United States Patent

Furuichi

[15] **3,687,539**

[45] **Aug. 29, 1972**

[54] **ELECTROPHOTOGRAPHIC APPARATUS**

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June 30, 1970 Japan 45/57068
July 27, 1970 Japan 45/65655

[52] **U.S. Cl.** **355/8,** 118/637, 355/3, 355/47

[51] **Int. Cl.** **G03g 15/02,** G03g 15/04

[58] **Field of Search** .....355/3, 8, 47; 96/1, 1.4; 340/173 PP; 118/637; 250/49.52 C

[56] **References Cited**

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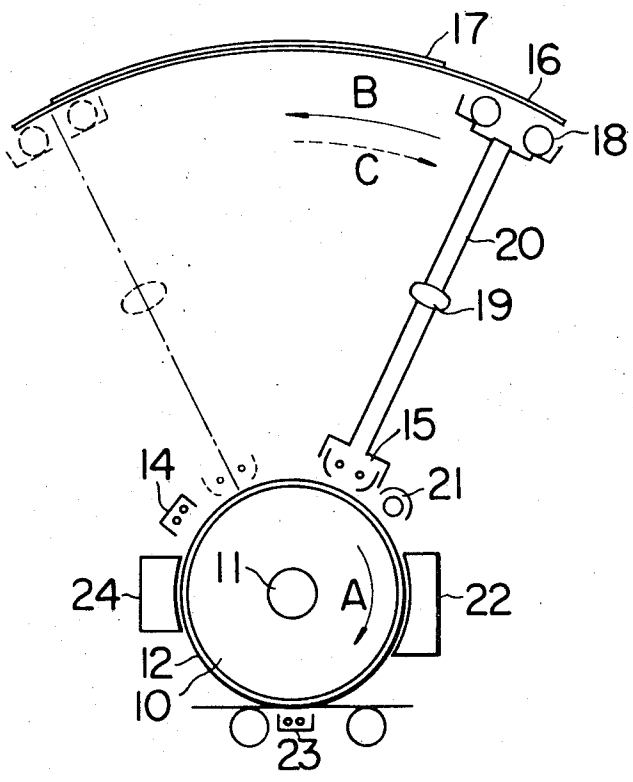
Primary Examiner—Samuel S. Matthews
Assistant Examiner—Robert P. Greiner

[57] **ABSTRACT**

In electrophotographic apparatus of the type comprising a rotary photosensitive element, a corona discharge unit for depositing a charge on the surface of the photosensitive element and an optical system for projecting an information containing light image through the corona discharge unit so as to form a latent image, the corona discharge unit and the optical system are rotated in unison about the rotary photosensitive element in a direction opposite to the direction of the rotation of the photosensitive element. The transfer printing device comprises means for bending the leading edge of a recording paper into a V shaped configuration, means for urging the recording paper against the rotary photosensitive element to transfer print a powder image onto the recording paper, a perforated suction cylinder to peel off the recording paper from the photosensitive element after transfer printing and means for admitting fluid under pressure into the space between the V shaped leading edge of the recording paper and the photosensitive element, and the cleaning device comprises a rotary brush in contact with the surface of the photosensitive element, a rotary hollow cylinder supporting the brush and provided with a plurality of perforations for supplying in from the interior of the cylinder to the brush, a stationary partition wall positioned in the hollow cylinder for dividing the interior thereof into two longitudinal compartments, a pair of corona discharge units of the opposite polarities disposed in respective compartments for ionizing the air therein, and means for supplying air under pressure into the compartments to discharge the ionized air toward the brush.

