United States Patent

[11] 3,600,086

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[21] Appl. No. **791,412**
[22] Filed **Jan. 15, 1969**
[45] Patented **Aug. 17, 1971**

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[54] AUTOMATIC PHOTOCONDUCTOR ADVANCE MECHANISM FOR A XEROGRAPHIC COPYING MACHINE

5 Claims, 10 Drawing Figs.

[52] **U.S. Cl.** **355/16,** 101/132, 242/55
[51] **Int. Cl.** **G03g 15/00**
[50] **Field of Search** 101/132; 242/55; 355/3, 16

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ABSTRACT: Apparatus automatically advances or replaces a reusable photoconductor element in a xerographic or similar copying machine is disclosed. The photoconductor element is stored in flexible strip form on supply and takeup rolls located within the interior of a copy drum. A counter is actuated each time a copy is produced. When a preset number of copies has been made the copy machine is automatically cycled into a photoconductor advance mode which causes a new length of photoconductor element to be drawn from the supply roll and disposed in operative relation about the outer periphery of the copy drum. A second counter records the number of times the photoconductor element is advanced and provides an indication to the operator when the supply of photoconductor element has been exhausted. Various electrical interlock and sequencing circuits are incorporated to prevent damage to the apparatus during a photoconductor advance cycle.

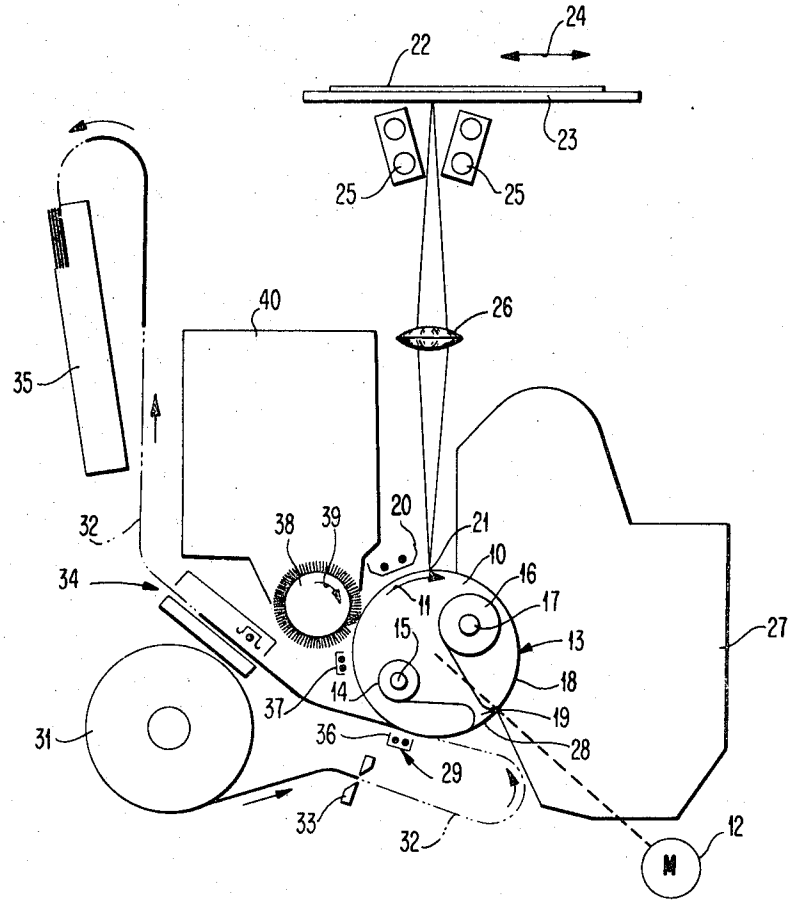


FIG. 1

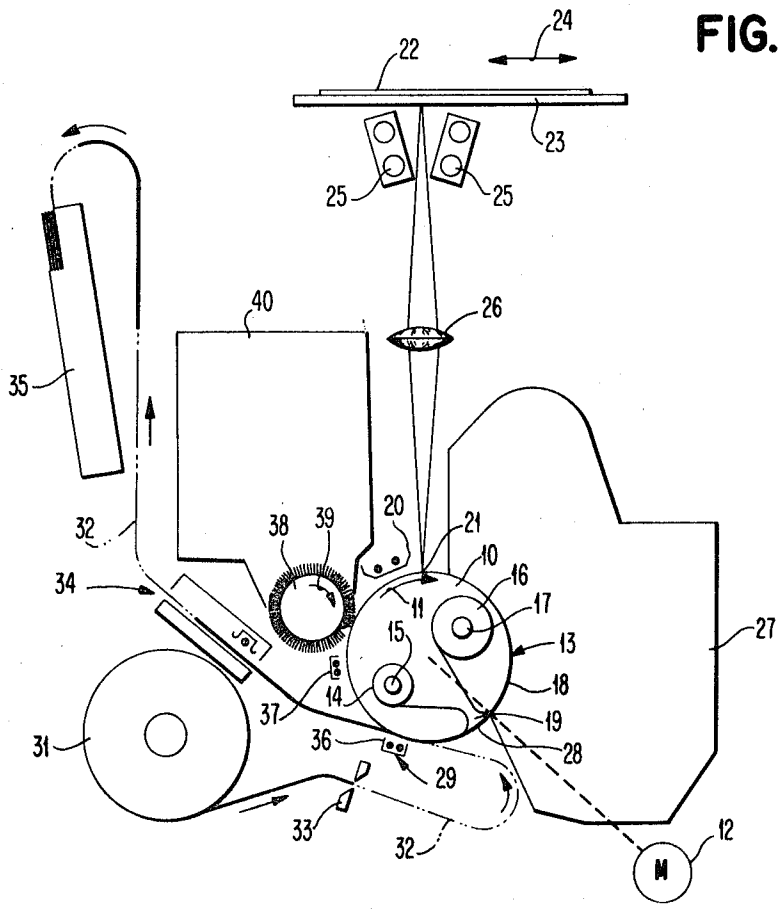
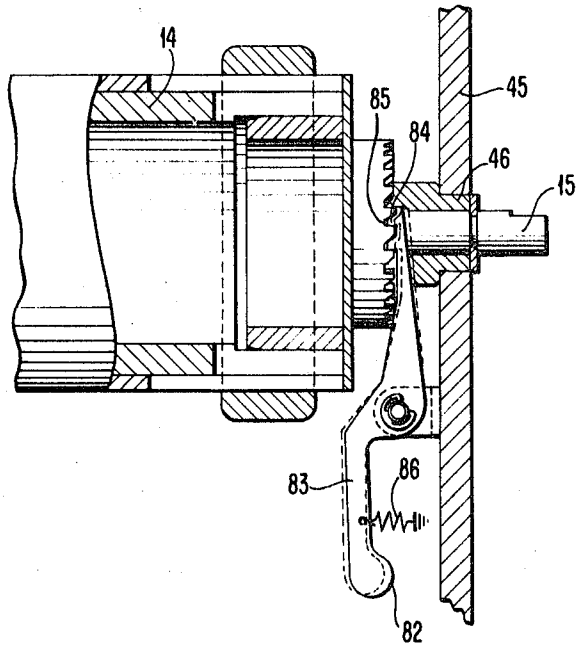


FIG. 7



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ATTORNEY.

