United States Patent [19]

Camis et al.

[11] **3,734,015**

[45] **May 22, 1973**

[54] **SINGLE PASS DUPLEXING BY SEQUENTIAL TRANSFER**

[75] Inventors: **Thomas Camis**, Fairport; **Steven A. Goss**, Rochester, both of N.Y.

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

[22] Filed: **Dec. 23, 1970**

[21] Appl. No.: **101,018**

[52] **U.S. Cl.**.....**101/229**, 101/231, 101/DIG. 13, 355/3

[51] **Int. Cl.**.....**B41f 5/02**

[58] **Field of Search**.....101/229, 231; 355/3

[56] **References Cited**

UNITED STATES PATENTS

3,318,212	5/1967	Rubin	355/3
530,813	12/1894	Wendte	101/231
3,124,457	3/1964	Schwertz	101/DIG. 13
857,331	6/1907	Cornwall	101/231 X

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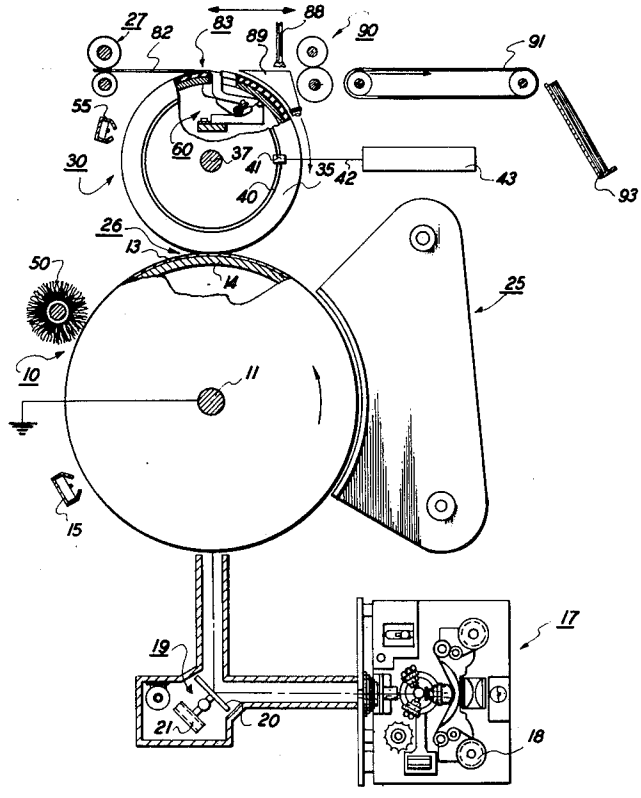
Attorney—James J. Ralabate, Donald F. Daley and Thomas J. Wall

[57] **ABSTRACT**

Method and apparatus are herein disclosed for producing duplex copy. First and second toner images are sequentially formulated on a moving image retaining element. A biased transfer roll is arranged to move in contact with the image retaining element whereby the first image is electrically transferred and temporarily stored on the roll surface. A sheet of final support material is placed over the first image and the top side of the sheet brought into contact with the second image whereby the second image is transferred to the top of the sheet. Finally, corona is applied to the top of the sheet of a magnitude and polarity to cause the first image to be transferred from the roll surface to the sheet and the sheet removed from the roll.

