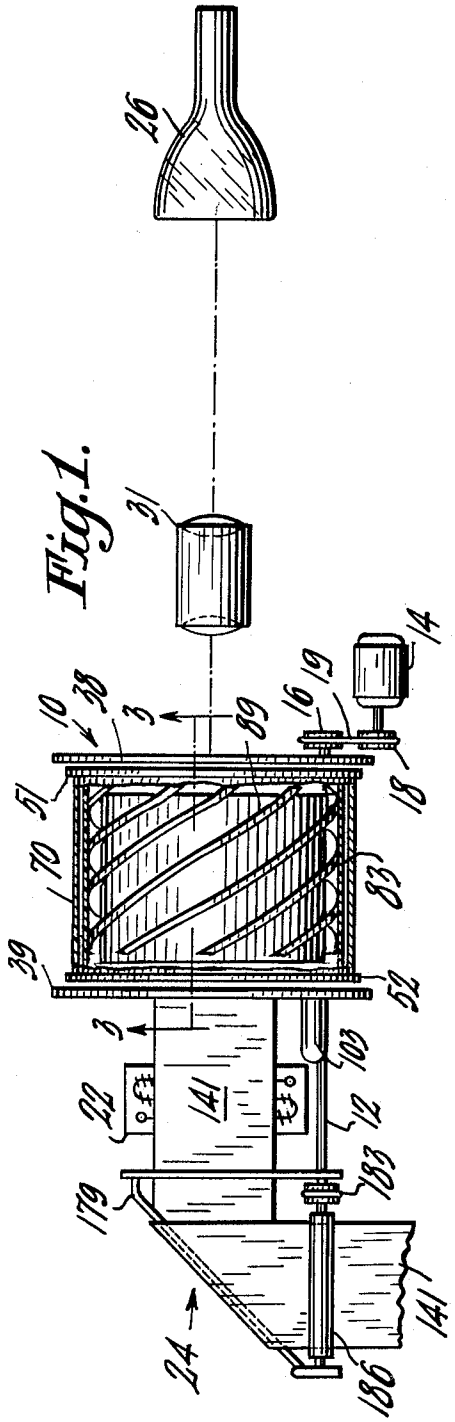
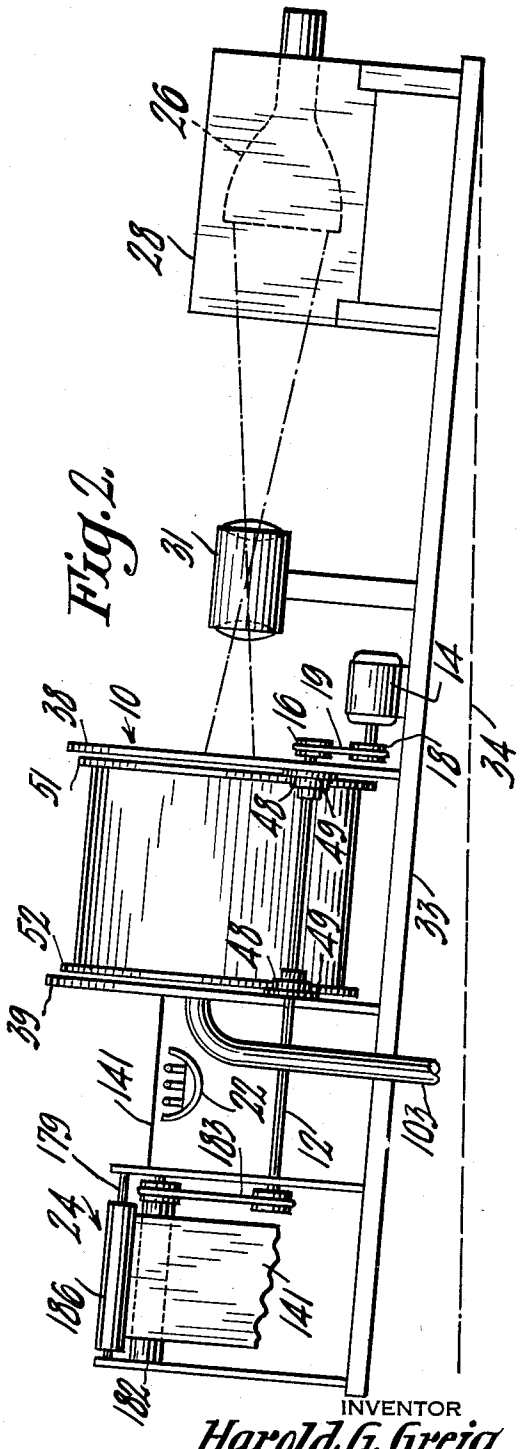
Jan. 10, 1956 H. G. GREIG 2,730,023