FIG. 2

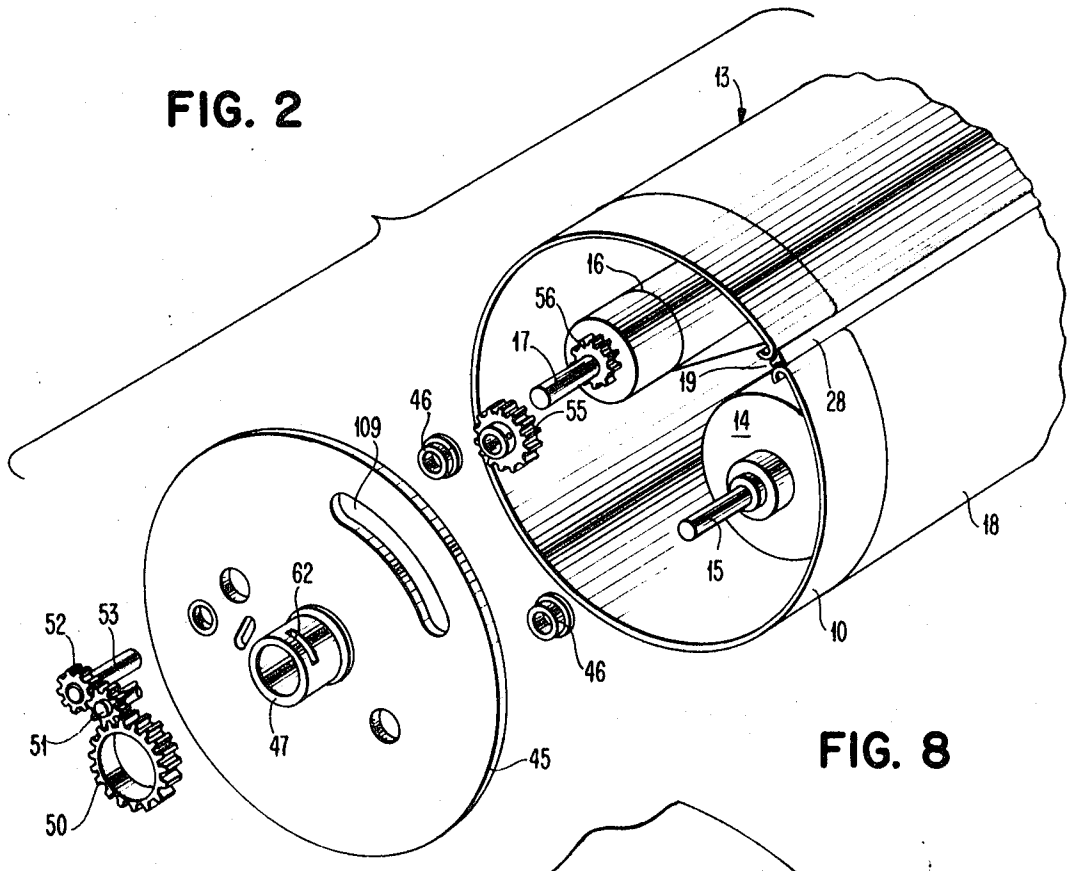

13
16
56
17
19
28
46
55
109
14
18
15
62
52
53
10
46
51
47
45
50

FIG. 8

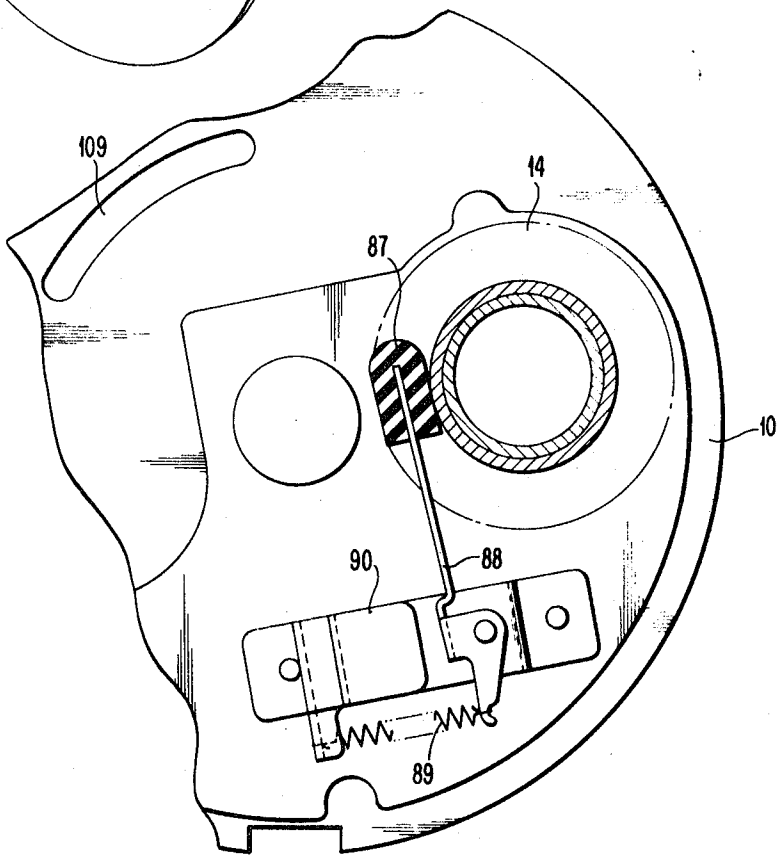