3 Claims, 8 Drawing Figures



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SHEET 1 OF 3

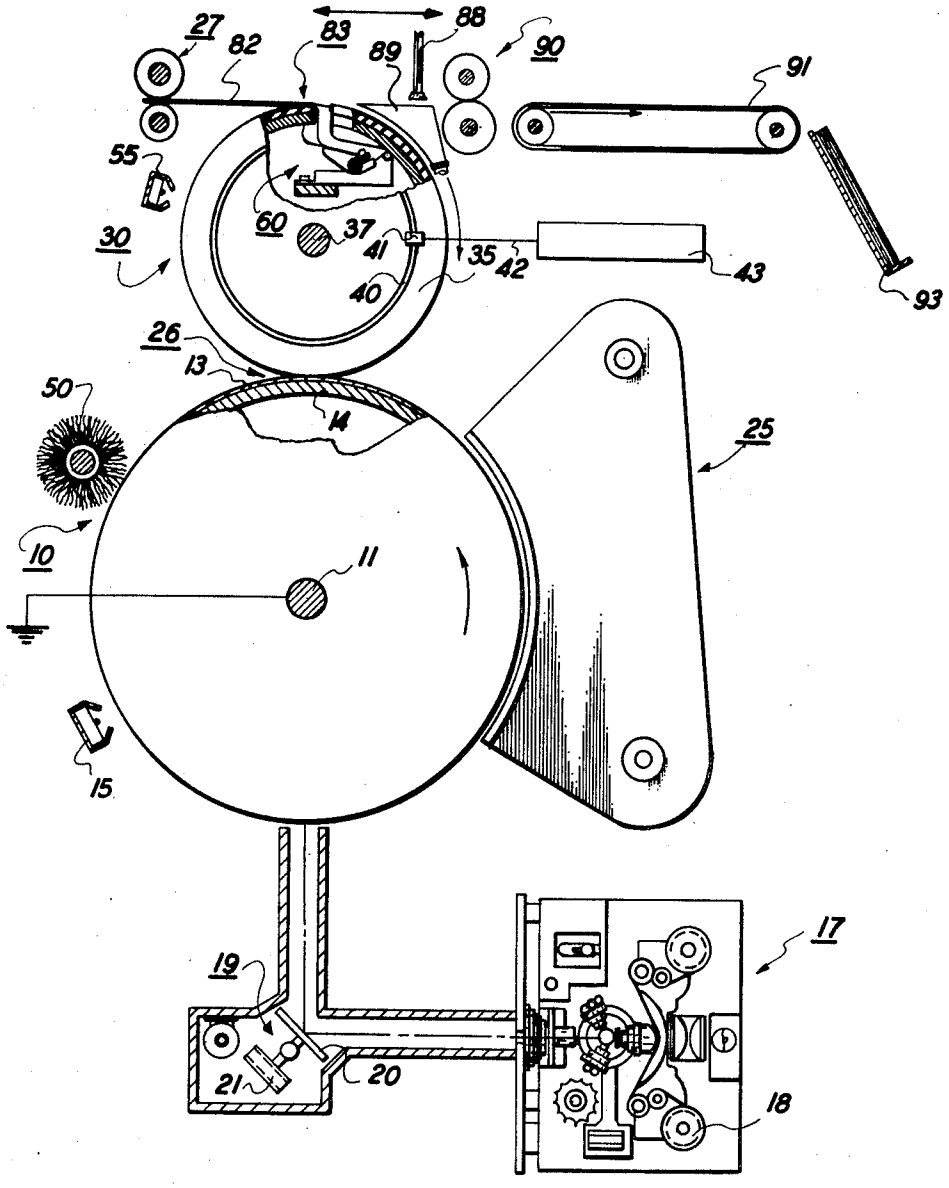

FIG. 1

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STEVEN A. GOSS
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BY
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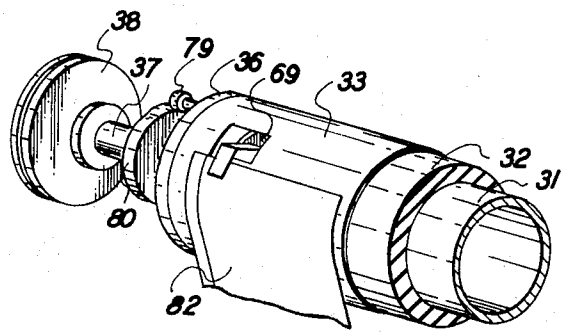
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FIG. 2

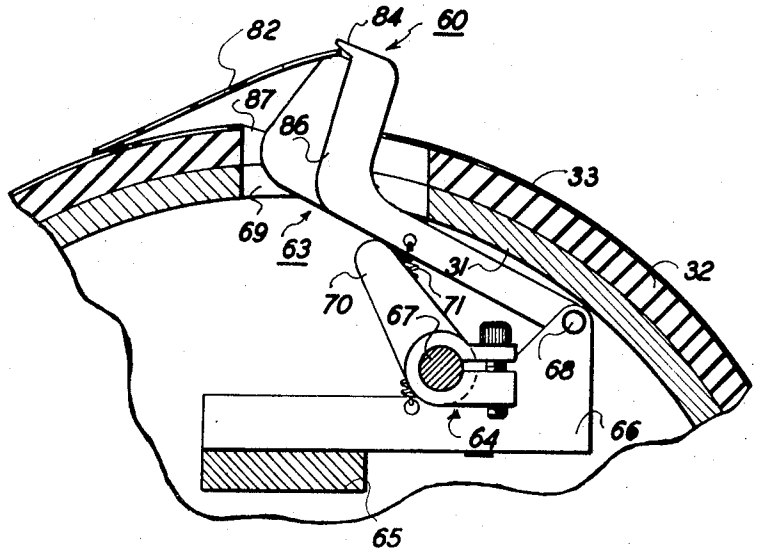
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FIG. 3

