United States Patent

Sullivan

[15] **3,697,171**

[45] **Oct. 10, 1972**

[54] SIMULTANEOUS IMAGE TRANSFER

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

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

[21] Appl. No.: **100,970**

[52] **U.S. Cl.** ....**355/17,** 96/1 R, 96/1.4, 355/3, 355/14, 355/16, 355/24, 355/26

[51] **Int. Cl.** **G03g 13/00,** G03g 15/00

[58] **Field of Search**............355/17, 3, 11, 14, 16, 26, 355/24; 96/1 R, 1 A, 1 C, 1.3, 1.4

[56] **References Cited**

UNITED STATES PATENTS

3,318,212	5/1967	Rubin	355/24 X
2,817,765	12/1957	Hayford et al.	96/1 X

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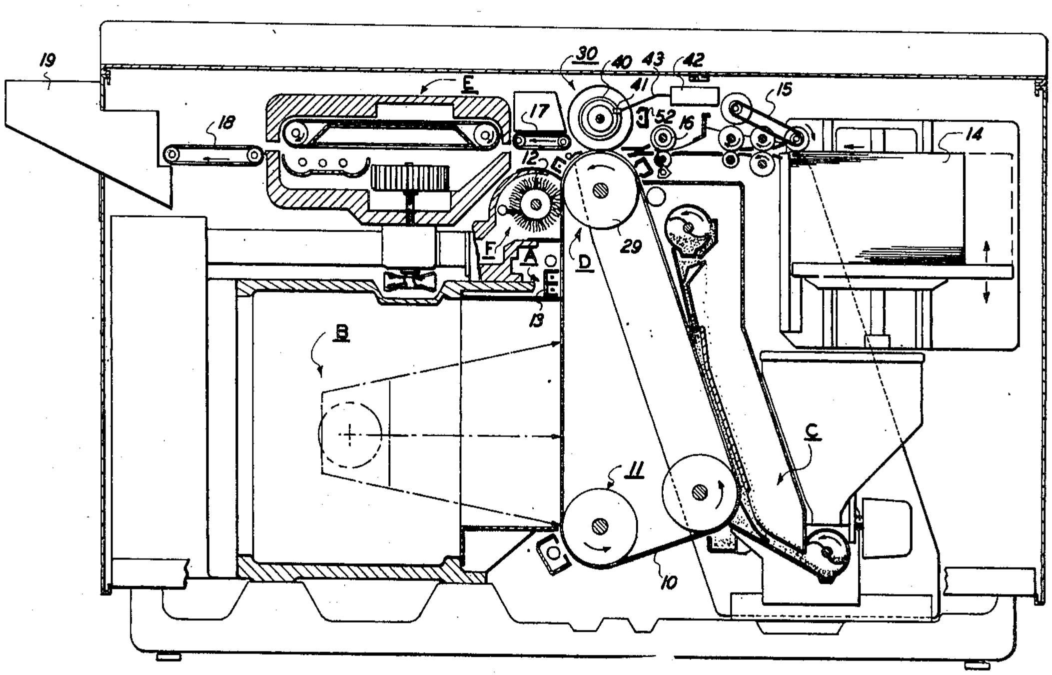
[57] **ABSTRACT**

Toner images are sequentially formulated on a photoconductive element. A biased transfer member, adapted to electrically coact with the photoconductor, is brought into operative communication therewith so that a first image is attracted from the photoconductor to the biased member. The image on the member is transported to a region of low voltage contrast and the charge on the image is reversed. A sheet of final support material is brought into contact with a second image on the photoconductor and simultaneously therewith, the first image on the biased member is applied to the opposite side of the sheet whereby the two images are electrostatically transferred to the sheet.