ELECTROPHOTOGRAPHIC RECORDER

Filed Nov. 26, 1951 3 Sheets-Sheet 1





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ELECTROPHOTOGRAPHIC RECORDER

Filed Nov. 26, 1951 3 Sheets-Sheet 2

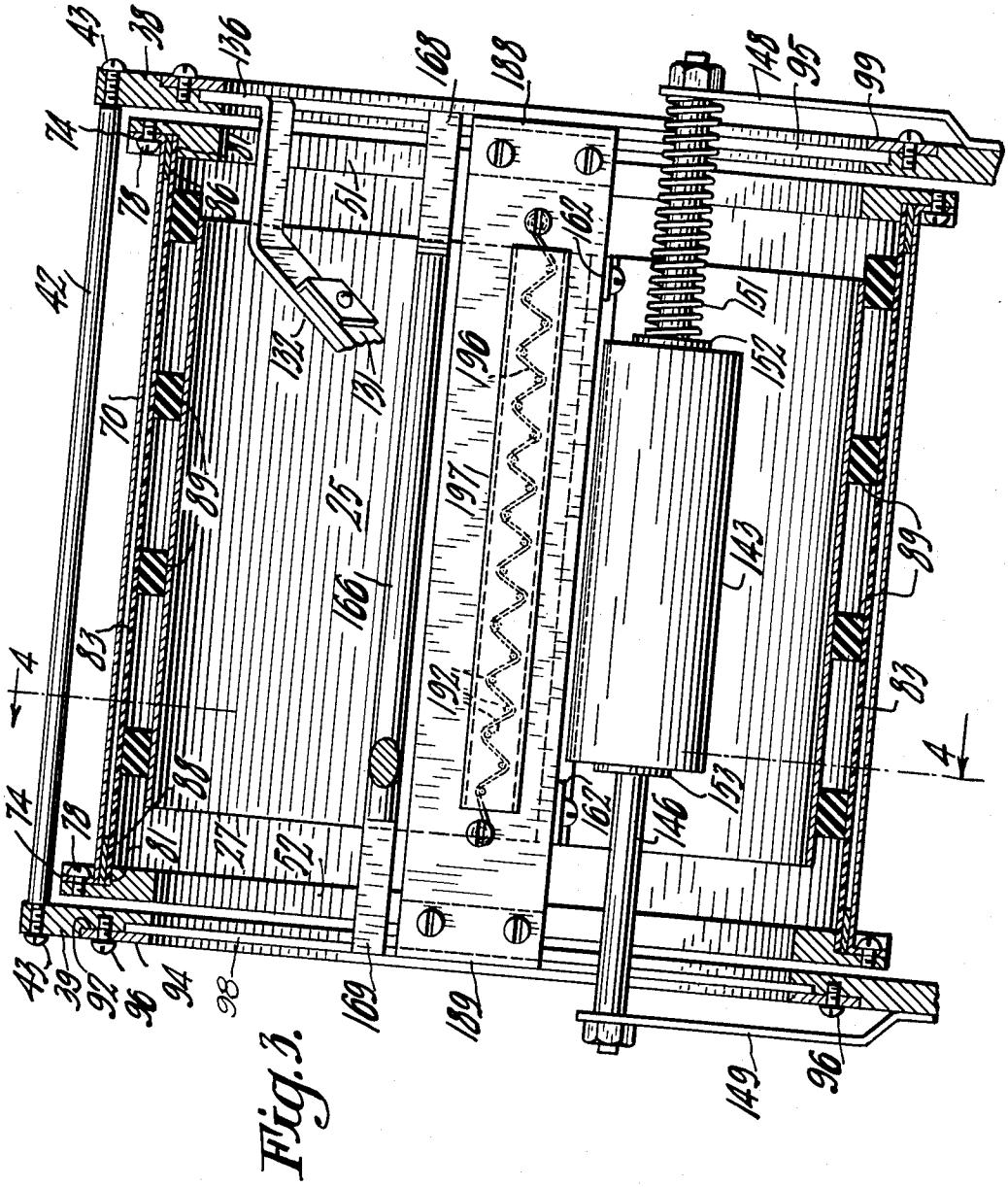


Fig. 3.

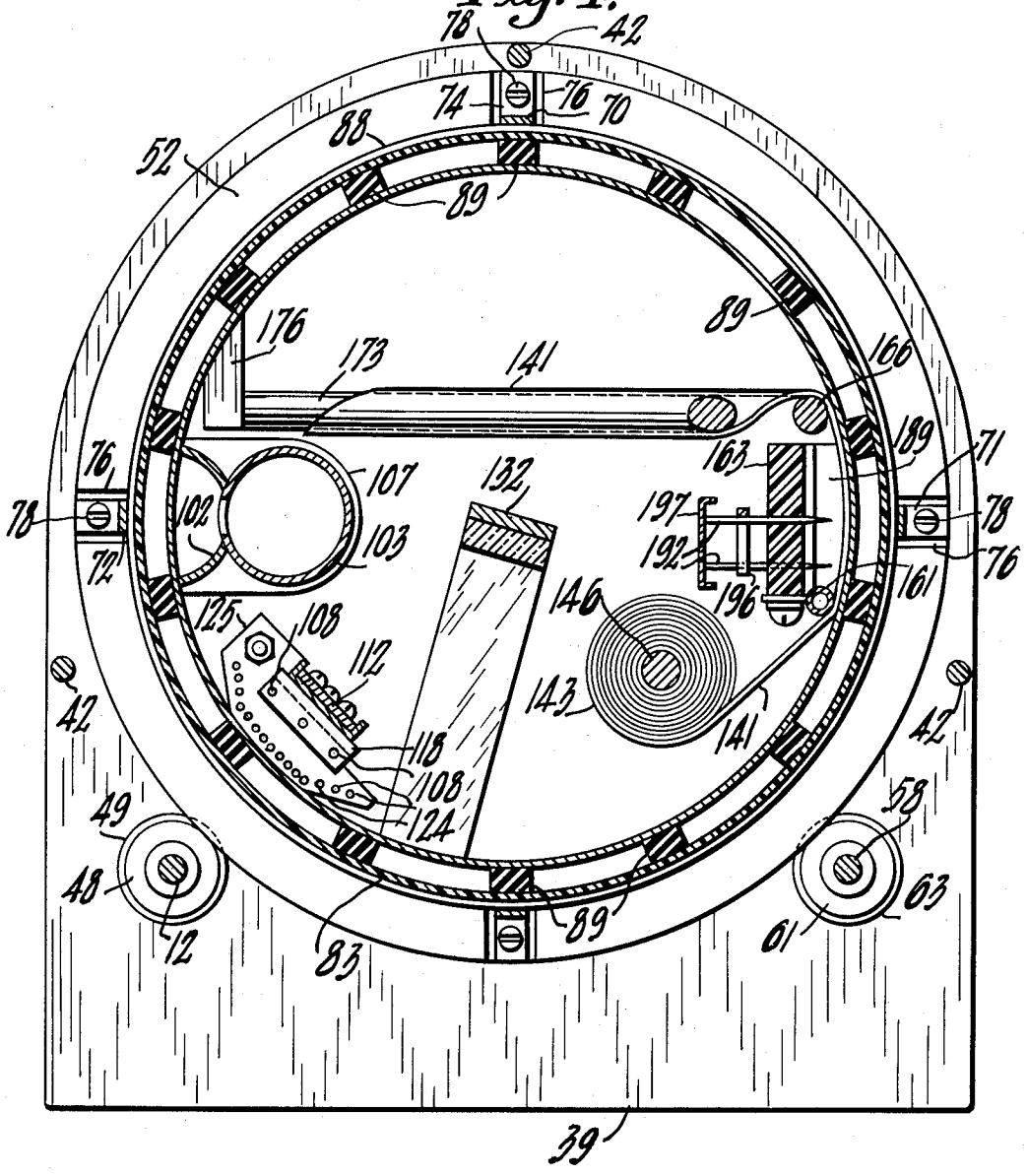
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Filed Nov. 26, 1951 3 Sheets-Sheet 3