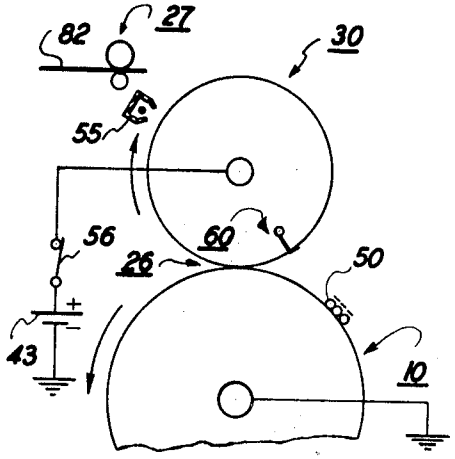

FIG. 4

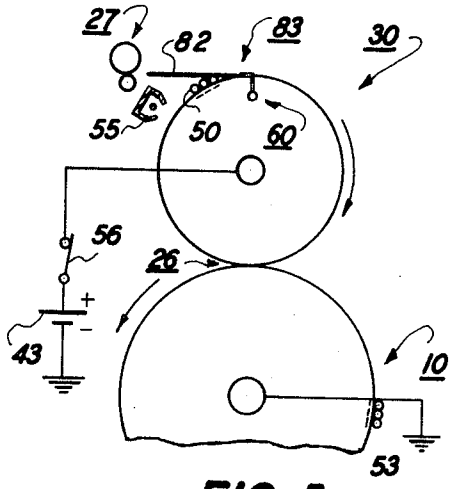

FIG. 5

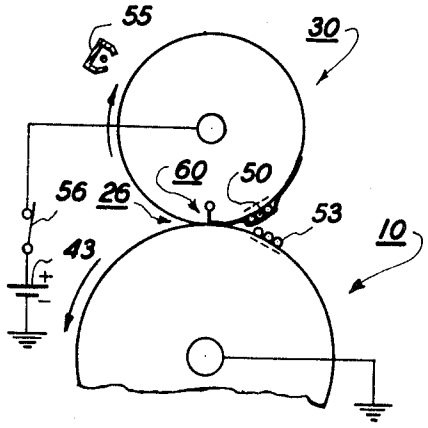

FIG. 6

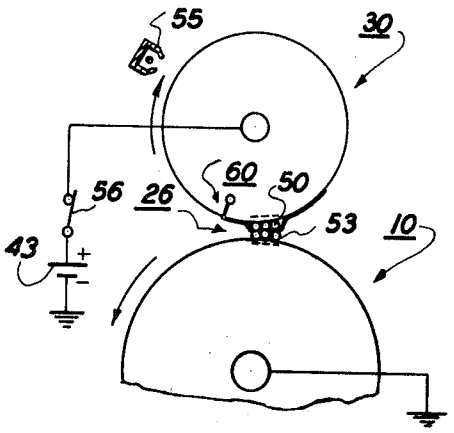

FIG. 7

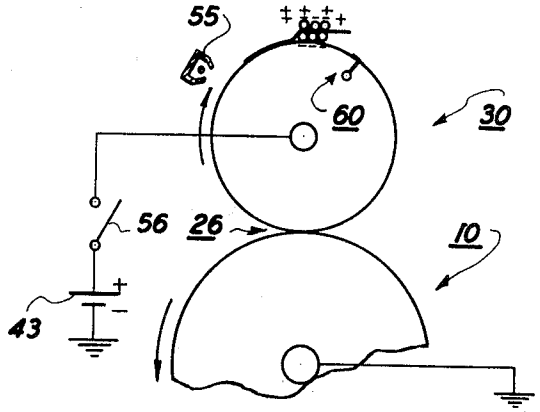

FIG. 8

SINGLE PASS DUPLEXING BY SEQUENTIAL TRANSFER

This invention relates to method and apparatus for xerographically producing duplex copy.

