reliable operation. This nozzle assembly utilizes the same primary nozzle assembly that has been previously described; however, an auxiliary nozzle **64** is provided to ensure even more positive control over the leading edge of the sheet as the leading edge is guided from the drum to the sheet transport **38** to eliminate any possibility that the sheet may be reattached to the surface of drum **10.** The auxiliary nozzle comprises a manifold enclosure **70** to which pressurized gas is introduced through line **62'.** A contoured portion **68** of the valve assembly in conjunction with shaped deflector member **66** forms the auxiliary nozzle **64** which may extend the width of sheet **14.** Auxiliary nozzle **64** produces a flow of air parallel to the sheet path at the same pressure level as the conveying pressure (such as 2 to 4 PSI, for example) in the main nozzle of the embodiment shown in FIG. **3** so that the flow is operable to hold the sheet closely adjacent to the surface but not touching the deflector member **66** of secondary nozzle **64.** Since this flow produces no vertical component of force, there is no tendency to force the leading edge of the sheet to reattach itself to the surface of drum **10.** This construction has the added advantage that the surface of the main nozzle and the surface of the auxiliary nozzle need not be in the same plane, so the auxiliary nozzle may be utilized to change the angle of the paper path to an extent as well as providing an added safety factor insofar as prevention of reattachment of the copy sheet to the surface of the drum **10.**

A further embodiment of a nozzle assembly is shown in FIG. **8.** The nozzle assembly comprises a first nozzle **72** to which the stripping pressure (such as 6 to 10 PSI, for example) of pressurized gas is applied through input **56''.** Nozzle **72** is followed along the direction of paper travel by a plurality of secondary nozzles **74** to which is applied the conveying level of pressurized gas through input **62''.** A row of nozzles **72, 74** are provided across the width of sheet **14** and the position of nozzles may be staggered if desired.

While the invention has been particularly shown and described with reference to preferred embodiments thereof, it will be understood by those skilled in the art that various changes in the form and details may be made therein without departing from the spirit and scope of the invention.

What is claimed is:

1. Apparatus for separating a transfer sheet having image forming toner particles loosely adhered to one surface thereof from a moving image forming member to which the transfer sheet is electrostatically attracted comprising:

a first transport means to convey the transfer sheet to a transfer area;

nozzle assembly means mounted adjacent the path of travel of the non-image surface of the transfer sheet, said nozzle assembly means producing a first direction of flow of pressurized fluid against the direction of movement of the transfer sheet and a second direction of flow of pressurized fluid in the direction of movement of the transfer sheet;

means for producing a high velocity flow of pressurized fluid from said nozzle assembly means as each sheet approaches for a predetermined time to detach the leading edge of the transfer sheet from the first transport means;

second transport means operative on the non-image surface of the transfer sheet to convey the transfer sheet away from the transfer area; and

means for producing a relatively low velocity flow of pressurized fluid from said nozzle assembly means to hold the non-image surface of the transfer sheet closely adjacent to said nozzle assembly means to guide the sheet away from the transfer area.

PO-1050
(5/69)

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,784,190 Dated January 8, 1974

Inventor(s) Roy P. Crawford

It is certified that error appears in the above-identified patent and that said Letters Patent are hereby corrected as shown below:

In Col. 5, line 28, the word "synchronous" should be

--asynchronous--.

Signed and sealed this 11th day of June 1974.

(SEAL)
Attest:

EDWARD M.FLETCHER,JR.
Attesting Officer

C. MARSHALL DANN
Commissioner of Patents