United States Patent [19]
Johnson

[11] **3,751,157**
[45] **Aug. 7, 1973**

[54] **ELECTROGRAPHIC PRINTER**

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[22] Filed: **Apr. 8, 1971**

[21] Appl. No.: **132,386**

[52] **U.S. Cl.** **355/3**, 355/8
[51] **Int. Cl.** **G03g 15/00**
[58] **Field of Search** 355/3, 8, 45

[56] **References Cited**

UNITED STATES PATENTS

3,628,859	12/1971	Zucker	355/8
2,968,553	1/1961	Gundlach	355/3 UX
2,730,023	1/1956	Greig	355/3
3,055,266	9/1962	Frantz et al.	355/45 X
2,968,552	1/1961	Gundlach	355/3 X
2,852,651	9/1958	Crumrine et al.	355/3 X

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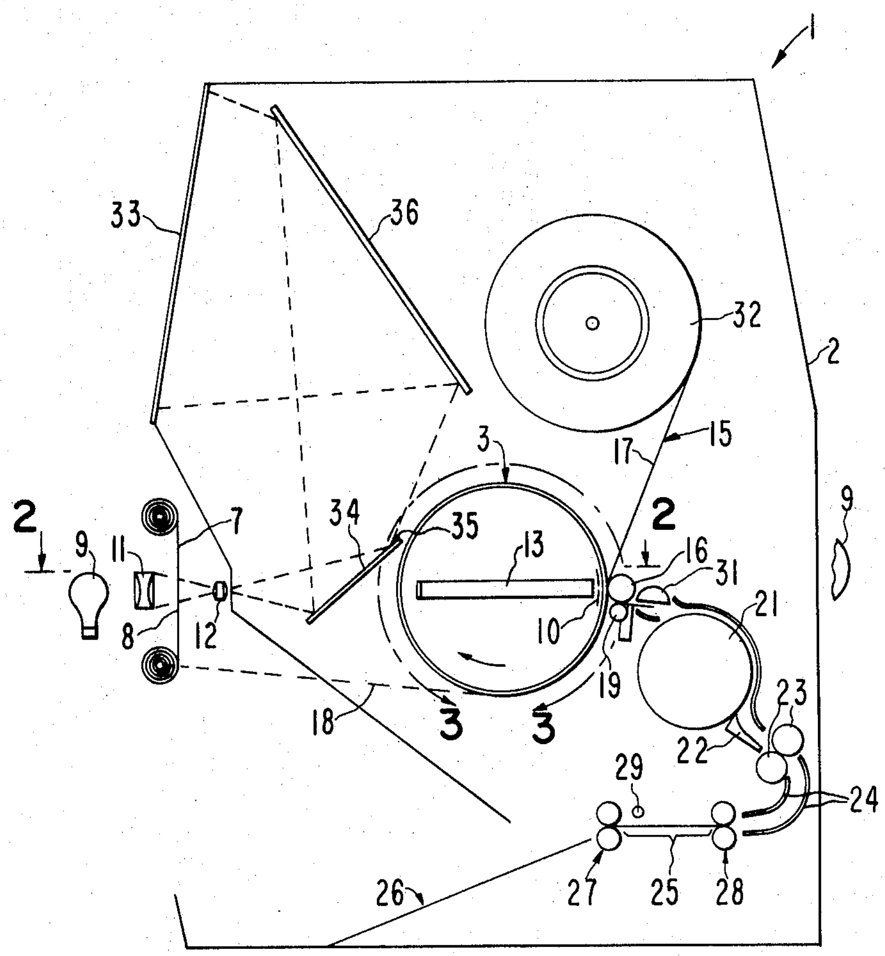
[57] **ABSTRACT**

In an electrostatic copying machine, a transparent cylindrical drum is coated with a layer of transparent conductive material, which serves as a conductive electrode, and which in turn is coated with a photoconductive layer. Optical images to be printed are projected along the axis of the drum to a mirror which reflects them radially onto a thin strip portion of the inside of the photoconductive layer through the transparent layers. Charge is conducted through the illuminated photoconductor to form a charge image on a charge retentive recording web in contact with the outside surface of the drum. The charge image is developed to produce a print of the optical image to be printed.