In the xerographic process, a plate, generally including a conductive backing upon which is placed a photoconductive insulating material, is charged uniformly and the photoconductive surface then exposed to a light image of the original to be copied. Under the influence of the light image, the photoconductive coating becomes conductive so as to selectively dissipate the electrostatic charge found thereon thus producing a latent electrostatic image containing the original input scene information. The latent image can be developed, or made visible, by application of any of a variety of pigmented resins, i.e. toners, that have been specifically developed for this purpose. The pigmented resin material is electrostatically attracted into the imaged areas on the photoconductive surface in proportion to the amount of charge found thereon so that areas of relatively small charge concentration become areas of low toner density while those areas of greater charge concentration become proportionately more dense. Conventionally, the developed image is transferred to one side of a single support sheet and permanently affixed thereto to produce a simplex copy of the original subject matter.

In the printing art, for reasons of economy and convenience, it is oftentimes desirous to place intelligent data on both sides of a single sheet of final support material. Rubin, in U. S. Pat. No. 3,318,212, discloses an automatic device for xerographically attaining this result. In Rubin, two distinct developed toner images are first formulated on the surface of a moving photoconductive plate and each image then transferred and temporarily stored upon the surface of a storage drum. While the images are stored on the drum surface, they are placed in a tackified condition by treating the images with a solvent vapor. To prevent the tackified image from offsetting or adhering to the drum surface, each drum is coated with a layer of Teflon and the Teflon coating, in turn, treated with an offset preventing silicone oil. While still in a tackified state, the images are rapidly placed in contact with the opposite sides of a final support sheet and the toner allowed to coalesce while in contact therewith so that the images are fused to the sheet thereby creating a duplex copy.

While the technique disclosed by Rubin provides a satisfactory means for creating a duplex copy, the process nevertheless suffers from certain inherent disadvantages that limits its application in the xerographic process. In order to obtain complete or total transfer of the tackified images from the drum surface to the final support sheet, the images must be rapidly applied to the sheet surface before coalescence can occur. This, of course, requires the use of complex vapor applying means as well as complex timing and control mechanisms. Furthermore, it has been found that by placing a final copy sheet, particularly paper, in direct contact with an oily surface degrades the quality of the copy produced because, inherently, some of the oil is inadvertently transferred to the copy sheet.

It is therefore an object of this invention to improve method and apparatus for producing copy having original input data recorded on both sides thereof.

A further object of this invention is to provide a relatively simple and efficient means for sequentially applying xerographic images to both sides of a final support sheet.

Still another object of this invention is to eliminate the need for solvent vapor transfer in xerographic duplexing apparatus.

These and other objects of the present invention are attained by formulating a first dry toner image on the surface of a photoconductive plate, contacting the toner image with a biased transfer roll being capable of electrically coacting with the plate to attract the toner image to the roll surface, storing the toner image on the roll while a second dry toner image is being created on the photoconductive plate. A sheet of final support material, as for example, paper, is placed over the first image, while the image is being supported on the transfer drum surface, and the opposite side of the sheet brought into contact with the second image formulated on the photoconductive plate whereby the second image is electrically transferred to the opposite side of the support sheet. The transfer roll is then moved to a region of low electric field intensity and the exposed side of the sheet sprayed with corona to electrically transfer the first toner image to the backside thereof. Finally, the sheet is stripped from the support drum and the images affixed thereto to form a permanent duplex copy.

For a better understanding of the present invention and other objects and further features thereof, reference is had to the following detailed description of the invention to be read in connection with the accompanying drawings wherein:

FIG. 1 is a schematic view in partial section illustrating an automatic xerographic reproducing apparatus embodying the present invention;

FIG. 2 is a perspective view in partial section showing the construction of a transfer roll suitable for use in the apparatus illustrated in FIG. 1;

FIG. 3 is a partial sectional view showing in greater detail the paper aligning and gripping mechanism associated with the transfer roll illustrated in FIG. 2;

FIGS. 4–8 are diagramatic views illustrating the process steps involved in transferring xerographic toner images to both sides of a sheet of final support material.