Fig. 4.



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ELECTROPHOTOGRAPHIC RECORDER

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Application November 26, 1951, Serial No. 258,145

8 Claims. (Cl. 95—1.7)

The present invention relates to an electrostatic printer or printers employing electrophotography, and more particularly, althought not necessarily exclusively, to means in a continuous electrostatic printer for feeding developer material in a novel manner over a light sensitive photoconductive surface.

The invention is embodied illustratively in an electrophotographic printer having a moving endless charge receiving surface which is continuously exposed to electrostatic charging means. A light image, of letter type, for example, is produced and projected on the endless charged surface either intermittently, for example a line of type at a time, or continuously by the production of successive elementary image strips. The moving surface, following exposure to the light image, however it may be applied, is subjected to a continuously maintained and preferably transverse flow of developer mix. The nature of the developer mix will be more fully described hereinafter for the sake of completeness of disclosure, although it is not part of the present invention. The flow of developer mix develops a latent image for transfer to the surface of a web or sheet. The charged moving surface bearing the developed or power image, a succession of such images, or successive parts of one such image is contacted in the presence of a member or members providing an electric charge by a web or sheet, of treated or untreated paper, or the like which receives the charge. Close interfacial contact between the charge receiving surface and the web or sheet is insured by the charge at the former surface. The contact between the web and the charge receiving surface need be maintained over a relatively short linear distance of the latter. The light sensitive photoconductive charge receiving surface is next subjected to a cleaning operation thereby to remove any remaining developer.

In accordance with the present invention, the quantity or bulk of the developer mix may be maintained below an excessive value to avoid loss of the latent image in a recorder embodying the present invention. Also, the rate of flow of developer mix may be controlled within suitable limits.

The principal object of the present invention is to provide novel means for applying a developer mix to a charge receiving surface in a printer for printing by electron photographic or electrostatic printing methods.

Another object of the invention is to provide novel means for causing a granular material continuously to transverse an inclined concave surface.

A further object of the invention is to provide a novel arrangement including a plurality of helices for returning a supply of granular material to a position for reuse.

Other objects and advantages of the invention will, of course, become apparent and immediately suggest themselves to those skilled in the art to which the invention is directed from a reading of the following specification in connection with the accompanying drawings in which:

Fig. 1 is a view in top plan showing, diagrammatically, a printer embodying the present invention associated with a cathode ray tube for producing a radiant energy or luminous image of subject matter to be recorded on a sheet or web of recording material;

Fig. 2 is a view in side elevation of the apparatus shown diagrammatically in Fig. 1;

Fig. 3 is a section, the section being taken on line 3—3 of Fig. 1 as viewed in the direction of the arrows;

Fig. 4 is a vertical section, the section being taken on line 4—4 of Fig. 3 as viewed in the direction of the arrows.