4 Claims, 8 Drawing Figures



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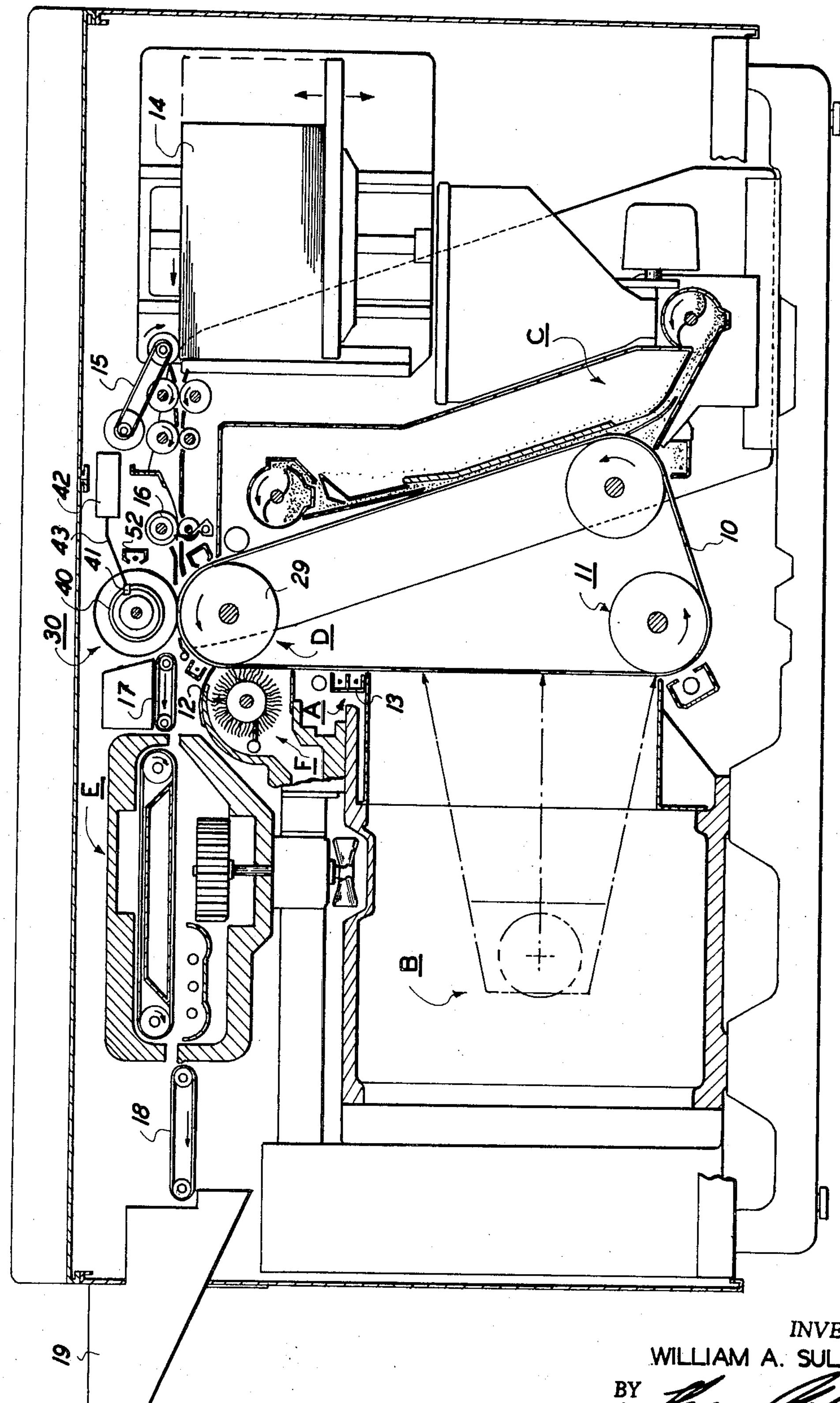