Referring now specifically to FIG. 1, the apparatus of the present invention for producing duplex copy is shown embodied in a drum type automatic xerographic reproducing device. The central element of this machine is a drum **10** which is mounted for rotation in the machine frame upon a shaft **11** and the drum driven in a clockwise direction by means of a motor (not shown). The drum basically comprises an outer surface having a layer of photoconductive insulating material **13**, such as vitreous selenium or any other suitable material, which is placed upon a grounded conductive substrate **14**.

A uniform electrostatic charge is placed on the photoconductive surface by means of a conventional corona charging device **15** similar to that disclosed by Vyverberg in U. S. Pat. No. 2,836,725. The uniformly charged surface is then moved past an exposure means, generally referenced **17**, capable of exposing the charged surface to a light image of the original input scene information to be reproduced thus forming a latent electrostatic image on the photoconductor. The optical system herein utilized is similar to that disclosed

in the aforetomentioned U. S. Pat. to Rubin where the original input data to be reproduced is stored as minified data upon a film input **18.** A movable reflecting means **19** is positioned in the optical light path and is arranged to redirect the flowing light image of the original onto the bottom portion of the drum surface. The reflecting means comprises a mirror surface **20** and a roof mirror **21** which, in operation, are alternately interposed into the optical system so that each successive image presented to the drum surface is optically reversed.

In operation, the optical means exposes the photoconductive drum to an input wherein a first, right reading, latent image is formulated thereon. Following the formation of the first right reading latent image, the image is caused to be moved past a conventional cascade developing device **25** adapted to bring the latent image into contact with a two component developer material wherein the charged toner particles are attracted into the imaged areas thus making the image visible.

After development, the now visible first right reading image is transported on the drum to a transfer station **26** where the image is transferred and temporarily stored in image configuration upon the surface of an intermediate transfer roll **30.** The transfer roll is arranged to extend transversely across the photoconductive drum surface and to move through a transfer zone in intimate contact therewith. In practice, the roll, which is placed at a relatively high bias potential, coacts electrically with the grounded photoconductive drum to establish an electric field in and about the contact region of sufficient strength to attract the charged toner particles from the photoconductive surface towards the transfer member.

Referring now more specifically to FIG. **2,** there is shown a cut-away view of the transfer roll **30** clearly illustrating the internal construction thereof. The roll is basically formed upon a rigid hollow cylinder **31** that is fabricated of a metal such as aluminum or the like capable of supporting a biasing charge. Over the core is placed a relatively thick intermediate blanket **32** of elastomeric material. The intermediate blanket is preferably formed of a polyurethane rubber having sufficient resiliency to allow the roll to deform when brought into moving contact with the photoconductive drum surface to provide an extended contact region of sufficient length to allow toner particles to be transferred between the contacting bodies. The intermediate blanket should be capable of electrically imparting the charge potential on the core to the outer extremeties of the roll surface and therefore the blanket should have a resistivity of between 10^2 and 10^{10} ohms-cm. Over the intermediate blanket is placed a relatively thin coating **33** which is also formed of an elastomeric material. However, in order to minimize ionization of the atmosphere in and about the contact region, it is preferred that the outer coating have a resistivity of between 10^{13} and 10^{14} ohms-cm. It is further preferred that the outer coating of the roll should be formulated of a material capable of providing a relatively smooth surface that exhibits relatively good mechanical release properties in respect to the toner materials employed. A polyurethane material manufactured by the duPont Company under the tradename "Adiprene" has been found to possess the heretofore mentioned desired electrical properties as well as showing extremely good release characteristics in respect to most commercially available toners.

The transfer roll member is closed at both ends by means of a pair of dielectric end caps **35, 36** which serve to electrically isolate the transfer roll member from the supporting machine frame. Segmented shafts **37** are secured in both end caps and are mounted in coaxial alignment with the cylindrical core **31.** The shafts, in turn, are journaled for rotation in the machine frame in bearing means provided so that the outer surface of the roll continually moves through the transfer zone in continuous contact with the photoconductor **13.** A pulley **38,** operatively connected to the machine's main drive system is secured to one end of the shaft and causes the transfer roll to be rotated in predetermined time relation with the moving photoconductive drum. A commutator ring **40** (FIG. **1**) is embedded in the end cap **35** and is arranged to pass through the cap so as to communicate electrically with the metal core **31.**

As shown in FIG. **1,** a commutating brush **41,** which is electrically connected to a suitable source of DC power via electrical connector **42,** is arranged to ride in contact with the outer surface of the commutator ring and thus provides a moving contact by which the conductive core is electrically connected, via line **42,** to biasing source **43.** In practice, any source of electrical power capable of placing the transfer roll member at a potential capable of attracting toner particles, brought into the contact region, from the photoconductive drum towards the roll surface may be employed in the practice of the present invention.