Referring to the drawing, and for the present, to Figs. 1 and 2 thereof, reference character **10** designates the illustrative embodiment of the printer of this invention in its entirety. The printer **10** includes mechanical driving means, the principal part of which is the shaft **12**. Driving power is imparted to the shaft **12** from a motor **14** through pulleys **16** and **18** and a belt **19**. The motor **14** may be of variable speed type or the belt and pulley arrangement may be replaced or preceded in the driving system by a suitable variable speed gear drive (not shown). The motor **14** should be capable of maintaining any selected operating speed reasonably constant.

The printer **10** has a fixing means such, for example, as the electrical or other type of heater **22** associated with it. The heater **22** may be included in the structure of the printer. The printer **10** also includes a suitably supported recording web driving and guiding mechanism indicated generally by reference character **24**.

As will appear hereinafter, the photoconductive surface of the printer **10** is so arranged that a luminous image may be projected thereon in a direction initially extending parallel to the axis of the printer. The photoconductive surface is cylindrical and, in the illustrative example, is presented by the interior surface **25** of a cylindrical member **27**. In the arrangement of Figs. 1 and 2, the luminous image to be recorded is produced by a cathode ray tube **26** which is mounted in a suitable protective shielding housing **28**. A lens system **31** serves to project the image appearing on the face of the cathode ray tube onto the photoconductive surface of the receiver. The printer **10**, including the web driving and guiding means **24**, is mounted on a base **33**. This base provides a convenient support also for the housing **28** and the lens system **31**. The base **33** is inclined to the horizontal when the printer **10** is in use as indicated by the angle made by the base with a horizontal dashed line **34**. The horizontal line **34** may represent a bench, table, or other support for the printer **10**.

The cathode ray tube **26** is provided with the usual appliances as will be understood by those skilled in the art to provide deflection of the cathode ray beam therein. This beam will be modulated by signals similar to video signals. Only horizontal deflection means may be provided in which case the second coordinate of deflection will be provided by movement of the light sensitive or charge receiving surface **25** of the recorder. The cathode ray tube **26** may be operated so as to produce characters similar to typewritten characters arranged in a horizontal row with a plurality of characters being formed successively. The formation of the row of characters is cyclically repeated with the same or different characters produced. The arrangement for producing a scanning line or an image of any desired type on the face of the cathode ray tube is not part of the present invention and need not be further disclosed herein. An arrangement for successively producing type characters arranged in a row is shown in the copending application of Warren H. Bliss, Serial No. 213,389, filed March 1, 1951. As disclosed in that application, 32 letters, for example, may be traced successively, in a horizontal row by deflection of the cathode ray beam in the tube **26**. These 32 letters are or may be produced in $\frac{1}{10}$ of a second. The peripheral speed of the charge receiving surface of the recorder **10**

is or may be such that its displacement is equivalent to the height of one line of type produced on the face of the cathode ray tube in 1/10 of a second. These figures are given by way of example only, and it will be understood that any luminous image, however produced, may be recorded by the recorder **10**.

The recorder **10** comprises stationary end plates **38** and **39**. The end plates **38** and **39** are united into a rigid structure and are spaced apart by a number of tie rods **42**, for example three (Fig. 3). Screws **43** serve to clamp the end plates against ends of the rods **42**. The end plates assembled with the rods **42** may rest upon or be secured to the base **33**.

A pair of rollers **48** (Fig. 2), each having a flange **49**, receives the end plates **51** and **52** of the supporting arrangement for the cylindrical member **27**. A pair of rollers **61**, each having a flange **63**, also receives the end plates **51** and **52**. The rollers **48** in combination with the angularly displaced rollers **61** serve as a cradle upon which the cylindrical structure comprising the member **27** rotates.