6 Claims, 4 Drawing Figures



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SHEET 1 OF 2

FIG. 1

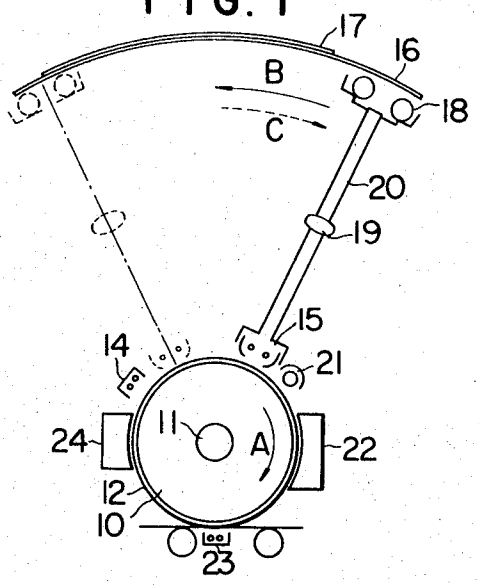

FIG. 2

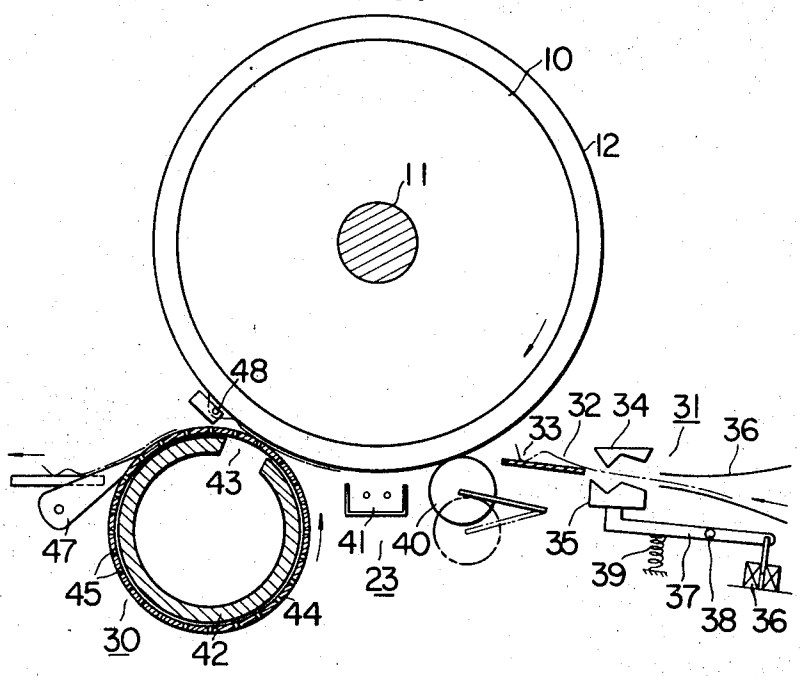

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FIG. 3

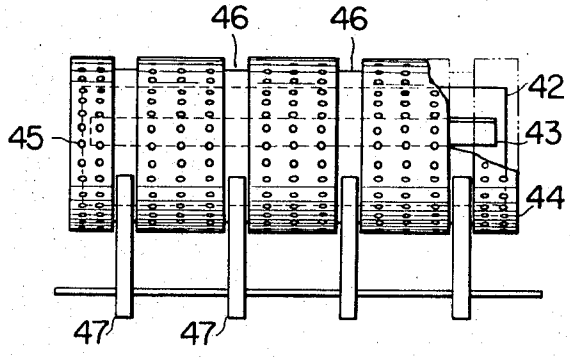
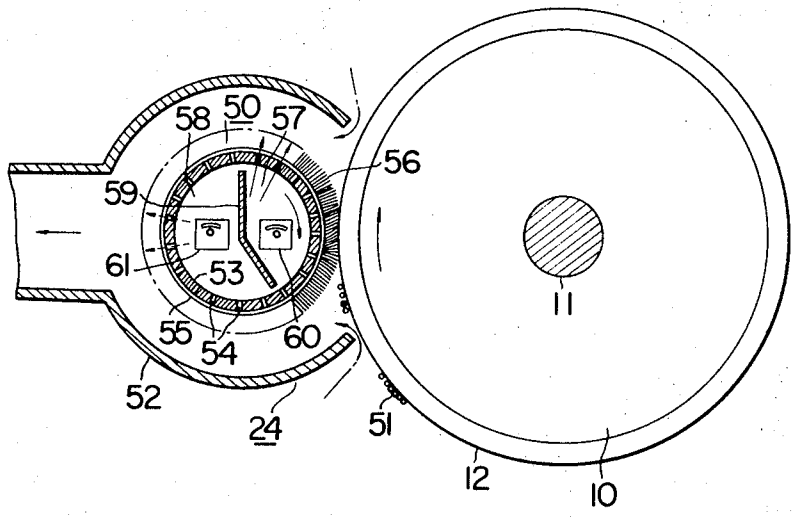


FIG. 4



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ELECTROPHOTOGRAPHIC APPARATUS

BACKGROUND OF THE INVENTION

This invention relates to electrographic apparatus.

In one type of electrophotographic copying apparatus there are provided a rotary photosensitive element carried by a rotary drum, at least one corona discharge unit for depositing a charge of a given polarity on the photosensitive element and a rotary mirror for scanning an object and projecting the light image thereof onto the photosensitive element through a lens. There are also used one or more stationary reflecting mirrors so as to reflect the light image several times. Such as arrangement increases the space occupied by the optical system and often projects the light image obliquely to the surface of the photosensitive element.