9 Claims, 3 Drawing Figures



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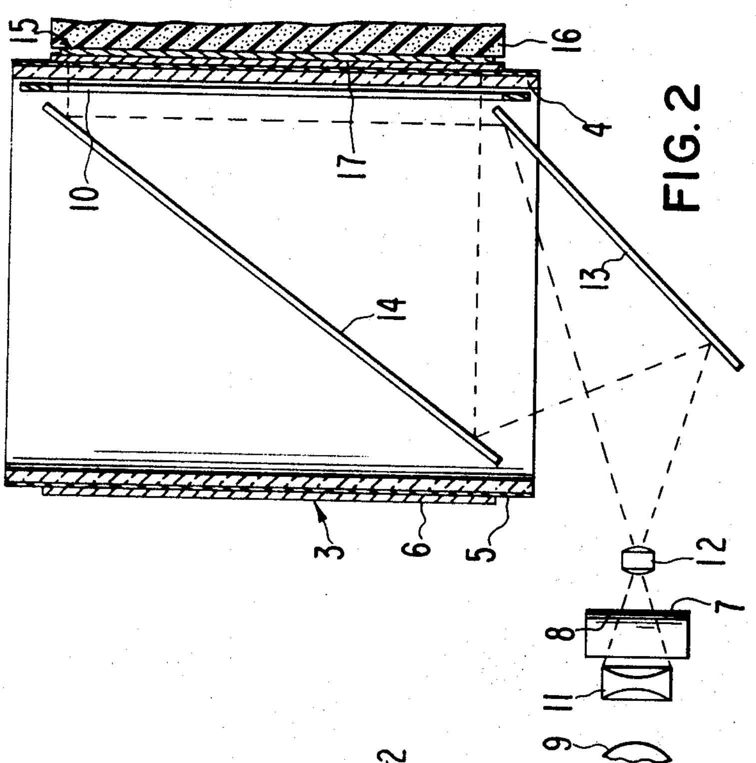

