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[54] PHOTOELECTROSTATIC COPYING MACHINE WITH CORONA MEANS ESTABLISHING A REFERENCE POTENTIAL

7 Claims, 2 Drawing Figs.

[52] **U.S. Cl.** **355/3**
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[50] **Field of Search** 355/3

[56] **References Cited**

UNITED STATES PATENTS

3,533,692	10/1970	Blachette et al.	355/16
3,456,109	7/1969	Gawron	355/3 UX

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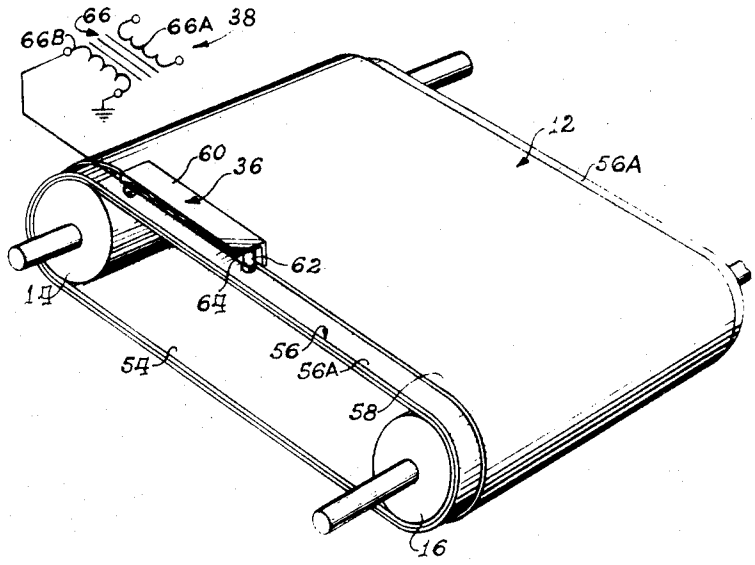
ABSTRACT: A moving, flexible belt type of copying machine in which the belt or loop is formed of an insulating base with an electrically conductive or metallized surface covered, except at the edges, by a photoconductive layer The machine has charging, exposing, developing, and transferring stations some of which bias or apply a charge to the photoconductive layer. A corona discharge unit disposed adjacent the exposed edge of the metallized surface on the moving loop couples the surface to a point of reference potential and obviates the need for any mechanical contact therewith.