In the ordinary electrophotographic apparatus the latent image is developed by a developer powder to form a powder image and the powder image is transfer printed onto a recording paper which is removed from the surface of the photosensitive element. However, since the developer powder is ordinarily charged positively or negatively and since a corona discharge unit is often used to enhance transfer printing, the separation of the recording paper after transfer printing is rather difficult owing to the electrostatic attractive force due to the charges. A similar problem occurs in the cleaning device. More particularly, the developer powder remaining on the surface of the photosensitive element after transfer printing is ordinarily removed by a rotary brush. However, during the operation of the rotary brush the removed developer powder gradually accumulates on the brush due to the electrostatic force thus rendering it ineffective. Thus, it is necessary to constantly remove the developer powder from the brush to maintain it clean state.

SUMMARY OF THE INVENTION

It is an object of this invention to provide a new and improved combination of a corona discharge unit and an optical system which does not increase the space necessary for these elements and can project a light image always normally to the surface of a rotary photosensitive element.

Another object of this invention is to provide an improved transfer printing device capable of readily peeling off the recording paper from the photosensitive element after transfer printing.

Still another object of this invention is to provide an improved cleaning device by which the rotary brush thereof is maintained clean.

According to one aspect of this invention, in electrophotographic apparatus of the type comprising a rotary drum, a photosensitive element carried by the rotary drum, a corona discharge unit for depositing an electric charge on the surface of the photosensitive element and an optical system for projecting an information containing light image upon the photosensitive element through the corona discharge unit, so as to form a latent image, the corona discharge unit and the optical system are rotated in unison about the axis of the rotary drum in a direction opposite to the direction of rotation of the rotary drum during operation of the corona discharge unit.

According to another aspect of this invention there is provided an improved transfer printing divice which

comprises means for feeding a recording paper toward a rotary photosensitive element, means for bending the leading edge of the recording paper into a V shaped configuration, means for urging the recording paper against the rotary photosensitive element to transfer print a powder image onto the recording paper, a perforated suction cylinder positioned close to the periphery of rotary photosensitive element to peel off the recording paper therefrom after transfer printing and means for admitting fluid under pressure into the space between the V shaped leading edge of the recording paper and the photosensitive element.

According to further aspect of the invention there is provided an improved cleaning device for removing a developer powder remaining on the surface of a rotary photosensitive element after transfer printing, said cleaning device comprising a rotary brush in contact with the surface of the photosensitive element, a rotary hollow cylinder supporting the brush, the hollow cylinder having a plurality of perforations for supplying air from the interior thereof to the brush, a stationary partition wall positioned in the hollow cylinder for dividing the interior thereof into two longitudinal compartments, a pair of corona discharge units of the opposite polarities disposed in respective compartments for ionizing the air therein, and means for supplying air under pressure into the compartments to discharge the ionized air toward the brush.

BRIEF DESCRIPTION OF THE DRAWINGS

In the accompanying drawings:

FIG. **1** is a diagrammatic side view of electrophotographic apparatus utilizing a rotary corona discharge unit and an optical system constructed according to the teaching of this invention;

FIG. **2** shows the detail of the improved transfer printing apparatus embodying the invention;

FIG. **3** is a plan view of the suction drum of the transfer printing device shown in FIG. **2**; and

FIG. **4** shows a cross-section of a cleaning device and a portion of a rotary photosensitive element.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

A preferred embodiment shown in FIG. **1** comprises a rotary drum **10** mounted on a rotary shaft **11** and carrying a photosensitive element **12** which may be any well known construction. However, in order to form a latent image by the method disclosed in U.S. PAT. Nos. 3,457,070 and 3,536,483, the photosensitive element comprises a photoconductive layer exhibiting persistent internal polarization, a transparent highly insulative layer bonded to one surface of the photoconductive layer and an electrode layer bonded to the opposite side of the photoconductive layer. The photosensitive element is wrapped about the periphery of the rotary cylinder with the highly insulative layer faced outside. As above described, according to the method disclosed in said patents, the latent image is formed on the surface of the highly insulative layer by the steps of applying a first electric field of one polarity by means of a first corona discharge unit across the photosensitive element, and applying a second electric field of the opposite polarity across the photosensitive element by means of a second corona discharge unit concurrently

with the projection of an information containing light image upon the photosensitive layer through the second corona discharge unit. In FIG. 1, numeral 14 designates the first corona discharge unit, and 15 the second corona discharge unit. An object to be copies 16 such as a manuscript is mounted on the inner side of a glass cylinder 17 concentric with drum 10 and illuminated by lamps 18. According to the method described above while drum 10 is rotated in the direction of arrow A, the object 16 is moved in the direction of arrow C at a speed synchronous with the pheripheral speed of drum 10 to project the light image of the object upon the photosensitive element through a lens 19 and the second corona discharge unit 15.