109
14
87
10
90
88
89

FIG. 3

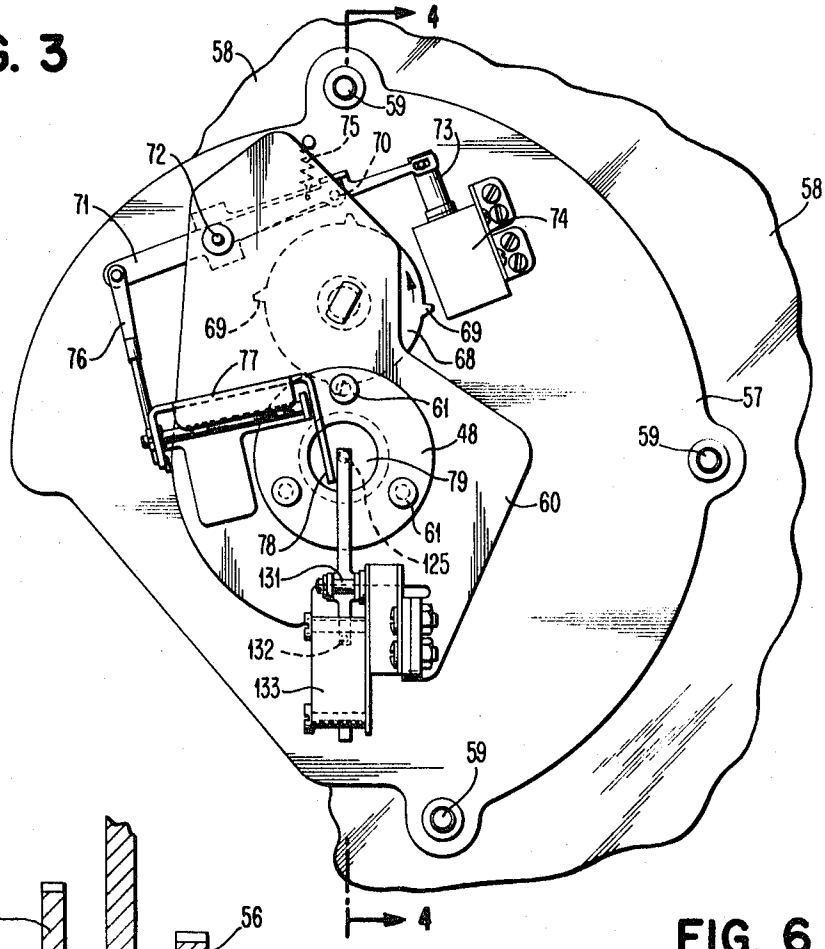

4
58
59
75
70
73
72
71
74
58
69
69
68
76
77
61
57
48
59
79
60
61
78
125
131
132
133
59
4