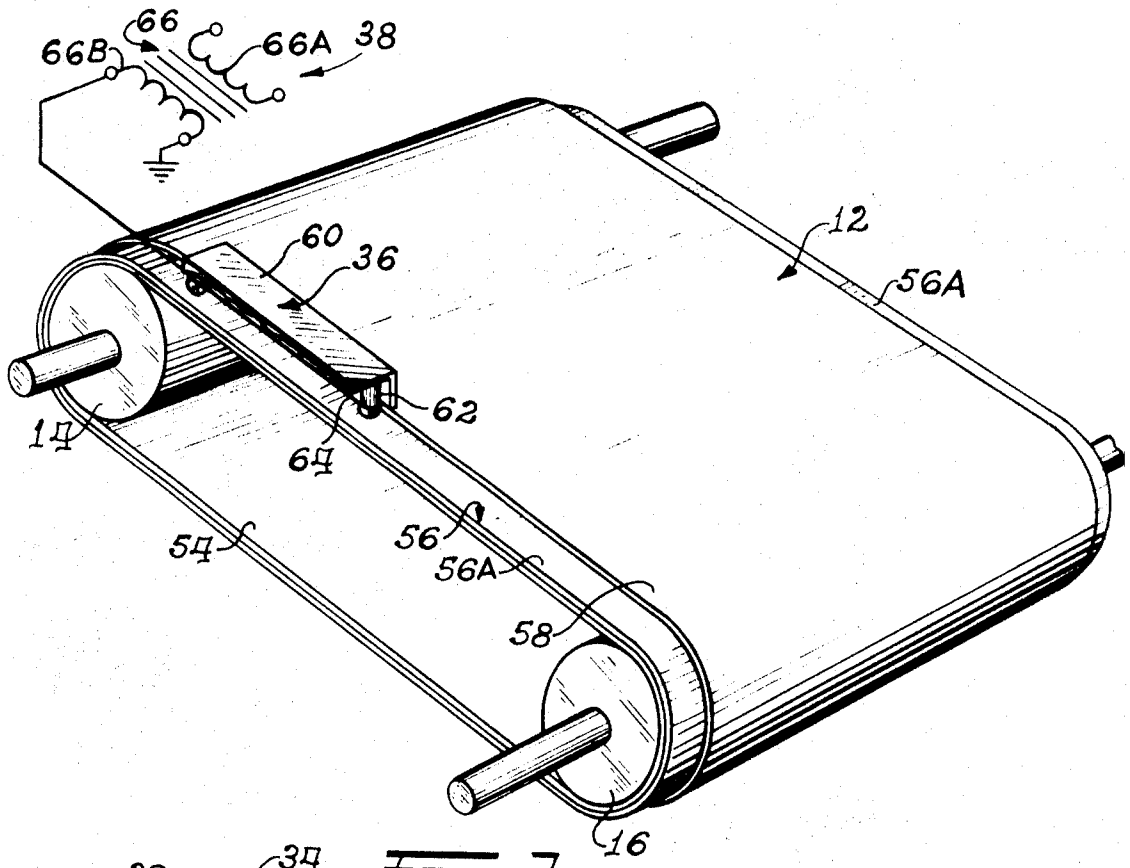


Fig. 2

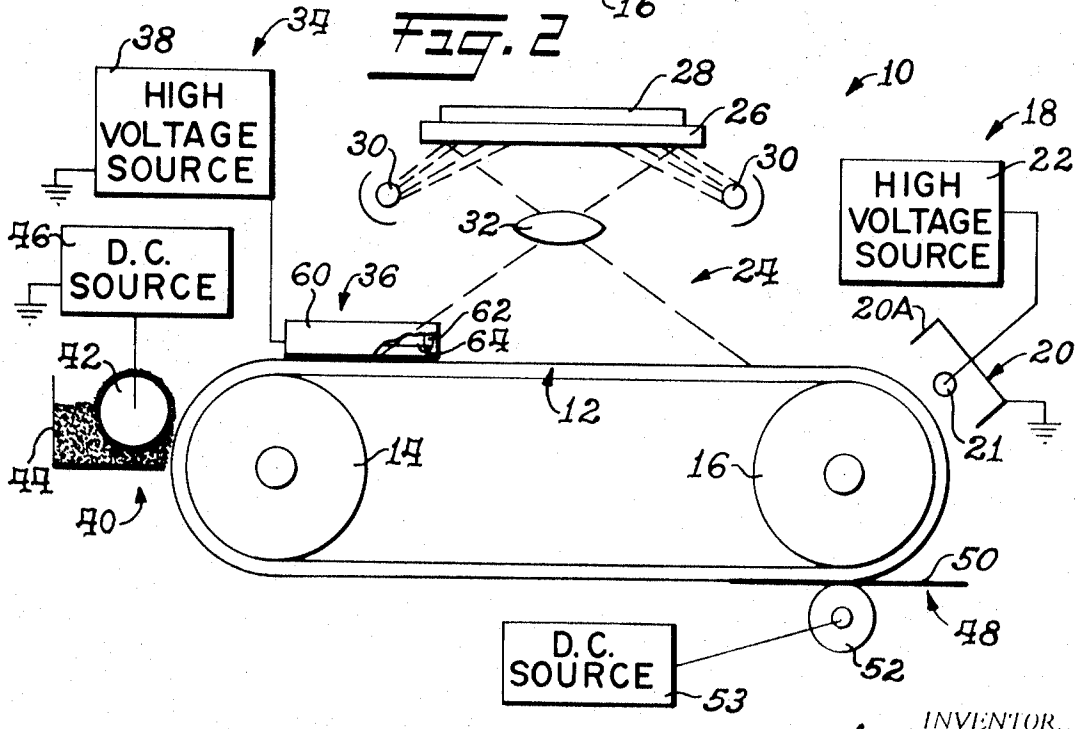


Fig. 1

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PHOTOELECTROSTATIC COPYING MACHINE WITH CORONA MEANS ESTABLISHING A REFERENCE POTENTIAL

BACKGROUND OF THE INVENTION

This invention relates to a copying machine using a member with a photoconductive layer on an electrically conductive surface and, more particularly, to a new and improved means for placing the electrically conductive surface at a reference potential.