FIG. 2

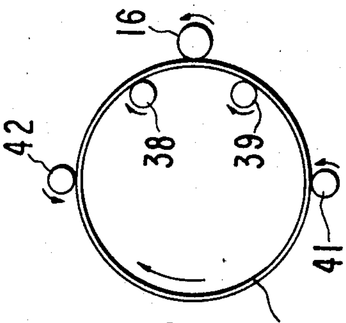

FIG.3

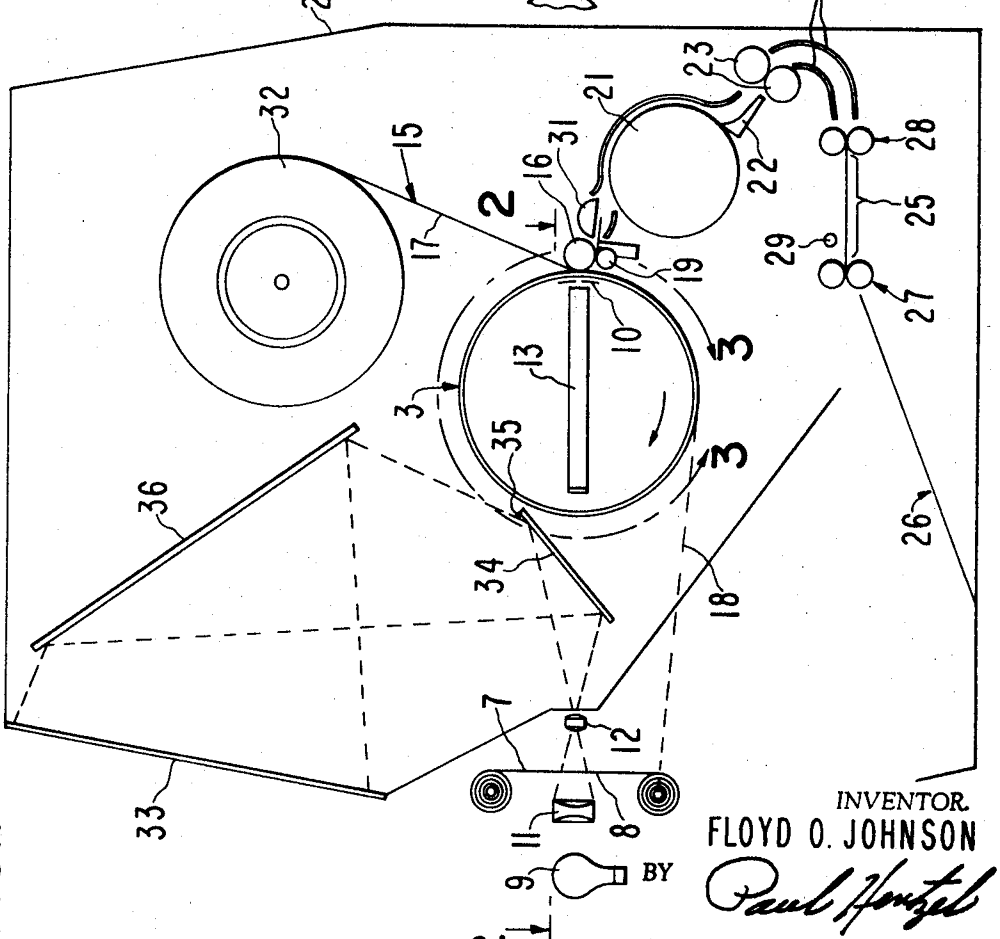

FIG.1

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ELECTROGRAPHIC PRINTER

DESCRIPTION OF THE PRIOR ART

Heretofore, electrographic printers have been proposed which employ a photoconductor deposited in an endless band on the inside surface of an optically transparent drum-shaped electrode. Optical images to be printed were projected onto the photoconductor either from the inside or the outisde of the drum. Charge was conducted through the illuminated photoconductor to produce a charge image pattern on the inside surface of the photoconductor, corresponding to the optical image to be printed. The charge image was transferred to an electrographic recording web inside the drum for subsequent development inside of the drum-shaped photoconductor. Such an electrographic printer is disclosed in U.S. Pat. No. 2,843,084 issued July 15, 1958.

It is also known from the prior art, in electrographic printers, to project an optical image to be recorded axially of the drum-shaped photoconductor and to reflect the image from a mirror inside the drum onto the photoconductor for producing a charge image pattern on the inside of a rotatable photoconductive drum. The charge image was then transferred to an electrographic recording web inside the drum for subsequent development. Such an electrographic printer is disclosed in U.S. Pat. No. 2,730,023 issued Jan. 10, 1956.

While such prior art endless photoconductive members permit printing of endless optical images, they have the disadvantage that the photoconductive drum must be relatively large to accommodate, within its interior, the electrographic recording web and image development stations.

It is also known from the prior art to coat only a semi-cylindrical portion of the outside surface of an optically transparent drum with a photoconductive layer. In this case the optical image to be printed is projected through the uncoated semi-cylindrical half of the drum onto the opposed photoconductive half of the drum. An electrographic recording web was brought into engagement with the illuminated portion of the photoconductive drum, externally thereof, for transferring a charge image pattern to the electrographic recording web. The charge image was developed externally of the drum. Such an apparatus is disclosed in U.S. Pat. No. 2,968,552 issued Jan. 17, 1961. The problem with this latter printer is that the photoconductor did not provide an endless band of material, such that continuous copy length was not obtainable due to the discontinuous nature of the photoconductive layer.

SUMMARY OF THE PRESENT INVENTION

The principal object of the present invention is the provision of an improved electrographic printer.

In one feature of the present invention, an endless band of photoconductive material is circulated around a closed path with an optical image to be printed being projected outwardly of the path through a transparent electrode and onto an inside portion of the endless band of material. Charge is transferred through the illuminated photoconductor, to form a charge image pattern on a charge retentive surface outside of the endless band of photoconductive material, whereby development of the charge image may be performed externally of the endless band of photoconductive material.

In another feature of the present invention, the optical image to be printed is projected axially of the circulating endless band of photoconductive material to a reflector within the band which reflects the image radially thereof onto the inside surface of the photoconductor.

In another feature of the present invention, the optical image projection system includes a viewing screen and means for projecting an optical image of the object over a second optical projection path to the viewing screen for viewing by the operator.

Other features and advantages of the present invention will become apparent upon a perusal of the following specification taken in connection with the accompanying drawings, wherein:

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic longitudinal sectional view of an electrographic printer incorporating features of the present invention,

FIG. 2 is an enlarged, simplified line diagram of a portion of the structure of FIG. 1 taken along line 2—2 in the direction of the arrows, and depicting one of the optical image projection paths for the apparatus of FIG. 1, and,

FIG. 3 is a schematic diagram of a portion of the structure of FIG. 1 delineated by line 3—3 and depicting a method and apparatus for driving the photoconductive drum of FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to FIG. 1, there is shown an electrographic printer 1 incorporating features of the present invention. Printer 1 includes a dark box housing 2 containing therewithin a cylindrical photoconductive drum 3. Details of the drum 3 are shown in FIG. 2.

Briefly, the phtoconductive drum 3 includes an optically transparent cylindrical substrate 4, as of pyrex glass. In a typical example, the pyrex glass has a thickness of 0.075 inch, is 6.0 inches in diameter, and has an axial length of 9.5 inches. A transparent conductive electrode 5, as of tin oxide, is deposited overlying the outer surface of the optically transparent drum 4. In a typical example, the tin oxide is deposited to a depth such that the oxide coating is optically transparent and has an electrical resistivity of approximately 100 ohms per square. A photoconductive layer 6 is deposited overlying the optically transparent electrode 5 to a thickness of approximately 60 microns. A suitable photoconductive layer 6 includes a matrix of cadmium sulfide particles in a glass binder.