The field strength associated with the electrically isolated transfer roll member is dependent upon the presence of a voltage contrast. A relatively strong electric force field is established between the transfer roll member and the grounded photoconductive drum within the transfer region; the strength of the force field being directly proportional to the initial charge voltage placed on the transfer roll and inversely proportional to the distance between the two contacting bodies. In order to maximize the transfer efficiency, it is preferred that the transfer roll be arranged to move through the transfer region in contiguous relation with the photoconductive plate.

Subsequent to the formation of the first right reading image upon the drum, a second area on the photoconductive surface thereof is again uniformly charged by means of the charging corotron **15.** This second uniformly charged area is then moved past exposure means **17** causing the photoconductor to be exposed to a flowing light image composed of additional input scene information and a wrong reading latent electrostatic image is formulated on the drum surface. To produce this wrong reading latent electrostatic image roof mirror **21** is interposed into the optical light path of the system replacing mirror **20.** This wrong reading latent electrostatic image is then transported on the moving drum surface to the development system and the second image is made visible in a manner similar to that herein described in reference to the first right reading image.

The time sequence of charging, exposing and developing the two oppositely reading images on the drum surface is controlled in predetermined timed relation by means of the machine control logic circuitry (not shown). Of course, the particular selection of the timed sequence of operation may be dependent on many fac-

tors, such as the location of the various processing stations around the drum surface, the length and velocity of the image storage member relative to the size of the drum surface, and the like. For convenience of illustration, the circumference of the transfer roll is deemed to be approximately one-half that of the photoconductive drum. The two members are driven at the same peripheral speed so that the first image, that is, the image stored on the transfer roll, is transported around a circular path of travel and delivered into the transfer station at approximately the same time that the second developed image arrives therein.

Accordingly, the leading edges of the two images lying respectively on the storage drum and the xerographic drum surface, confront each other at approximately the same moment. However, prior to bringing the two toner images together within the contact region, a sheet of final support material, such as paper or the like, is secured to the transfer roll member in a manner wherein the sheet overlies the first image supported thereon. A sheet gripping device is herein provided to align and secure individual sheets of material to the transfer roll. Basically, two sheet aligning and gripping assemblies **60** (FIG. 3) are supported on spaced parallel alignment within the transfer roll and are arranged to act upon the leading edge corners of a support sheet brought into operative communication therewith. Each assembly is made up of two main components, a lever arm component **63** and a lifting component **64** and are supported upon a common base plate **65** that is rigidly affixed to the inner walls of the roll member upon a mounting bracket **66.** The mounting bracket also serves to rotatably support a control shaft **67** which runs longitudinally across the interior of the roll and extends through the end cap **36** (FIG. 2).

Each lever arm component is rotatably secured to bracket **66** by means of a pin **68** and the arm arranged to rotate within opening **69** provided in the roll. Lifting element **64** is secured to the control shaft **67** and is adapted to move in cooperation therewith. The cam portion **70** on the lifting element is biased into contact with the bottom surface of the lifting arm by means of a spring **71.** A cam follower **79** (FIG. 2) is secured to the extended end of the control shaft and rides in contact with a profile surface **80** which is arranged to impart a predetermined motion to the lever arm **63.**

In operation, individual sheets of support material **82** are forwarded from a supply bin (not shown) or the like into a sheet receiving station **83** (FIG. 1) by means of a feed roll assembly **27.** At this time, tabs **84** on the lifting arms are elevated slightly above the roll surface and the sheet driven into alignment against stop faces **85.** Once aligned, the tab elements are moved downwardly locking the sheet against recess surface **87.** In the locking position, the entire gripping mechanism is retracted below the roll surface a distance sufficient to allow the roll to move freely through the contact or transfer zone.

With the leading edge of the sheet secured to the roll, the roll continues to rotate in the direction indicated and then the trailing portion of the sheet allowed to move in contact with the roll over the first image thereon. The first image, with the support sheet in contact therewith, is recirculated through the transfer zone in synchronization with the second image carried on the photoconductive drum. As the second image passes through the directional force field within the transfer region, it is electrically transferred from the photoconductor to the outer surface of the final support sheet.