The end plates **51** and **52** of the rotatable supporting structure for the cylindrical member **27** are joined by strips **70**, **71**, and **72** of sheet metal or the like. Each strip is turned upwardly at each end as indicated at **74**. The ends **74** are engaged in radial grooves **76** in the plates **51** and **52** and are secured by screws **78**. Each end plate has a circular groove **81** and a cylindrical member **83** formed of a transparent plastic sheet is engaged at its ends in the circular grooves. A circular sheet metal ring **86** is engaged in the groove **81** in the plate **51** to serve as a reinforcement for the cylindrical member **83**. A similar metal ring **88** is engaged in the groove **81** in the end plate **52**. The cylindrical member **83** is preferably, but not necessarily, made of transparent material. The cylindrical member **83**, if transparent, permits observation of circulation of the developer mix.

The previously mentioned cylindrical member **27** is spaced from the circular member **83** by a plurality of helically arranged strips **89**. In the illustrative example, fourteen strips **89** are provided which may be secured to the cylindrical member **27** by any suitable means, such as by cementing, to form a plurality of channels as hereinafter set forth. The strips **89** extend beyond the edge of the member **27** on the side of the rotatable device bounded by the end plate **51**. This extension may be approximately 1 inch, for example. The ends of the strips **89** stop short of the edge of the cylindrical member **27** adjacent the end plate **52**. For example, the strips may extend to within one-half inch of the edge of the cylindrical member **27**.

The cylindrical member **27** is a metal cylinder the inside surface **25** of which is polished and coated with a photoconductive material such, for example, as selenium. Aluminum is a suitable material. The selenium coating is, or may be, applied by evaporation at reduced pressure.

The several appliances for obtaining the record on a paper web as well as the web reel and the guide for the web are carried by the end plates **38** and **39** in such a way that their position may be circumferentially adjusted about the interior of the photosensitive surface **25**. The end plate **39** is recessed as indicated at **92** which is covered by a ring **94** to provide a circular groove **98**. The ring **94** is secured to the end plate **39** by means of screws **96**. The plate **38** is also recessed to provide a groove **95** in conjunction with a ring **99** similar to the ring **94**. In the illustrative example of a printer involving the present invention, the cylindrical member **27** is rotatable in a counter-clockwise direction as viewed in Fig. 4 of the drawing.

The appliances associated with the photoconductive surface will be described in the order in which they cooperate with said surface beginning with the arrangement for cleaning the surface of excess developer mix or powder remaining following take off on the paper web of the characters to be recorded. Reference character **102** indicates a channel shaped member, the open side of which is spaced slightly from the photosensitive surface **25**. The interior of this channel shaped member **102** is in communication with a conduit **103** which may be connected to any suction line or suction device such as, for example, a vacuum cleaner.

The surface **25** is charged to a high positive potential in the illustrative machine **10** by a plurality of wires **108**. These wires may, for example, be three in number and may be spaced 7/16 inch from the selenium surface. A bar member **112**, provided with angularly turned ends seated in the grooves **95** and **98**, carries insulating wire holders **118** between which the wires **108** are stretched. The wires **108** are connected to a 6.5 kv. source of positive potential, for example. A grid of wires **124** is stretched between insulating wire holders **125**. The latter are also secured to the bar member **112**. In the illustrative example, nineteen wires **124** are provided which are spaced 1/8 inch apart and grounded to the frame of the machine. The central portion of this grid of wires is 3/32 inch from the selenium surface. The dimensions are given solely by way of example.

As previously described, the image on the cathode ray tube **26** is projected on the selenium surface **25** by the lens system **31**. This is accomplished by a mirror **131** which is inclined as shown with respect to the axis of the machine **10** to project the image from the cathode ray tube face, or other image source, onto the surface **25** following exposure to the high positive potential applied by the wires **108**. The image, so projected, is located axially along the surface **25**. The mirror **131** is secured in any suitable manner to a metal or other sufficiently rigid strip **132**. This strip is bent so as to provide radially extending ends **136** which are received in the grooves **95** and **98**.