An optical image to be printed, such as that produced by projecting light through a microfilm negative 7 is projected onto a thin strip portion of the inside of the photoconductive layer 6 through the transparent substrate 4 and optically transparent electrode 5. More particularly, the microfilm strip 7, comprising a negative of images to be printed, is disposed in a film plane 8. Light from a source 9 is condensed by condensing lens 11 and projected through the film 7 in the film plane 8 to a projection lens 12. The projection lens 12 projects the optical image onto a first mirror 13 of an image projection system.

The image is reflected from mirror 13 in a direction generally axially of the cylindrical photoconductor 6 to a second mirror 14 disposed within the cylindrical photoconductor 6 and inclined at such an angle as to reflect and focus the image onto the inside surface of the photoconductive layer 6. The mirrors 13 and 14 are relatively narrow and they project only a narrow transverse slit-like portion of the optical image onto the photoconductor 6. In addition, a narrow slit iris 10, as of 1/32 inch wide, is provided adjacent the inside surface of the drum 6 to further limit the width of the image projected onto the inside surface of the photoconductor 6.

An electrographic recording web 15 is fed between the rotatable cylindrical photoconductor 6 and an electrically conductive sponge roller 16. The electrographic recording web 15 comprises a conductive paper web coated with a dielectric charge retentive layer 17. The charge retentive layer 17 is brought into nominal contact with the photoconductor 6, whereas the sponge roller 16 makes electrical contact to the back of the charge retentive layer. An electrical potential is applied between the transparent electrode 5 and the conductive backing roller 16 such that charge is transferred through the photoconductor 6 to the charge retentive surface 17 of the recording web 15 in accordance with the pattern of illumination projected onto the inside surface of the photoconductor 6. In this manner, a charge image pattern of the optical image being projected through the microfilm 7 is formed on the charge retentive surface 17 of the recording web 15.

Microfilm 7 is advanced in synchronism with the peripheral velocity of the cylindrical photoconductor 6, as by a suitable gear train or belt and pulley drive, schematically indicated at 18 in FIG. 1. More particularly, if the optical projection system for projecting the image of the microfilm 7 onto the photoconductor 6 has a magnification factor m, then the peripheral velocity of the photoconductor 6 is driven at m times the velocity of the film 7.

Referring now to FIG. 1, the charge image, as deposited upon the charge retentive surface 17 of the electrographic recording web 15, passes between the sponge roller 16 and an idler roller 19 and thence around the outer periphery of a liquid toning drum 21 for development of the charge image upon the charge-bearing surface 17 of the web 15. The liquid toning drum 21 comprises a porous metal development electrode operated at ground potential and contains liquid electrographic toner comprising electroscopic pigment particles suspended in a dielectric liquid. The liquid electrographic toner is forced through the perforated electrographic toning drum 21 against the charge image-bearing surface 17 for developing the charge image on the recording web 15.

The developed electrographic recording web 15 is picked off the toning drum 21 by a pickoff 22 and fed through a pair of squeegee rollers 23 for removing depleted toner from the web. The developed web is then deflected via web deflectors 24 and fed through a drying station 25 and into a copy exit tray 26. The drying station includes two sets squeegee rollers 27 and 28 with an infrared heat lamp 29 disposed between the rollers and over the charge image-bearing surface 17 of the drying web.

A paper cutting station 31 is disposed intermediate the sponge roller 16 and the toning drum 21 for cutting the paper at pre-determined intervals, as determined by a front panel setting of the electrographic printer 1. The idler roller 19 is geared to a paper measuring device which actuates a rotary solenoid for rotating the cutter and cutting the paper after the selected length of paper is passed through the sponge roller 16 and idler roller 19. dielectric-coated electrographic recording web 15 is drawn from a supply roll 32.

A front panel viewing screen 33 is provided to allow the operator to view the microfilm images to be printed. For viewing, a hinged mirror 34, which is hinged at 35, is lowered into position to intercept the entire optical image projected through the projection lens 12. The mirror 34 reflects the entire optical image to a second mirror 36 which is inclined at an angle to the viewing screen 33 for reflecting focused and magnified optical image onto the viewing screen 33 for viewing.

The optical path length of the second optical projection path from the film plane 8 to the viewing screen 33 is the same identical distance as the first optical path length from the film plane 8 to the photoconductor 6. In this manner, the operator sees on the viewing screen 33 the exact image that will be focused upon the photoconductor 6. However, in the case of the viewing screen 33, the operator sees the entire image, whereas the image as projected to the photoconductor 6 includes only a very narrow element of the entire image as projected onto the viewing screen 33.