Copying machines using a flexible loop or belt having an insulating base with a metallized or electrically conductive surface partially covered by a photoconductive layer to leave one or both edges or margins or the metallized surface exposed are known. One such machine is shown, for example, in a copending application of Robert G. Blanchette and Loren E. Shelffo, Ser. No. 702,917 filed Feb. 5, 1968, now U.S. Pat. No. 3,533,692, and assigned to the same assignee as the present application. In the belt copier, biasing and charging potentials are applied to or across the photoconductive layer at various processing stations along the path of movement of the belt. The effectiveness of these processes is dependent on the establishment of a point of reference potential, commonly ground, at one side of the photoconductive layer to permit, for example, the removal of charge from the photoconductive layer at the exposing station or the establishment of a desired potential gradient across the layer at the charging, developing, or transferring stations. Prior machines have used a mechanical contact in, for example, rolling or wiping engagement with the metallized surface to hold this surface at a reference potential. This results in wear and ultimately damage to the belt because of the rather fragile nature of the metallized surface.

SUMMARY OF THE INVENTION

In accordance with the present invention, mechanical engagement of the metallized surface of the loop or belt is obviated by using a corona discharge unit as a means for coupling the metallized surface to or holding the metallized surface at a reference potential. A copying machine uses a belt or loop formed of an insulating base with a thin metal layer or surface on one side. This metal layer is covered by a photoconductive layer except for a continuous exposed portion preferably along one edge. The belt is driven past charging, exposing, developing, and transfer stations at which, respectively, the photoconductive layer is uniformly charged, the charged surface is selectively discharged in accordance with the original to be copied, the charge image is developed as a powder image, and the powder image is transferred to and fixed on a copy sheet. At various of these stations it is desirable or necessary to insure that the metal layer or surface underlying the photoconductive layer is held at a reference potential, commonly ground. At the charging station for example, a given potential gradient should be established between the metal layer and the corona discharge unit to insure a proper uniform charge on the photoconductive layer. At the exposure station a discharge path for the photoconductive layer must be provided. At the developing station the bias is commonly applied across the photoconductive layer to improve controlled powder deposition, and at the transfer station the bias is applied across the copy sheet and the photoconductive layer to improve powder image transfer.

In the apparatus of the present invention a corona discharge unit is provided overlying the exposed continuous area of the metal layer spaced away from the photoconductive layer. In one embodiment this corona discharge unit extends parallel to the direction of movement of the belt or loop and is energized by a potential of a polarity opposite to the polarity of the uniform charge on the photoconductive layer. This corona discharge unit ionizes the gaseous medium between the exposed metal area and the corona unit to provide a conductive path from the metal layer to a point of reference potential, commonly ground, in the power supply for the corona discharge unit. This avoids any mechanical contact with the fragile metal layer or surface, and increases the useful life of the copying belt.

BRIEF DESCRIPTION OF THE DRAWINGS

Many other objects and advantages of the present invention will become apparent from considering the following detailed description in conjunction with the drawings in which:

FIG. 1 is a schematic view of a copying apparatus embodying the present invention; and

FIG. 2 is a perspective view of a flexible belt and corona discharge unit included in the apparatus shown in FIG. 1.