FIG. 6

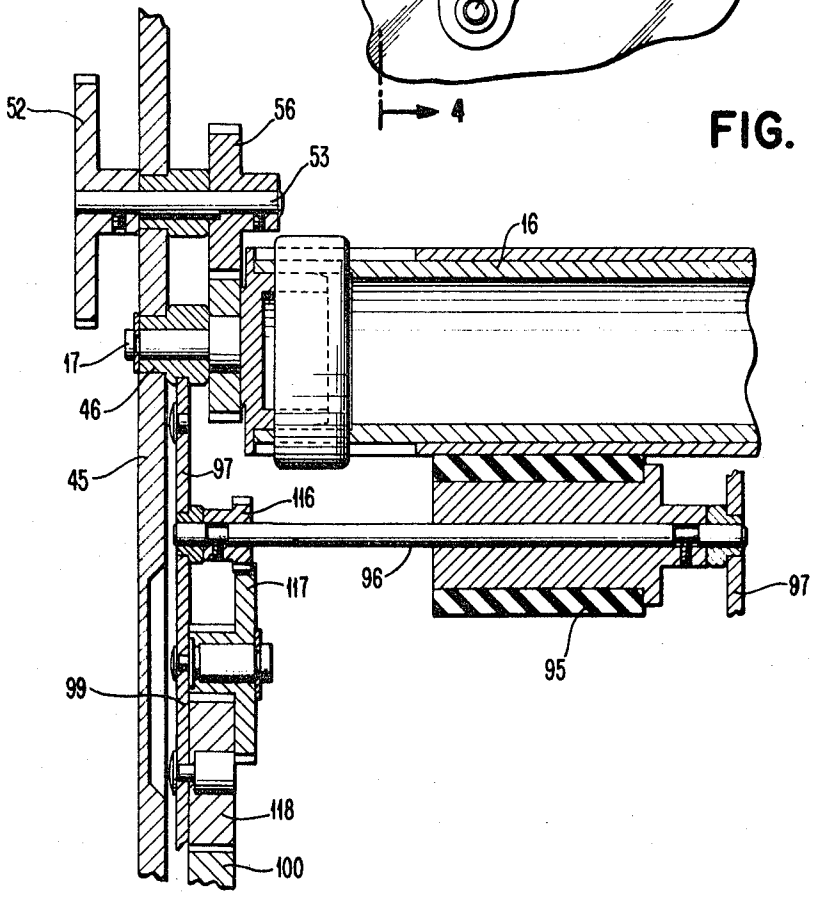

52
56
53
16
17
46
45
97
116
117
96
97
95
99
118
100

FIG. 4

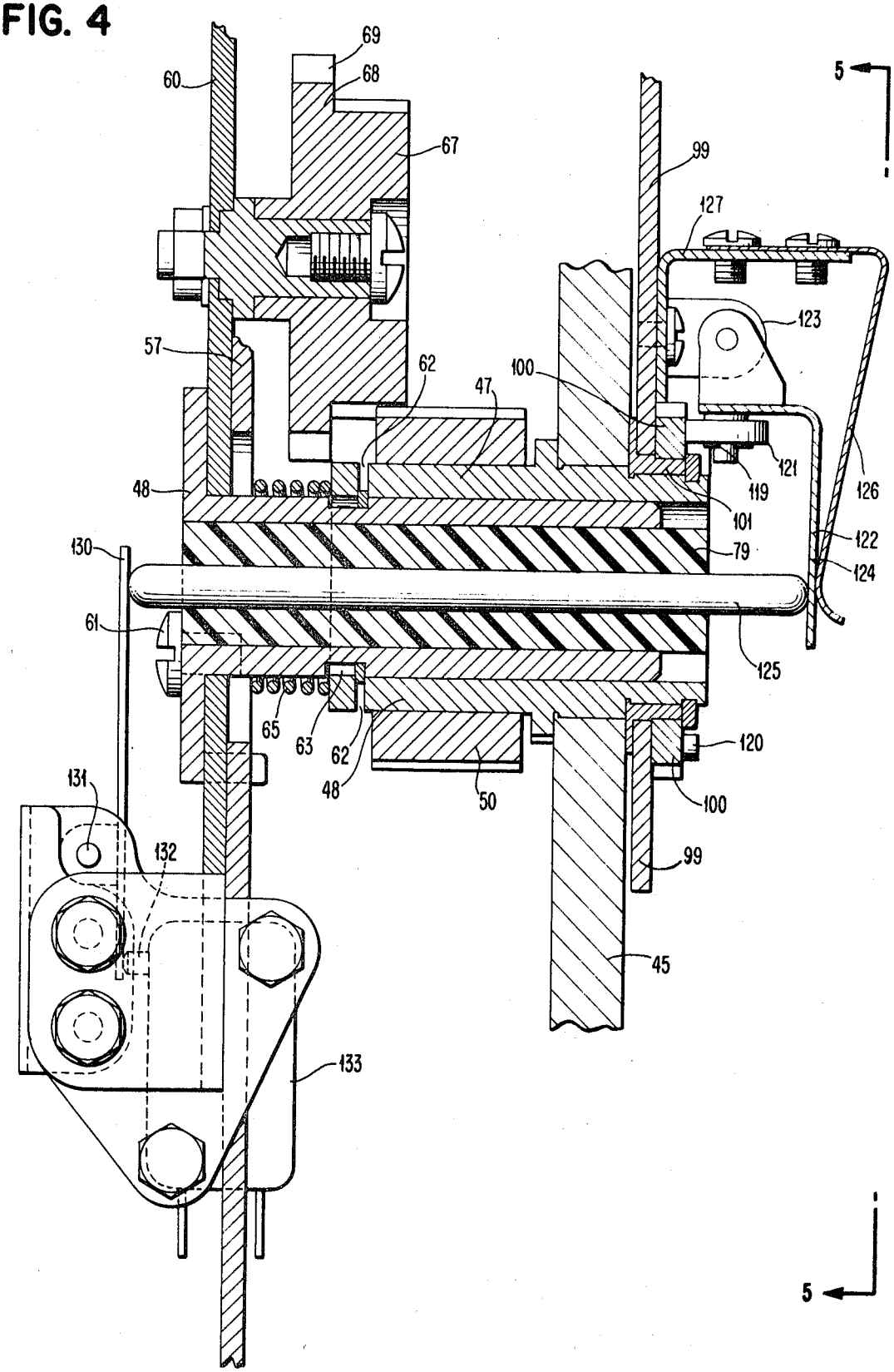

69
68
60
67
99
5
127
123
57
62
47
100
121
119
126
48
101
122
130
79
124
61
125
65
63
62
120
48
50
100
131
132
99
45
133
5