After transfer, the support sheet is moved on the roll surface under the influence of a corona generator **55** similar to that described in the previously noted Vyverberg patent. The generator is positioned in a region of relatively low voltage contrast, that is, in a region wherein the biased roll does not electrically communicate with another voltage source. It should be understood that the term voltage source, as herein used, is broad enough to include a grounded body or the like. The generator is adapted to apply corona to the top side of the support sheet of a polarity to cause the first image to be transferred from the transfer roll to the bottom side of the support sheet. Alternately, the bias potential on the roll can be removed prior to applying a corona to the support sheet.

With the two toner images thus electrically adhering to opposite sides of the final support sheet, the sheet is once again transported on the roll surface into loading station **83** and the sheet removed from the transfer roll. To accomplish the intended sheet removal, the two lever arms **63** of the gripping mechanism are moved to a fully extended position as shown in FIG. **3.** The sheet is thus elevated well above the roll surface causing the leading edge portion of the sheet to be stripped from the roll. The stripped portion of the sheet is operatively engaged by a forwarding mechanism **88** which advances and guides the leading edge of the sheet into the nip of fuser **90.** A high volume-low velocity air transport is established under the stripped portion of the support material thereby preventing the sheet from falling back into contact with the roll. This high volume-low velocity air transport is created by means of a discharge manifold **89** positioned adjacent to the roll surface as shown in FIG. **1.** The manifold has a series of nozzle openings provided therein capable of discharging an aeriform fluid in a manner to produce a barrier or cushion capable of supporting and directing the leading edge of the stripped sheet into the nip of pressure roll fuser **90.** The aeriform fluid is delivered by the manifold at a volume and a pressure sufficient to support the stripped sheet of material, but insufficient to disturb the xerographic toner image supported thereon. Fur further information concerning this type of aeriform transport, reference is had to U. S. Pat. No. 3,506,259 filed in the name of Caldwell et al.

Although any fusing device capable of fixing the toner images to both sides of the final support material may be employed in the practice of the present invention, fuser **90,** shown in FIG. **1,** is basically of the heat pressure fixing type. The fuser basically is composed of two heated cooperating roll members adapted to rotate in the direction indicated so as to support the sheet of final support material in pressure contact therebetween. Sufficient heat and pressure in the energy are delivered by the rolls into the imaged areas to permanently bond the toner to the support sheet. After the images are permanently affixed to both sides of the support sheet, the sheet is advanced to a collecting tray **93** wherein the duplexed copies are collected and stored.

Finally, the rotating photoconductive surface is brought into operative communication with a fibrous brush member **50** that is moving at a speed sufficient to dislodge any residual toner remaining on the drum surface after the transfer operation. The residual toner is then collected and removed from the apparatus.

The operation of the present duplexing apparatus will be explained in greater detail with reference to FIG. 4–8. Initially, a negatively charged first right reading image 50 (FIG. 4) is formulated on the photoconductive drum 10 and the image transported thereon into transfer zone 26. A potential of between 2,000 and 3,500 volts DC is applied to the transfer of transfer roll 30 by means of a suitable biasing source 43. As the image passes through the transfer zone, it is electrically transferred in image configuration from the photoconductive surface to the surface of the transfer roll member where the image is temporarily stored.

The stored image is transported on the transfer roll over a closed path of travel as shown in FIG. 5 so that the image will be eventually reintroduced into the transfer zone. During this time, a second negatively charged wrong reading toner image 53 is formed on the photoconductive drum and is being carried towards the transfer station on the drum in synchronization with the first image on the transfer roll whereby the leading edges of both images will enter the transfer zone at approximately the same time. However, as illustrated in FIG. 5, a sheet of final support material 82, such as paper or the like, is first delivered into the transfer station 83 just prior to the arrival thereof of the first toner image and the front edge of the final support sheet is aligned and secured to the transfer roll surface by gripping means 60 in a manner herein described.

As shown in FIG. 7, the first and second toner images move into the contact region 26 in a manner wherein the support sheet is sandwiched therebetween. As the support sheet moves through the region of high voltage contrast, i.e., the transfer zone 26, the second image is attracted from the photoconductive surface to the outside surface of the support sheet. In effect, the first image is now electrically held to the transfer roll and the second image is electrically held to the support sheet.