DESCRIPTION OF THE PREFERRED EMBODIMENT

Referring now more specifically to FIG. 1 of the drawings, therein is illustrated a photoconductive copying machine which is indicated generally as **10** and which embodies the present invention. The construction of the copying machine can be of the same general type as a number well known in the art such as the one shown in a copending application of Loren E. Shelffo, Ser. No. 792,617, filed Jan. 21, 1969 and assigned to the same assignee as the present invention. In general, the copying machine **10** includes a flexible belt, web, or loop **12** passing around a pair of rollers **14** and **16** at least one of which is driven in a counterclockwise direction so that the belt **12** moves through a given path.

As the belt **12** passes a charging station indicated generally as **18**, a corona discharge unit indicated generally as **20** supplied with a high-voltage potential by a high-voltage source **22** applies a uniform charge to the outer surface of the photoconductive belt **12**. The corona discharge unit **20** includes a corona shield or housing **20A** connected to a point of reference potential such as ground in which is mounted in an insulating relation thereto a corona wire **21**. The corona wire, which is coupled to the output of the high voltage source **22**, extends generally transverse to the direction of movement of the flexible belt **12** and overlies the photoconductive surface or layer thereon.

Continuing movement of the belt **12** moves the uniformly charged surface into an exposure station indicated generally as **24** which includes a transparent platen **26** on which is disposed an original **28** to be copied. When the charged surface of the belt **12** is disposed in the exposure area schematically delineated by the dashed lines in FIG. **1**, a pair of lamps **30** are momentarily energized to provide a light image of the original **28** to be copied which is focused on the belt **12** in the exposure area by a lens system schematically illustrated at **32**. The selective illumination of the uniformly charged surface of the belt **12** in accordance with the image of the original to be copied selectively discharges the layer to provide a latent or charge image corresponding to the original to be copied. Although a projection type system is shown at the exposing station **24**, this station can also comprise contact printing or cathode ray exposing means of either the full frame or line-by-line scanning type.

To permit and facilitate the selective discharge of the photoconductive belt **12** at the exposure station **24** and the establishment of potential gradients across the belt **12** at other stations, there is provided a reference potential coupling or connecting means indicated generally as **34** which includes a corona discharge unit **36** connected to a high potential source **38**. The corona discharge unit **36** is so disposed as to ionize the air between an electrically conductive backing for the photoconductive layer on the belt **12** and the unit **36** so that this electrically conductive surface is returned to a reference potential such as ground in the high-voltage source **38**. Thus, a conductive path is provided to the electrically conductive part of the belt **12** in the exposure area without requiring mechanical contact with the belt **12**.

Continuing movement of the belt **12** carries the charge image on its outer surface to a developing station indicated generally as **40**. This developing station may comprise a

variety of known developing devices such as cascade developers, powder cloud developers, or brush-type developers including magnetic brush developers. In FIG. 1 of the drawings, the developing station **40** is shown as including a magnetic brush **42** of known construction disposed in a trough or receptacle **44** containing a mixture of magnetically attractable carrier particles and electrostatically attractable toner particles. The toner particles may be heat fusible onto a copy sheet, or they may be fixed by pressure or solvent vapors.

The developing station **40** also includes means for applying a direct current biasing potential across the photoconductive belt **12** to improve image development. When the belt **12** uses an organic photoconductive material, it has been found to be particularly advantageous to provide a bias or potential gradient between the photoconductive layer and the magnetic brush **42** because it tends to give an apparent increase in the photo response of what is otherwise a relatively slow responding photoconductive material. Accordingly, a direct current biasing potential source **46** is coupled to the electrically conductive magnetic brush **42** to apply a biasing potential across the photoconductive belt **12**. This belt is returned to a reference potential such as ground using the connecting or coupling means **34**.

Following the conversion of the charge image into a powder image at the developing station **40**, continuing movement of the belt **12** moves the powder image to a transfer station indicated generally as **48**. At the station **48** a copy sheet **50** is fed between the belt **12** and a pressure roller **52** so that the powder image is transferred from the outer surface of the belt **12** to the adjacent surface of the copy sheet **50**. It has been determined that this transfer is more expeditiously effected by applying a direct current bias across the belt **12** and the copy sheet **50** during this pressure transfer. Accordingly the roller **52** is formed of an electrically conductive material and is coupled to a direct current biasing potential source **53**. As set forth above, a return for the source **53** is afforded through the connecting or coupling assembly **34** which holds the electrically conductive surface underlying the photoconductive surface on the belt **12** at a point of reference potential.