FIG. 1

INVENTOR.
WILLIAM A. SULLIVAN
BY [signature]
ATTORNEY

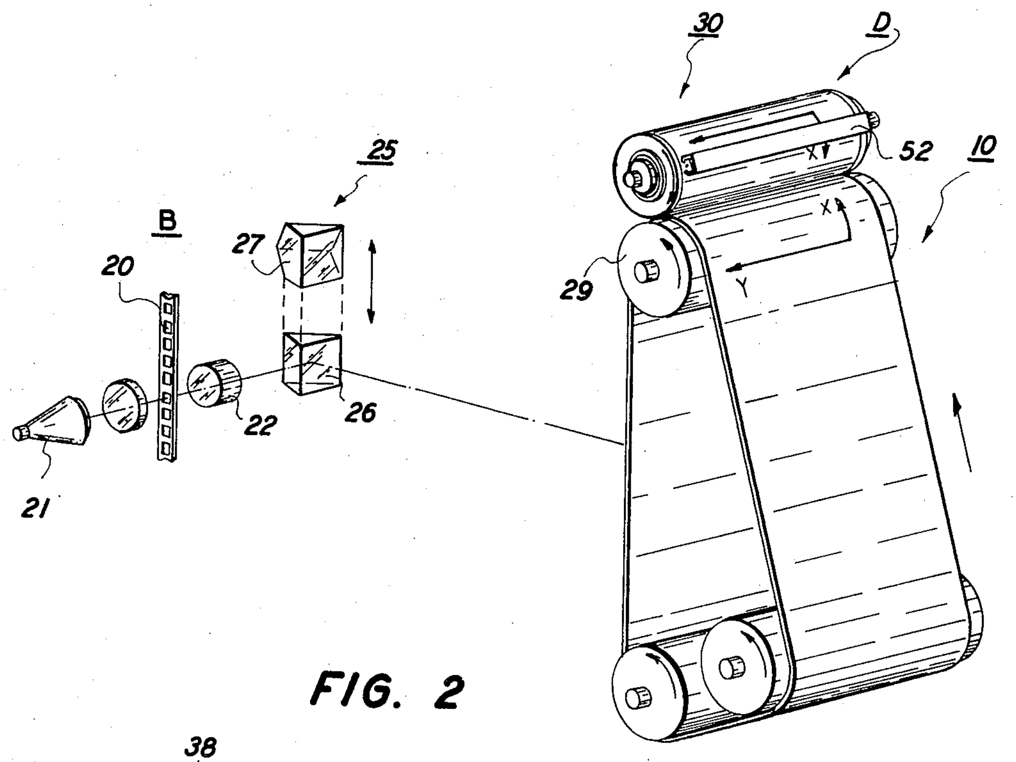

FIG. 2

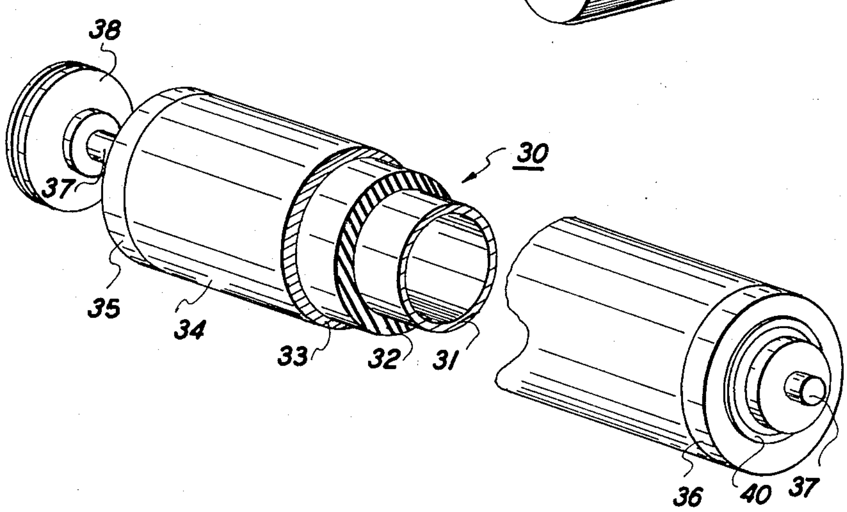

FIG. 3

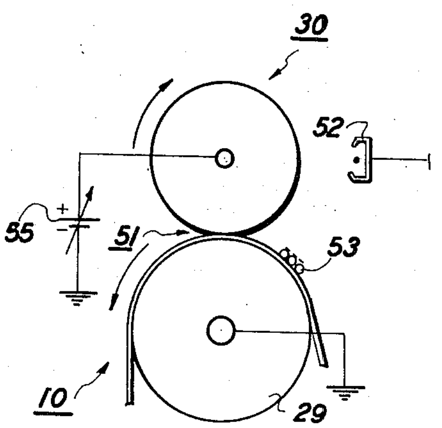

FIG. 4

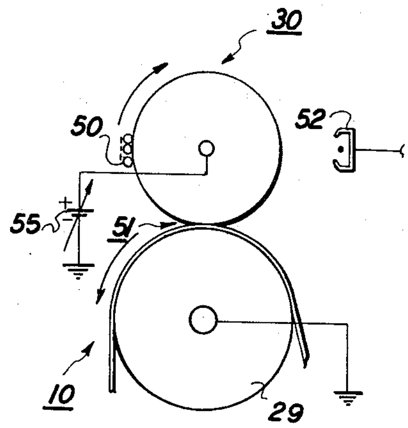

FIG. 5

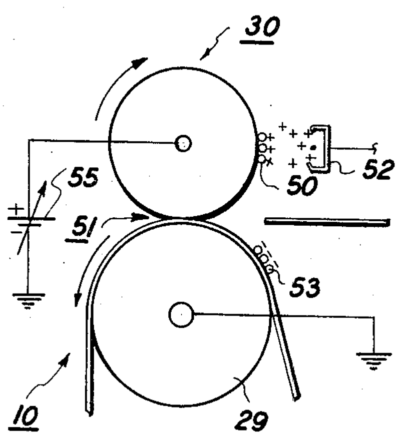

FIG. 6

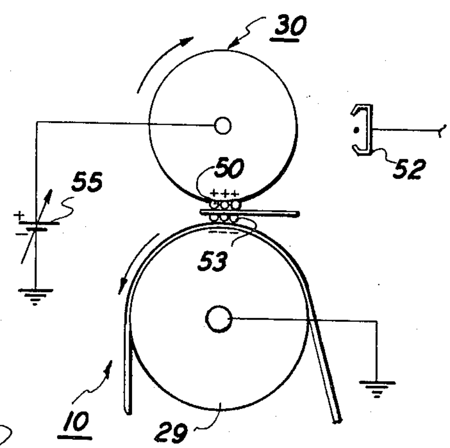

FIG. 7

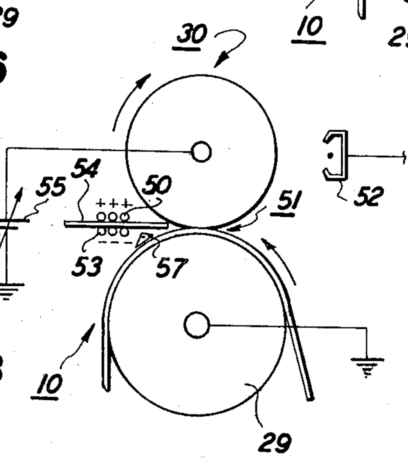

FIG. 8

SIMULTANEOUS IMAGE TRANSFER

This invention relates to method and apparatus for producing copy having original input data recorded on both sides thereof. More specifically, this invention relates to a xerographic method for producing duplex copy.

Rubin, in U.S. Pat. No. 3,318,212 discloses xerographic reproducing apparatus for placing images simultaneously on both sides of a single sheet of final support material. To accomplish this end, Rubin formulates two charged toner powder images on the surface of a photoconductive plate and then transfers the images onto separate storage drums. While on the surface of the storage drums, each of the toner images is tackified by application of a solvent vapor. In order to prevent the tackified images from adhering to the drum surface, the outside of each drum is covered with a Teflon coating and the Teflon treated with silicone oil. The tackified images are then pressed into contact with opposing sides of a receiving sheet, such as paper or the like, whereby the images adhere to the support sheet. As the support sheet is separated from the drums, the images are pulled or stripped from the oil treated drum surfaces completing the transfer operation.

Although the techniques disclosed by Rubin provide a satisfactory means for producing duplex copy, the process nevertheless suffers from certain apparent disadvantages that limit its application, particularly in the xerographic process. Complex vapor sealing means must be employed to contain the solvent vapor within the system. Upon tackification, the toner images must be rapidly applied to the final support sheet in order to obtain complete image transfer. This, of course, presents an undesirable timing and control problem. Contacting the final support sheet with an oily storage drum has also been found to be objectionable because, invariably, some of the oil is transferred from the drum to the final support material reducing the quality of the copy produced.

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.

Another object of this invention is to provide a relatively simple and efficient means of xerographically producing duplex copy.

Yet another object of this invention is to eliminate the use of a solvent vapor in xerographic duplexing apparatus.

A still further object of this invention is to simultaneously transfer dry toner images to both sides of a final support sheet.