A quantity of developer is placed in the cylindrical member **27** and this powder flows axially along the surface **25**. The path of powder flow is angularly displaced counter-clockwise from the line or lines of impingement of the image projected by the mirror **131** as viewed on Fig. 4 of the drawing. Suitable developers for xerography use are known and it will be understood that the machine **10** can be used with any suitable powder having predetermined triboelectric properties. A form of developer giving excellent results in the machine **10** is made up of glass beads and sulphur particles coated with coprecipitated organic coloring matter. The coloring matter is, for example, spirit soluble nigrosine and spirit soluble Iosol Black. The glass beads are negative with respect to the sulphur coated with the coprecipitated coloring matter. The latter takes a positive charge. The developer powder briefly described herein as giving excellent printing results is fully disclosed in a copending application for Letters Patent of Harold G. Greig, Serial No. 187,827, filed September 30, 1950, and entitled "Improvement in Electrostatic Printing."

In the illustrative machine **10**, the quantity of developer is circulated by the helical strips **89** as the cylinder rotates. The surplus developer after traversing the surface **25** may be collected in a second hopper after being discharged by gravity from the lower end of the cylinder.

The projecting ends of the strips opposite the end plate **38**, as they continuously pass the lowest point of the rotating cylinder, scoop up or trap a quantity of the developer powder which rests by gravity in the lowermost part of the cylinder. It will be understood that as the cylinder rotates, the powder will flow at a controlled rate axially along the cylinder and that the path of flow will be displaced to the right of the axial plane of the cylinder as it is viewed in Fig. 4 of the drawing. This feature of a machine embodying the present invention provides some additional angular spacing between the wires **108** and the point of impingement of the luminous

image on the surface 25. It will be understood that as the cylinder rotates, the developer which is trapped in the channels between the strips 89 will be discharged from these channels, and that the excess or overflow, which is continuously transferred to the bottom of the cylinder, will flow across the cylindrical member. It will be noted that the strips 89 do not extend for the full length of the cylinder 27 to the left as viewed in Fig. 3. This permits smoother flow of the accumulated powder onto the inner selenium surface 25.

The paper web, designated by reference character 141, is fed from a roll 143. This roll is conveniently mounted on a spindle 146 supported by brackets 148 and 149. A helical spring 151, bearing against a disc 152, assists in centering the roll by biasing it into contact with a second disc 153. The web 141, as it feeds from the roll 143, passes under a rod 161 so that it is substantially in contact with the surface 25. The web is held against the surface 25 by the electrostatic charge from the transfer unit and is peeled from the surface at the point where it passes over a second rod 166. The rod 166 is carried by a bracket 168 which is received in the groove 95. The other end of this rod is carried by a second bracket 169 received in the groove 98. A second rod 173 extends diagonally across the machine substantially in the horizontal plane of the rod 166. The rod 173 is supported at one end by the bracket 169 and at its other end by a bracket 176. The bracket 176 is received in the groove 98. After passing over the rod 166, the paper web also passes over the rod 173 and passes from beneath this last named rod to an inclined rod 179 (Fig. 1). The rod 179 forms part of the previously mentioned web driving and guiding means 24. The previously mentioned power shaft 12 drives a roll 182 through the belt and pully connections 183. The driven roll 182, along with an idler roll 186, forms a pair of driving pinch rollers through which the web is passed after being turned over the top of the inclined rod 179.

The transfer unit as shown in Fig. 3 comprises the previously mentioned insulating member 163 carried by brackets 188 and 189, received in the grooves 95 and 98. The member 163 is pierced at intervals to receive pointed electrodes such as needles 192 which project toward the portion of the web 141 in contact with the surface 25. A connection to each of the needles 192 from a suitable high voltage source (not shown) is made by a conductor 196. Th outer ends of the needles are protected by a corona shield 197.

I claim:

1. An electrophotographic recorder comprising an imperforate hollow cylinder, means to impart rotation to said cylinder, a second imperforate hollow cylinder nested within said first named cylinder, said second cylinder having a photoconductive inner surface, means for spacing said second named cylinder substantially coaxially with said first named cylinder, said last named means providing one or more helical passageways between said first named and said second named cylinders extending substantially from end to end axially of said cylinders.