However, according to this invention, the object is held stationary and the second corona discharge unit 15 and lens 19 are rotated in the direction of arrow B or in the direction opposite to that of the rotation of the drum 10. For this purpose, the second corona discharge unit 15 is secured to the lower end of a hollow tube 20 extending in the radial direction of the rotary drum and the lens 19 is mounted at an intermediate point of tube 20. Although in the illustrated example, lamps 18 are mounted on the upper end of tube 20, they may be held stationary. The tube 20 may be interlocked with shaft 11 so as to be rotated at a given speed for a predetermined angle by means of a suitable gearing, belt or another transmission mechanism, not shown. Upon completion of the scanning operation, the tube 20 is returned quickly to the original position shown in FIG. 1 as shown by arrow C. The ratio of the scanning speed and the peripheral speed of drum 10 is determined dependent upon the power of magnification or reduction. For example, in the case of a unity magnifying power the speed ratio is 1 : 1. Likewise the position of the lens 19 along the axis of the tube varies dependent upon the power of magnification or reduction. With this arrangement, the light beam impinges upon the photosensitive element always at right angles to the surface thereof so that off focusing can be avoided. Use of a lens of a short focal length decreases the length of the tube 20 thus decreasing the dimension of the electrophotographic apparatus.

Where the photoconductor of the photosensitive element contains a large number of deep charge trap levels such as a phosphor, a lamp 21 may be provided to irradiate the latent image formed on the surface of the highly insulative layer to increase the contrast of the reproduced image as fully discussed in U.S. Patent No. 3,457,070.

The latent image if then developed by a developing device 22 of any well known suitable type to form a powder image and the powder image is transfer printed onto a recording medium by a transfer printing device 23. The developing powder remaining on the surface of the photosensitive element after transfer printing is removed by a cleaning device 24 for preparing the photosensitive element to the next cycle. Although not shown in the drawing, an AC field is applied across the photosensitive element for completely depolizing the element before re-use.

The invention further contemplates the provision of an improved transfer printing device including an improved paper peel-off device as shown in FIGS. 2 and 3.

More particularly, as shown in FIG. 2, the transfer printing device 23 comprises a suction drum 30 positioned close to the periphery of the photosensitive element 12 carried by rotary drum 10 and a press 31 positioned on the entry side of the transfer printing device for bending the leading edge of a recording paper 32 into a letter V shaped configuration as shown by a reference numeral 33. The press 31 comprises a stationary upper mould 34 and a movable lower mould 35 which is operated by an electromagnet 36 through a lever 37 pivoted at 38. The lever 36 is normally held in the position shown by means of a return spring 39. When the leading edge of the recording paper appears at the exit of a shute 36 it is detected by suitable means such as a micro-switch or a photoelectric cell (not shown) which energizes the electromagnet 36. As a result, the leading edge is bent into a V shaped configuration by the co-operation of upper and lower moulds 34 and 35. As the leading edge of the recording paper comes into contact with the periphery of the photosensitive element a roller 40 is moved upwardly from the dotted line position to the solid line position to urge the recording paper against the periphery of the photosensitive element. The powder image is then transfer printed onto the recording paper by the contact pressure between roller 40 and the photosensitive element. If desired, a third corona discharge unit 41 may be provided for improving the transfer printing in a manner well known in the art. The charge deposited by the third corona discharge unit attracts the paper to the photosensitive element. However, the bent portion 33 still maintains its configuration during transfer printing.

The suction drum 30 comprises an inner cylinder 42 with one side close to the photosensitive element opened as at 43 and an outer cylinder 44 with a number of perforations 45. The interior of the inner cylinder 42 is communicated with a suction device, not shown, to attract the recording paper onto the periphery of the outer cylinder 44 at the opening 43. As shown in FIG. 3, the outer cylinder 44 is formed with a plurality of parallel spaced apart circumferential grooves 46 and perforations 45 and is rotated about the inner cylinder 42 by an electric motor, not shown. A plurality of stripping members 47 are received in respective grooves 46 in the tangential direction with respect to the periphery of the outer cylinder. Accordingly, when the paper is advanced to the position of opening 43, the paper will be attracted onto the outer cylinder by the suction applied through perforations 45. An air nozzle 48 is provided to direct compressed air in the transverse direction of the drum 10 to admit air to the inside of the bent leading edge thus peeling off it away from the photosensitive element. The paper is then transferred to a heated fixing device, not shown.