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 transfer roll, the roll being biased to a potential sufficient to attract toner images from the plate to the roll surface, and storing the toner image on the roll as a second dry toner image is being formulated on the photoconductive plate. After reversing the polarity of the first image, while the image is stored on the roll surface, the two toner images are simultaneously brought into contact with opposite sides of a final support sheet. Because of the nature of the electrostatic relationships involved, the first image is repelled from the surface of the transfer roll and electrostatically tacked to one side of the support sheet while, simultaneously therewith, the second toner image is attracted from the photoconductive plate and electrostatically tacked to the opposite side of the support sheet.

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 showing the exposure mechanism for sequentially recording images on the surface of the photoconductive plate of the apparatus illustrated in FIG. 1;

FIG. 3 is a perspective view in partial section showing the construction of a transfer roll suitable for use in the apparatus illustrated in FIG. 1;

FIGS. 4–8 are diagramatic views illustrating the process operations involved for transferring toner images to both sides of a final support sheet.

For a general understanding of the xerographic reproducing apparatus incorporating the teachings of the present invention, reference is now had to FIGS. 1–3. As in most conventional electrophotographic reproducing devices of this type, a photoconductive plate is first charged uniformly and then exposed to a light image of the original subject matter to be reproduced to selectively dissipate the charge in the light struck regions whereby the original input scene information is recorded on the plate surface in the form of a latent electrostatic image. Thereafter, the latent image is developed by contacting the more highly charged areas on the plate surface with an oppositely charged electroscopic marking powder, i.e. toner, thus producing a visible image corresponding to the original input scene information. The toner image is generally transferred in some manner to a final support sheet, such as paper or the like, and the image affixed thereto to form a permanent record of the original.

For explanatory purposes, the original subject matter to be reproduced is illustrated in FIG. 2 in the form of minified data stored upon a film strip 20. However, it should be clear to one skilled in the art that any type of input data may be employed in the present apparatus without departing from the teachings of the present invention. Initially, a uniform electrostatic charge is placed upon xerographic plate 10 at charging station A (FIG. 1) by means of a corona generator 13 similar to that disclosed by Vyverberg in U. S. Pat. No. 2,836,725. In this preferred embodiment, the plate is in the form of an endless belt comprising a photoconductive outer layer placed over a conductive backing. The belt is slidably mounted within the machine frame upon a belt assembly 11 and is arranged to move at a constant rate in the direction indicated. For further information concerning this type of belt assembly reference is had to U.S. Pat. No. 3,500,694.

In operation, the sensitized belt is subsequently moved through an exposure station B. The moving photoconductive surface is flash exposed by means of a light image of the original input scene to record a latent electrostatic image thereon. During exposure, the film strip 20 is sequentially illuminated by means of illumination source 21 to create a spatial light image containing the original input scene data. The spatial image is then passed through a lens 22, which serves to both expand and focus the light image in the plate of the photoconductor, and an image reflecting system, generally referenced 25. For reasons which will become apparent from the disclosure below, the projection of the light image through the reflecting system is achieved alternately by means of a reflecting prism 26 and a roof prism 27 disclosed in U.S. Pat. No. 2,940,358. The reflecting prism and the roof prism are arranged to be selectively interposed into the optical light path of the system to transmit either a right reading or a wrong reading image onto the surface of a photoconductive plate. In practice, the exposure apparatus is programmed such that a right or direct reading image is first created on the sensitized belt surface.

Upon the formation of the first right reading latent electrostatic image, the image is transported on the moving belt surface through a cascade development station C. Here a two component developer material, which is made up of finely divided charged toner particles transported on the surface of relatively coarser carrier beads, is cascaded or poured over the plate surface. The toner particles, being charged to a polarity opposite that of the latent electrostatic image, are attracted into the imaged areas thereby making the image visible. For explanatory purposes, the plate will be herein deemed to be initially charged to a positive potential and is developed using a negatively charged toner.

The now visible first toner image is next transported to a transfer station D where the image is temporarily transferred and stored in image configuration upon the surface of an intermediate transfer roll member 30. The transfer roll is arranged to cooperate with backup roll 29, which forms part of the belt drive assembly 11, to secure the photoconductive surface in moving contact against the transfer roll. Image transfer is accomplished electrically in the contact region by placing the transfer roll at a bias potential sufficient to attract the charge toner particles from the photoconductive surface towards the transfer member. Roll 29, which contacts the conductive backing of the belt, is placed at a ground potential and coacts electrically with the biased transfer roll to establish a relatively strong force field in and about the contact region.