2. An electrophotographic recorder comprising an imperforate hollow cylinder, flanges at each end of said member, rotatable rollers for receiving said flanges to support said cylinder and to impart rotation thereto, a second imperforate hollow cylinder nested within said first named cylinder, said second cylinder having a photoconductive inner surface, means for spacing said second named cylinder substantially coaxially with said first named cylinder, said last named means providing one or more helical passageways between said first named and said second named cylinders extending substantially from end to end axially of said cylinders.

3. An electrophotographic recorder comprising an imperforate hollow member, means to impart rotation to said cylinder, a second imperforate hollow cylinder nested within said first named cylinder, said second cylinder having a photoconductive inner surface, means for spacing said second named cylinder substantially coaxially with said first named cylinder, said last named means comprising helically disposed strips to provide one or more helical passageways between said first named and said second named cylinders extending substantially from end to end axially of said cylinders.

4. An electrophotographic recorder comprising an imperforate hollow cylinder, means providing a partial closure for each end of said cylinder whereby to contain a quantity of fluent material, means to impart rotation to said cylinder, a second imperforate hollow cylinder nested within said first named cylinder, said second cylinder having a photoconductive inner surface, means for spacing said second named cylinder substantially coaxially with said first named cylinder, said last named means providing one or more helical passageways between said first named and said second named cylinders extending substantially from end to end axially of said cylinders whereby to cause fluent material to be returned from one end to the other of said cylinders.

5. An electrophotographic recorder comprising an imperforate hollow cylinder, means providing a partial closure for each end of said cylinder whereby to contain a quantity of fluent material, means to support said cylinder with its axis inclined to the horizontal, a second imperforate hollow cylinder nested within said first named cylinder, said second cylinder having a photoconductive inner surface, means for spacing said second named cylinder substantially coaxially with said first named cylinder, said last named means providing one or more helical passageways between said first named and said second named cylinders extending substantially from end to end axially of said cylinders whereby to cause fluent material to be returned from one end to the other end of said cylinders.

6. An electrophotographic recorder comprising an imperforate hollow cylinder, means providing a partial closure for each end of said cylinder whereby to contain a quantity of fluent material, means to support said cylinder with its axis inclined to the horizontal, a second imperforate hollow cylinder nested within said first named cylinder, said second cylinder having a photoconductive surface, a plurality of helically disposed strips for spacing said second named cylinder substantially coaxially with said first named cylinder, said strips being spaced to provide a plurality of helical passageways between said first named and said second named cylinders extending substantially from end to end axially of said cylinders whereby to cause fluent material to be returned from one end to the other of said cylinders.

7. An electrophotographic recorder comprising a transparent cylindrical member, a flange at each end of said cylindrical member providing a partial closure for each end of said cylindrical member whereby to contain a quantity of fluent material, means to support said cylindrical member with its axis inclined to the horizontal, means to impart rotation to said inclined cylindrical member, a second cylindrical member nested within said first named cylindrical member, the interior surface of said second cylindrical member being photoconductive, a plurality of helically disposed strips for spacing said second named cylindrical member substantially coaxially with said first named cylindrical member, said strips being spaced to provide a plurality of helical passageways between said first named and said second named cylindrical members extending substantially from end to end axially of said cylindrical members whereby to cause fluent material to be returned from one end to the other of said cylindrical members.

8. An electrophotographic recorder comprising a cylindrical member, means providing a partial closure for each end of said cylindrical member whereby to contain a quantity of fluent material, means to support said cylindrical member with its axis inclined to the hori-

zontal, means to impart rotation to said inclined cylindrical member, a second and axially shorter cylindrical member nested within said first named cylindrical member, a plurality of helically disposed strips for spacing said second named cylindrical member substantially coaxially with said first named cylindrical member, said strips extending beyond the end of said second cylindrical member at the lower end thereof and ending short of the higher end, said strips being spaced to provide a plurality of helical passageways between said first named and said second named cylindrical members extending substantially from end to end axially of said cylindrical members whereby to cause fluent material to be returned from one end to the other of said cylindrical members.

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