In this manner, the bent portion 33 of the recording paper does not adhere to the periphery of the photoconductive element during transfer printing so that the compressed air admitted into the space between the bent portion and the photosensitive element enhances the separation of the recording paper. Of course the operation of forming the latent image and the feed of the recording paper are suitably synchronized so as to anoide transfer printing of the latent image upon the bent up portion. Thus, the invention is especially suitable for recording papers of relatively large width.

Another feature of the invention lies in the provision of an improved cleaning device. As shown in FIG. 4, the cleaning device 24 comprises a rotary brush 50 which is rotated in the direction of an arrow to remove a developer or toner powder 51 remaining on the surface of the photosensitive element after transfer printing. The removed powder is discharged to the outside through an exhaust duct 52 having a base surrounding the brush. The rotary brush 50 includes a hollow cylinder 53 with a plurality of small perforations 54, and an air permeable cloth 55 surrounding cylinder 53 and implanted with bristles 56. Bristles 56 and cloth 55 may be replaced with an animal fur. The interior of the hollow cylinder 53 is divided into two longitudinal compartments 57 and 58 by a longitudinal partition wall 59 of any desired configuration. Corona discharge units 60 and 61 are disposed in compartments 57 and 58, respectively. The hollow cylinder 53 and bristles 56 are rotated whereas partition wall 59 and corona discharge units 60 and 61 are held stationary. One end of the cylinder 53 is closed and air under pressure is admitted into the opposite end by a suitable fan, not shown. The polarity of corona discharge unit 60 is selected to enhance removal of developer powder 51 away from the photosensitive element whereas that of corona discharge element to enhance removal of the powder away from the bristle. The air in compartment 57 is ionized by corona discharge unit 60 and is then discharged to the out side of cylinder 53 through perforations 54 as shown by solid line arrows whereas the air in compartment 58 is ionized by corona discharge unit 61 (opposite polarity to corona discharge unit 60) and is then discharged outwardly as shown by dotted line arrows.

When brush 50 is rotated with a predetermined contact pressure to the photosensitive element 12 the remaining developer powder 51 is swept away and attracted by bristle 56. Since the air ionized to one polarity by corona discharge unit 60 fills the interstices between the bristles, the remaining powder can be readily removed from the surface of the photosensitive element. As the brush is rotated further, the powder collected by the bristle is readily separated therefrom by the air ionized to the opposite polarity by corona discharge unit 61. The separated powder is exhausted to the outside together with the air.

By the action of two corona discharge units of the opposite polarities, not only the powder remaining on the photosensitive element can be readily removed, but also the powder collected by the brush can be readily removed.

I claim:

1. In electrophotographic apparatus of the type comprising a rotary drum, a photosensitive element carried by said rotary drum, a corona discharge unit for depositing an electric charge on the surface of said photosensitive element and an optical system for projecting an information containing light image upon said photosensitive element through said corona discharge unit so as to form a latent image, the improvement which comprises means for rotating in unison said corona discharge unit and said optical system about the axis of said rotary drum in a direction opposite to the direction of rotation of said rotary drum during operation of said corona discharge unit.

2. The electrophotographic apparatus according to claim 1 which further comprises a stationary corona discharge unit which is operated prior to the operation of said movable corona discharge unit to deposite a charge of a polarity opposite to that deposited by said movable corona discharge device.

3. The electrophotographic apparatus according to claim 1 wherein a hollow cylinder extending in the radial direction of said rotary drum is provided between said photosensitive element and a stationary object, said movable corona discharge unit is mounted on the inner end of said hollow tube and said optical system is mounted at a point intermediate the opposite ends of said hollow tube.

4. The electrophotographic apparatus according to claim 3 wherein said hollow tube is rotated about the axis of said rotary drum at a speed corresponding to the power of magnification or reduction.

5. The electrophotographic apparatus according to claim 2 wherein said photosensitive element comprises a photoconductive layer exhibiting persistent internal polarization, a highly insulative layer bonded to one side of said photoconductive layer and an electrode layer bonded to the opposite side of said photoconductive layer, said photosensitive element being mounted on said rotary drum with said highly insulative layer faced outward.

6. The electrophotographic apparatus according to claim 3 wherein said hollow tube carries a lamp for illuminating said object.

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