In this manner movement of the belt or loop **12** through its closed path past the charging station **18**, the exposing station **24**, the developing station **40**, and the transfer station **48** produces a copy of the original **28** which is transferred as a fixed powder image to the copy sheet **50**. Incident to carrying out the various steps at these stations, charging and biasing potentials are applied to the belt **12** making use of the ground or reference potential plane or return provided by the assembly **34** which uses a corona discharge to effect the establishment of the reference potential point on the belt **12** without mechanical contact.

Referring now more specifically to FIG. **2** of the drawings, therein is illustrated in somewhat enlarged form the belt **12** used in the copying machine **10** of the present invention. The construction of the belt or loop **12** is set forth in detail in the above-identified Blanchette et al. application. In general, this belt includes a flexible insulating base **54** that can be formed of a number of materials but in a preferred embodiment is a polyester terephthalate film sold under the trademark "-MYLAR." Applied to one surface of the insulating base or base layer **54** is a continuous layer or film **56** of a good electrical conductor such as aluminum or copper. This layer or metallized surface can have a thickness ranging from 0.05 mil to 0.50 mil. The characteristics and method of application of this layer are set forth in detail in the above-identified Blanchette et al. application.

A layer **58** of photoconductive material is disposed on the thin metal film or metallized surface **56**. The composition and method of applying the layer **58** is set forth in detail in the above-identified Blanchette et al. application. In a preferred embodiment the layer **58** comprises an organic photoconductive polymeric film such as polyvinyl carbazole. When the layer **58** is applied or formed, it is disposed inwardly from the marginal edge or edges of the belt **12** so as to leave a continuous area or surface **56A** of the electrically conductive layer or film **56** exposed. This exposed area **56A** is used to establish a reference potential connection to the layer **56**.

This is accomplished by the connecting or coupling means **34** including the high-voltage source **38** and the corona discharge unit **36**. The unit **36** includes a corona shield or housing **60** connected to a point of reference potential such as ground in which is supported by a pair of insulating posts **62** a corona discharge wire **64** extending generally parallel to the path of movement of the belt **12** spaced immediately above the exposed area **56A** on the electrically conductive surface **56** and offset from the photoconductive layer **58**. The corona wire **64** is connected to the output of the high-voltage source **38** and may, for instance, be connected to a secondary winding **66B** of a high-voltage output transformer **66**, a primary winding **66A** of which is supplied with a pulsating potential of a large enough magnitude to effect the desired corona discharge. The other terminal of the secondary winding **66B** is returned to the desired reference potential such as ground. The primary winding **66A** can be connected to any of a number of well-known circuits for supplying the necessary pulsating potential. The polarity of the voltage applied to the corona wire **64** is opposite to polarity of the potential applied to the corona wire **21** in the corona discharge unit **20**.

Assuming that in the machine **10** the high-voltage source **22** supplies a negative potential to the corona wire **21** in the corona discharge unit **20**, the high-voltage source **38** supplies a positive potential to the corona wire **64** in the discharge unit **36**. The potential supplied to the corona wire **64** is sufficient to ionize the gaseous medium, generally air, disposed between this corona wire and the underlying exposed portion or area **56A** on the electrically conductive layer **56**. This establishes a conductive path from the point of reference potential or ground to which one terminal of the secondary winding **66B** is connected, through this winding, the connecting circuitry, the corona wire **64**, and the ionized medium to the exposed area **56A** on the metallized surface or electrically conductive layer **56**. Thus, the entire under surface of the photoconductive layer **58** is held at the point of reference potential, and with respect to the corona discharge unit **20** provides a virtual ground plane beneath the charging unit **20** so that a uniform and controllable blanket of negative charge is established on the outer surface of the photoconductive layer **58**. This connection of the reference potential to the layer **56** also provides a path over which the negative charge on the photoconductive layer **58** is selectively discharged to ground in the exposure station **24** as a result of the selective illumination of the layer **58** in accordance with the light image of the original **28** to be copied. Further, this connection of the layer **56** to the reference potential establishes a return circuit by which the desired potential gradients can be established across the photoconductive layer **58** or this layer and the copy sheet **50** at the developer station **40** and the transfer station **48**. By the provision of the corona discharge unit **36** as a part of the coupling or connecting assembly **34**, the electrically conductive layer **56** on the flexible belt **12** is held at a reference potential without the necessity of mechanically engaging the very thin and fragile electrically conductive film **56** forming a part of the belt **12**.