After the operator is assured that the apparatus is in focus and that he has the desired frames to be printed, he actuates a front panel control which raises the hinged mirror 34 out of the projection path to the photoconductor 6. When the mirror 34 is out of the first projection path, the film 7 is advanced at such a rate as to be scanned in synchronism with the peripheral velocity of the endless band of photoconductor 6, such that the optical image on the film 7 is converted to a charge image, magnified by the magnification factor m, such magnified image being deposited on the charge retentive surface 17 of the web 15 for subsequent development.

As an alternative to the mirror 34 being hinged and moved out of the first optical path for printing, the mirror 34 may be stationary and made only partially reflective, such that a portion of the image is projected to the viewing screen and another portion of the image is projected to the photoconductor 6.

Referring now to FIG. 3, there is shown the various support and drive rollers for driving the cylindrical photoconductor 6 about its longitudinal axis. More particularly, a first pair of drive rollers 38 and 39 are disposed inside the transparent drum 4 near to and on opposite sides of the conductive sponge roller 16. The sponge roller 16 is spring biased toward the two drive rollers 38 and 39 to stabilize rotation of the drum 4 and to provide the frictional drive force between the drive rollers 38 and 39 and the drum 4.

In addition, the spring force on the sponge roller 16 serves to hold the recording web 15 into firm engagement with the photoconductive surface and to synchronize the velocity of the web 15 with the peripheral velocity of the photoconductor 6. A pair of idler wheels 41 and 42 are positioned at the top, dead center, and bottom, dead center, of the drum 4 for adding further stability and support for the drum 4 as it rotates about its longitudinal axis.

The advantage of the electrgraphic printer 1 is that the cylindrical photoconductor 6 provides charge transfer to an external electrographic recording web 15 which allows the development station to be positioned externally of the drum for relatively high speed printing. For example, electrographic printing at paper velocities in excess of 25 inches per second are readily obtained. In addition, relatively inexpensive dielectrically coated electrographic recording paper **15** may be employed. Due to the rotating contact between the web and the drum, wear on the photoconductor **6** is minimized, thereby extending the life of the photoconductor **6**. Lastly, the dual optical image projection system facilitates viewing and setting the proper focus for printing.

What is claimed is:

1. An electrographic device for forming an image on a charge retentive recording medium:

an endless band of photoconductive material;

means for circulating the endless band around a closed path;

optically transparent electrode means in electrical contact with the inside surface of the endless band;

means for projecting an optical image to be reproduced into the endless band and onto a portion of the transparent electrode for exposing the photoconductor causing the photoconductor to become selectively conductive;

means for urging the recording medium against the outside surface of the endless band proximate the exposed portion thereof;

means for applying a voltage between the transparent electrode and the recording medium across the exposed portion of the photoconductor to establish an electric current to form a charge image on the recording medium; and

charge image developing means mounted externally of the endless band for developing the charge image formed on the recording medium into a visible image.

2. The apparatus of claim **1** wherein said endless band of photoconductive material comprises a cylinder of photoconductive material.

3. The apparatus of claim **2** wherein said optical image projecting means includes means for projecting the optical image into said cylindrical photoconductor from one end thereof.

4. The apparatus of claim **1** wherein said optical image projecting means includes means for projecting an optical image into said closed path along an optical path having a substantial component of its length axially directed of said closed path.

5. The apparatus of claim **1** wherein said optical image projecting means includes a mirror disposed within said closed path, said mirror being inclined at an angle relative to the axis of said closed path to reflect the optical image radially of the closed path and onto the inside surface of said photoconductive material.

6. The apparatus of claim **1** wherein said optical image projecting means includes means for scanning an optical image pattern to be printed at a certain scanning rate, means for synchronizing the peripheral velocity of said circulating band of photoconductive material with the optical scanning rate.

7. The apparatus of claim **6** wherein said optical image projecting means magnifies the optical image to be projected and as projected onto said photoconductor by a magnification factor of m, and wherein said synchronizing means causes the peripheral velocity of said photoconductive material to be m times the velocity at which the optical image to be projected is scanned.

8. The apparatus of claim **1** wherein said recording medium comprises a conductive paper web having a dielectric coating thereon, such coating forming the charge retentive surface of said recording medium.

9. The apparatus of claim **1** wherein said feed means for feeding the recording medium feeds said recording medium over said photoconductor with a velocity in synchronism with the velocity of said photoconductor material as it traverses its closed path.

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