Referring more specifically to FIG. 3, 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 made of a conductive metal such as aluminum or the like capable of supporting a biasing charge. Over the core is placed a relatively thick intermediate blanket 32 fabricated of an elastomeric material. The intermediate blanket is preferably made of a polyurethane rubber having sufficient resiliency to allow the roll to deform when brought into moving contact with the photoconductive belt thus providing an extended contact region in which image transfer is achieved. The intermediate blanket should be capable of electrically imparting the charge potential on the roll core to the outer extremities of the roll and therefore the blanket should have a resistivity of between 10^8 and 10^{13} ohms cm. Over the intermediate blanket is placed a relatively thin coating 33 which is also formulated of an elastomeric material. In order to prevent ionization of the air, in and about the contact region, it is preferred that the outer coating of the roll have a resistivity of about 3.2×10^{14} ohms cm. It is also preferred that the outer coating of the roll should be formulated of a material capable of providing a relatively smooth surface exhibiting good mechanical release properties in respect to the toner material employed. A polyurethane material manufactured by the du Pont Company under the tradename "Adiprene" has been found to possess the required electrical properties as well as showing extremely good release properties 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 and 36 serving to electrically isolate the roll member from the supporting machine frame. Segmented shafts 37 are secured in both end caps co-axially aligned with the cylindrical core 31 and the shafts journaled for rotation within the machine frame by means of a bearing (not shown). A pulley 38 (FIG. 3), operatively attached to the machine's main drive system, is secured to one of the shafts and rotates the transfer roll in predetermined timed relation with the moving photoconductive belt 10. A commutator ring 40 is embedded in end cap 36 and is arranged to pass through the end cap to communicate electrically with the metal core 31. As shown in FIG. 1, a commutator brush 41, that is electrically connected to a variable source of DC power via electrical connector 43, is arranged to ride in contact with the outer surface of the commutator ring and provides a moving contact by which the conductive core is electrically connected to the biasing source. In practice, any source of electrical power capable of placing the transfer roll member at a potential sufficient to attract toner images from the photoconductive belt towards the roll may be employed in the practice of the present invention. However, it is preferred that a variable biasing source capable of maintaining the roll member at various discrete DC levels be herein employed.

In operation, the first developed toner image introduced into the transfer zone is attracted in image configuration from the photoconductive belt onto the transfer roll surface. After transfer, as the roll continues to rotate in the direction indicated, the image stored thereon is transported through a circular closed path of travel and reintroduced into the transfer station. However, prior to delivery into the contact region, the polarity of the first toner is reversed so that the image carries a charge similar in polarity to that applied in the transfer roll into the transfer zone. It is found that this unique charge reversal operation can be accomplished without deleterious effects to the image by applying corona to the image in a region where little or no voltage contrast exists between the roll and some other body.

The field strength associated with the electrically isolated transfer roll member is dependent upon the presence of a voltage contrast. For instance, a relatively strong force field is established between the roll member and the grounded photoconductive belt in the transfer region with the strength of the force field being proportional to the initial charge voltage on the transfer roll member and inversely proportional to the distance between the two contrasting bodies. However, where there is no voltage contrast, such as between adjacent regions on the roll surface, there will be little or no force field present. With the exception of the photoconductive belt, the roll surface is isolated from other bodies. The force field associated with the biased member as it moves through its circular path of travel therefore is relatively weak. A corona generating device **52**, similar to that disclosed in the previously noted Vyverberg patent, is positioned within this region and is arranged to apply corona to the first toner image supported thereon, prior to reintroducing this image into the contact region, to change the polarity of the image.

Subsequent to the formation of the first right reading image, a second area on the moving photoconductive surface is uniformly charged by means of charging corotron **13**. The second charged area is moved into the exposure station B wherein a wrong reading latent electrostatic image containing additional subject matter to be reproduced is formed on the sensitized surface of the belt. To produce this wrong reading electrostatic image, the film strip **20** (FIG. **2**) is advanced to present a new original to the exposure mechanism and, at the same time, the roof prism **27** is positioned in the optical light path of the system to replace the reflecting prism **26**. A second exposure is then made to create a latent electrostatic image on the plate. The second image is transported to developing station C wherein the image is made visible in a manner similar to that herein described in reference to the first direct reading image.