Although the invention has been described with reference to a single illustrative embodiment thereof, it should be understood that numerous other modifications and embodiments can be devised by those skilled in the art that will fall within the spirit and scope of the principles of this invention.

What is claimed and desired to be secured by Letters Patent of the United States is:

1. In a copying apparatus using a member formed of a photoconductive layer on an electrically conductive surface having an area not covered by the photoconductive layer, the member being movable over a path past spaced stations at least one of which stations applies a potential to the photoconductive layer, the improvement which comprises

a corona discharge means disposed along the path adjacent the uncovered area,

and circuit means coupled between the corona discharge means and a point of reference potential and effective to establish an electrically conductive path between the point of reference potential and the uncovered area of the electrically conductive surface which includes the air gap between the corona discharge means and the uncovered area.

2. A copying apparatus using a member formed of an insulating base carrying a photoconductive layer with an electrically conductive surface interposed therebetween, the electrically conductive surface having an area not covered by the photoconductive layer,

driving means for moving the member over a path,

means for applying a potential to said member at a point along said path including a potential source and an electrically conductive means disposed adjacent the member,

and means for coupling the electrically conductive surface to a point of reference potential including a corona discharge means adjacent said uncovered area and spaced from the photoconductive layer.

3. In a copying apparatus using a flexible loop formed of an insulating base with an electrically conductive layer on which is disposed a photoconductive layer that is less than coextensive with the electrically conductive layer to leave an uncovered area of the electrically conductive layer,

drive means for moving the loop over a path,

charging and exposing stations spaced along said path, the charging station including means for applying a uniform charge to the photoconductive layer and the exposing station including means for selectively discharging the photoconductive layer,

and means for establishing a connection between the electrically conductive layer and a point of reference potential including a corona discharge means disposed adjacent said uncovered area and spaced from the photoconductive layer.

4. In a copying apparatus using a flexible loop formed of an insulating base with an electrically conductive layer on which is disposed a photoconductive layer that is less than coextensive with the electrically conductive layer to leave an uncovered area of the electrically conductive layer,

drive means for moving the loop over a path,

and a charging means for applying a uniform charge to the photoconductive layer including a first corona discharge means extending generally transverse to the direction of movement of the member and overlying the photoconductive layer and a second corona discharge means spaced from the first corona discharge means in a position extending generally parallel to the direction of movement of the member and overlying said uncovered area.

5. The apparatus set forth in claim 4 wherein

an exposing station is provided spaced from the charging means for selectively discharging the uniform charge on the photoconductive layer,

and the second corona discharge means is disposed adjacent the exposing station.

6. A copying apparatus using a flexible loop formed of an insulating base having an electrically conductive layer partially covered with a photoconductive layer to leave at least one continuous edge or marginal area uncovered, comprising

drive means for moving the loop and including a pair of rollers around which the loop passes,

a charging station disposed along said path for applying a uniform charge to the photoconductive layer,

an exposing station disposed along said path spaced from the charging station in the direction of movement of the loop for selectively discharging the photoconductive layer,

and connecting means for connecting the electrically conductive layer to a point of reference potential to establish a point of common reference for the charging and discharging of the photoconductive layers, said connecting means including a first corona discharge means overlying the uncovered marginal area of the electrically conductive layer and operative to establish a path of current flow through an ionized medium between said uncovered area and the first corona discharge means.

7. The apparatus set forth in claim 6 in which the charging station includes a second corona discharge means overlying the photoconductive layer.

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