As the roll continues to rotate in the direction indicated (FIG.8) the biasing source is inactivated by means of a switch 56 and a transfer corotron 55 actuated. As noted above, the outside surface of the final support sheet is now treated with a positive corona which electrically tacks the second image to one side of the sheet while, simultaneously therewith, causes the first image to be electrically transferred from the roll surface and tacked to the opposite side of the sheet. It has been found that a conventional corona generator of the type herein described operating at about 10 microamperes per linear inch can effectively transfer the first image to the final support in the manner herein described when the apparatus is operating at speeds in excess of 20 inches per second and the generator being positioned approximately ⅜ inch above the transfer roll surface. The output of the corona generator can be measured by mounting a conductive strip of known surface area upon an insulating base and placing the base the desired distance from the generator. By electrically connecting the strip to the corona generator shield, and measuring the current flow therebetween, the output of the generator can be determined.

Finally, as shown in FIG. 8, the support sheet is stripped from the transfer roll surface and delivered into the fuser assembly wherein the toner images are permanently affixed to the support sheet.

In the above disclosure, there is described a preferred method of effectively creating a duplexed reproduction of desired input information. For the sake of convenience, reference has been made throughout this specification to developing the photoconductive belt surface with negatively charged toner particles. It should be understood, however, that this description of the specific nature of the charges involved is not intended to limit the invention to any specific charge relationships. FOr instance, it would be possible to utilize a carrier material and a toner material having different charge relationships in regard to their triboelectric properties whereby the toner applied to the photoconductive belt would be positive in nature. This, of course, would call for a similar change in the relationship of all the charges involved. Therefore, all references to positive or negative charges in this specification are considered as merely defining a relationship and it should be clear that the teachings of the present invention can be practiced as long as these relationships are maintained.

While this invention has been described with reference to the structure disclosed herein, it is not necessarily confined to the details as set forth and this application is intended to cover such modifications or changes as may come within the scope of the following claims.

What is claimed is:

1. Apparatus for producing a duplex copy including means to sequentially formulate a first and a second image of charged toner grounded on a moving grounded photoconductive surface,

a biased transfer roll bearing a charge opposite to that of said toner arranged to move in timed relation with said photoconductive surface through a region of electrical communication with said photoconductive surface wherein a first toner image is electrostatically transferred from the photoconductive surface to the roll surface and recirculated thereon through said region in synchronization with said second image on the photoconductive surface,

gripping means operatively associated with said transfer roll to, and in electrical contact with, secure a sheet of final support material to said transfer roll with a first side of said sheet overlying said first image prior to recirculating said first image through the region of electrical communication wherein said second image is electrostatically transferred to the second side of said sheet,

corona generating means positioned in a region of low voltage contrast to apply corona to the second side of said sheet to transfer electrostatically said first image from said roll surface to said first side of said sheet,

switching means synchronized with said transfer roll to remove the bias from said transfer roll and to energize said corona generating means after said second image is transferred to said sheet to transfer said first image from said transfer roll to said sheet and

means to strip said sheet from said transfer roll including said means for securing the sheet to said transfer roll, whereby said second and first images are sequentially transferred to said sheet.

2. The apparatus of claim 1 having further means to fix the toner images to opposite sides of said support sheet.

3. The apparatus of claim 1 wherein said gripping means to secure a sheet of final support material to said transfer roll includes sheet gripping means coupled to the transfer roll.

* * * * *

UNITED STATES PATENT OFFICE
CERTIFICATE OF CORRECTION

Patent No. 3,734,015 Dated May 22, 1973

Inventor(s) Thomas Camis and Steven A. Goss

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

IN THE CLAIMS:

Claim 1, line 3, delete "grounded";

Claim 1, line 15, delete ", and in electrical contact with,";

line 16, after "to" insert --, and in electrical contact with--.

Signed and sealed this 27th day of November 1973.

(SEAL)
Attest;

EDWARD M. FLETCHER, JR.
Attesting Officer

RENE D. TEGTMEYER
Acting Commissioner of Patents

FORM PO-1050 (10-69)

USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334.

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Attesting Officer

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USCOMM-DC 60376-P69
* U.S. GOVERNMENT PRINTING OFFICE : 1969 O—366-334.