The timed sequence of charging, exposing and developing of the two oppositely reading images is programmed in the present apparatus so that the leading edge of the second toner image moves into the transfer station in synchronization with the leading edge of the first image stored on the transfer roll surface. However, before the two images come together, a sheet of final support material is inserted into the nip formed between the transfer roll and the moving belt surface.

The individual sheets of final support material are separated from a supply stack **14** (FIG. **1**) and advanced toward the transfer station by means of the sheet forwarding mechanism **15**. Prior to entering the transfer station, however, the leading edge of each support sheet is registered and aligned in relation to the two toner images by means of sheet registering mechanism **16** and the sheet advanced into the contact region slightly in advance of the leading edges of the toner images. As can be seen, the two oppositely charged toner images are thus brought into moving contact with opposite sides of the final support sheet. Because of the nature of the force field established in the contact zone, the first image stored on the transfer roll surface is repelled from the transfer roll onto one side of the support sheet and, simultaneously therewith, the second oppositely charged image supported on the photoconductive surface is attracted from the belt to the opposite side of the support sheet.

After transfer, the image bearing support sheet is conveyed by means of a transport system **17** (FIG. **1**) into a fusing station E wherein the images are affixed to the support sheet to form a permanent duplex copy containing the original input scene information. Fixing of the image can be accomplished by means of any suitable xerographic fusing device. The fixed copy is then transported by means of a conveyor belt **18** to a discharge station **19** wherein the copy sheets are collected. Finally, any residual toner remaining on the belt surface after the transfer operation is removed at a cleaning station F by contacting the photoconductive surface with a fibrous brush member **12**, the brush fibers of which are arranged to rapidly move in contact with the photoconductive belt.

The duplexing operation of the present invention will be explained in greater detail with reference to FIGS. **4–8**. As shown in FIG. **4**, a first right reading negatively charged image **50** is transported on the photoconductive belt from the developing station into the nip **51** formed between transfer roll **30** and the photoconductive belt as it passes over a grounded backing roll member **29**. The transfer roll is initially placed at a high positive bias, generally in the range of approximately 3,500 volts DC by means of a suitable variable voltage supply **55**. A region of high voltage contrast is established in and about the nip **51** so that the first image moving through the nip is transferred, in image configuration, from the photoconductive surface to the transfer roll. As seen in FIG. **5**, the image is temporarily stored on the roll surface and, as the roll continues to rotate in the direction indicated, is transported around towards the transfer zone.

After the first image is transferred to the surface of the transfer roll, but before the image is reintroduced into the nip **51**, the bias potential on the transfer roll is decreased from about a positive 3,500 volts to approximately a positive 2,400 volts DC to prevent ionization of the air in and about the transfer zone during the next subsequent image transfer operation.

After a reduction in the transfer roll voltage has been accomplished, the first image on the transfer roll is brought under the influence of a corona generator **52** similar to that described in the previously mentioned Vyverberg patent. The generator is located some distance from the nip **51** in an area of extremely low voltage contrast. The polarity of the originally negative first image is made positive by subjecting the toner image to a discharge of positive ions emitted by the corona generator. Complete reversal of the image charge potential has been achieved by positioning the corona generator at approximately one-half inch above the surface of the transfer roll and operating the generator at a current output of approximately 22 microamperes per linear inch. The current output of the generator is generally determined by mounting a conductive strip of known surface area on an insulating base and electrically connecting the strip to the shield of the corona generator. The test strip is then placed the desired distance from the generator and the current flow between the grounded generator shield and the conductive strip noted.

During the period in which the first image is being transferred and stored on the transfer roll surface, a second wrong reading image **53** (FIG. **6**) is developed on the photoconductive belt surface. The formation of the second powder image is programmed in timed relation with the first image so that corresponding regions on the two images approach the transfer zone in synchronization with each other. However, just before the two images are brought together, a sheet of material such as paper **54** is forwarded from the registration means and inserted into nip **51**.

As seen in FIG. **7**, the two oppositely charged toner images being transported into the nip are brought into moving contact with opposite sides of the final support sheet. As the images move through the region of high electrostatic contrast, the now positively charged first image on the transfer roll surface is repelled from the transfer roll and is electrostatically bonded to the top side of the final support sheet. Simultaneously therewith, the negatively charged second toner image, supported on the photoconductive belt surface, is electrostatically attracted to the opposite side of the support sheet.

Finally, as illustrated in FIG. **8**, the final support sheet, having the two images electrostatically tacked thereto, is removed from the photoconductive belt surface by means of a mechanical stripping finger **57** and the sheet advanced to the next xerographic processing station wherein the toner powder images are permanently affixed to both sides of the final support sheet thereby formulating a duplex copy containing the original input scene information.

In this disclosure, there is described a preferred method of effectively creating a duplexed reproduction of predetermined input scene information in which a positively charged photoconductive belt surface is developed with negatively charged toner particles. It should be understood, however, that this description of the specific nature of the charge relationships involved is not intended to limit the invention to these specific relationships. For instance, it is quite possible to utilize a carrier and toner material having different triboelectric properties whereby the toner applied to the photoconductive belt would be positive in nature. This, of course, would require that similar changes be made in the relationship of all subsequent charges. 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 this structure disclosed herein, it is not necessarily confined to the details set forth and this application is intended to cover any modifications or changes as may come within the scope of the following claims.

What is claimed is:

1. The method of simultaneously transferring charged powder images to both sides of a sheet of final support material including
   - formulating a first and a second charged powder image on the surface of an image retaining element,
   - bringing said first formulated image into operative communication with an electrically biased transfer member, said transfer member being biased to a potential to attract said charged powder images from said image retaining element towards said transfer member whereby said first developed image is transferred from a retaining element to said transfer member,
   - changing the polarity of said first powder image on the surface of said transfer member to a polarity similar to that of the biasing potential on said transfer member,
   - contacting one side of the final support sheet with said first powder image on said transfer member and, simultaneously therewith contacting the opposite side of said support sheet with said second powder image on the surface of said image retaining element whereby the images are transferred to said final support material, and
   - reducing the bias potential on said transfer member prior to contacting the final support sheet to prevent air breakdown in and above the contact region.

2. Apparatus for producing duplex copy including
   - means to sequentially formulate a first and a second charged powder image on the surface of a moving photoconductive element,
   - an electrically isolated transfer roll being arranged to move through a transfer zone in operative communication with said photoconductive element,
   - means operable to bias said transfer roll to a potential to attract the charged powder image in said transfer zone from said photoconductor towards said transfer roll,
   - drive means to move said roll in predetermined timed relation with said photoconductor wherein said first image on the photoconductor is electrostatically transferred to the roll and transported thereon over a closed path of travel and recirculated through the transfer zone adjacent to said second image on the photoconductor,
   - corona generating means positioned along the closed path of travel in a region of relatively low electrostatic contrast and being arranged to change the polarity of said first image transported on said transfer roll surface,
   - sheet feeding means operable to interpose a sheet of final support material between the first second images moving through the transfer zone whereby said first image is electrostatically transferred from the transfer roll to one side of the final support material and simultaneously therewith said second image is transferred from the photoconductive surface to the opposite side of said sheet of final support material, and
   - means to reduce the bias potential on said transfer roll prior to recirculating said first image through the transfer zone to prevent air breakdown in and about said transfer zone.

3. Apparatus for producing duplex copy including
   - means to sequentially form a first right reading charged powder image and a second reverse reading charged powder image, with the charged particles in both images charged to the same polarity, said images being formed on a surface of a recirculating photoconductive member,
   - a transfer roll journaled for rotation adjacent the photoconductive member defining a transfer zone wherein charged powder images on the photoconductive member are transferred from the photoconductive member as it moves past the transfer roll, said roll coupled to an electrical potential relative to the potential of the photocon-

ductive member to effect the transfer of charged powder images,

drive means to rotate the roll in predetermined timed relation with the photoconductive member movement for electrostatic transfer of the first image to the transfer roll and for recirculating the first image through the transfer zone simultaneously with the passage of the second image through the transfer zone,

corona generating means adjacent the transfer roll coupled to an electrical potential for depositing electrostatic charge on the first charged powder image to change the polarity of the charged powder relative to the polarity of the charged powder in the second charged powder image and

sheet feeding means supported adjacent said transfer zone to advance a support material between the transfer roll and photoconductive member in register with the images for the simultaneous transfer of the first and second images from the transfer roll and photoconductive member, respectively, to opposite sides of the support material.

4. The apparatus of claim 3 further including means for fixing said first and said second images to the opposite sides of said support material.

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