FIG. 5

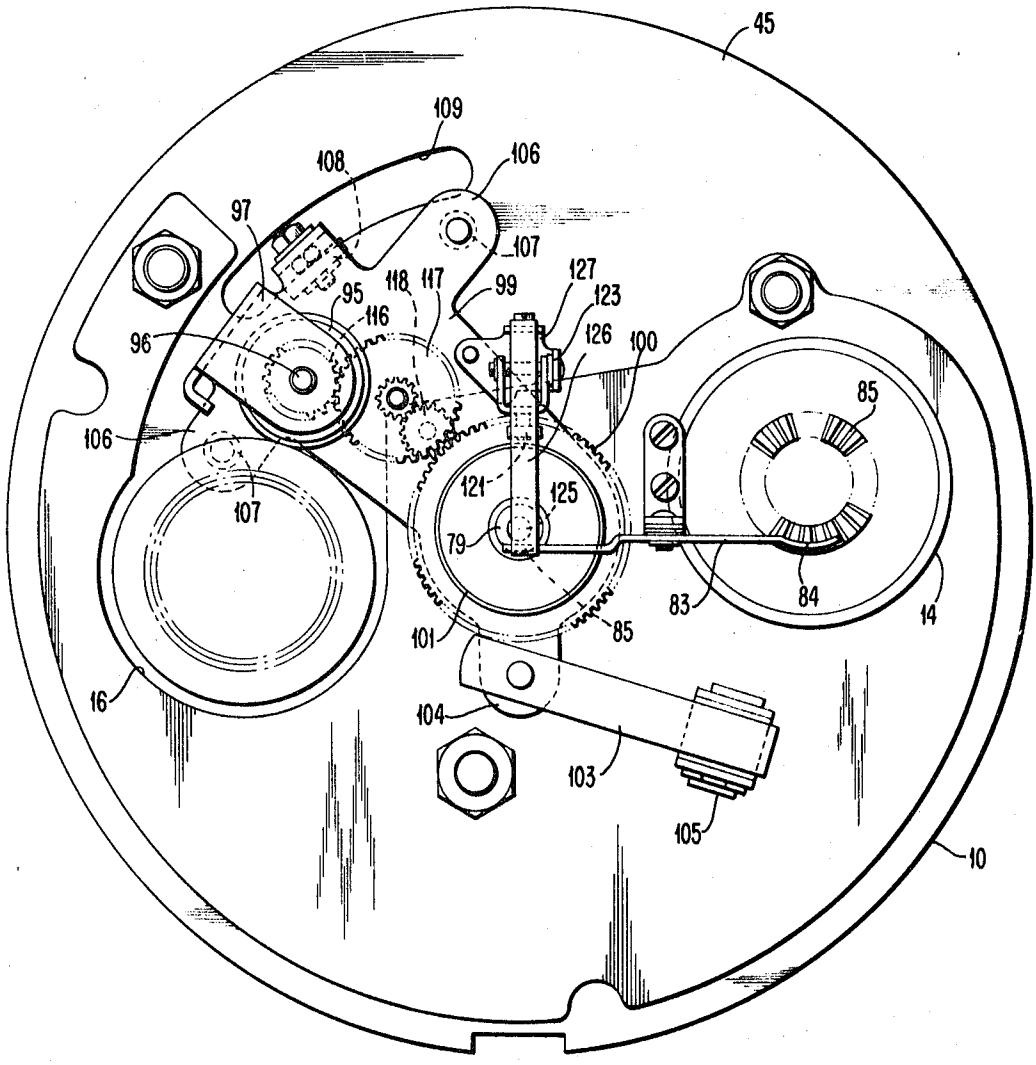

45
109
108
106
97
107
95
118
117
99
127
123
116
126
96
100
85
106
121
125
107
79
83
84
14
101
85
16
104
103
105
10

FIG. 9

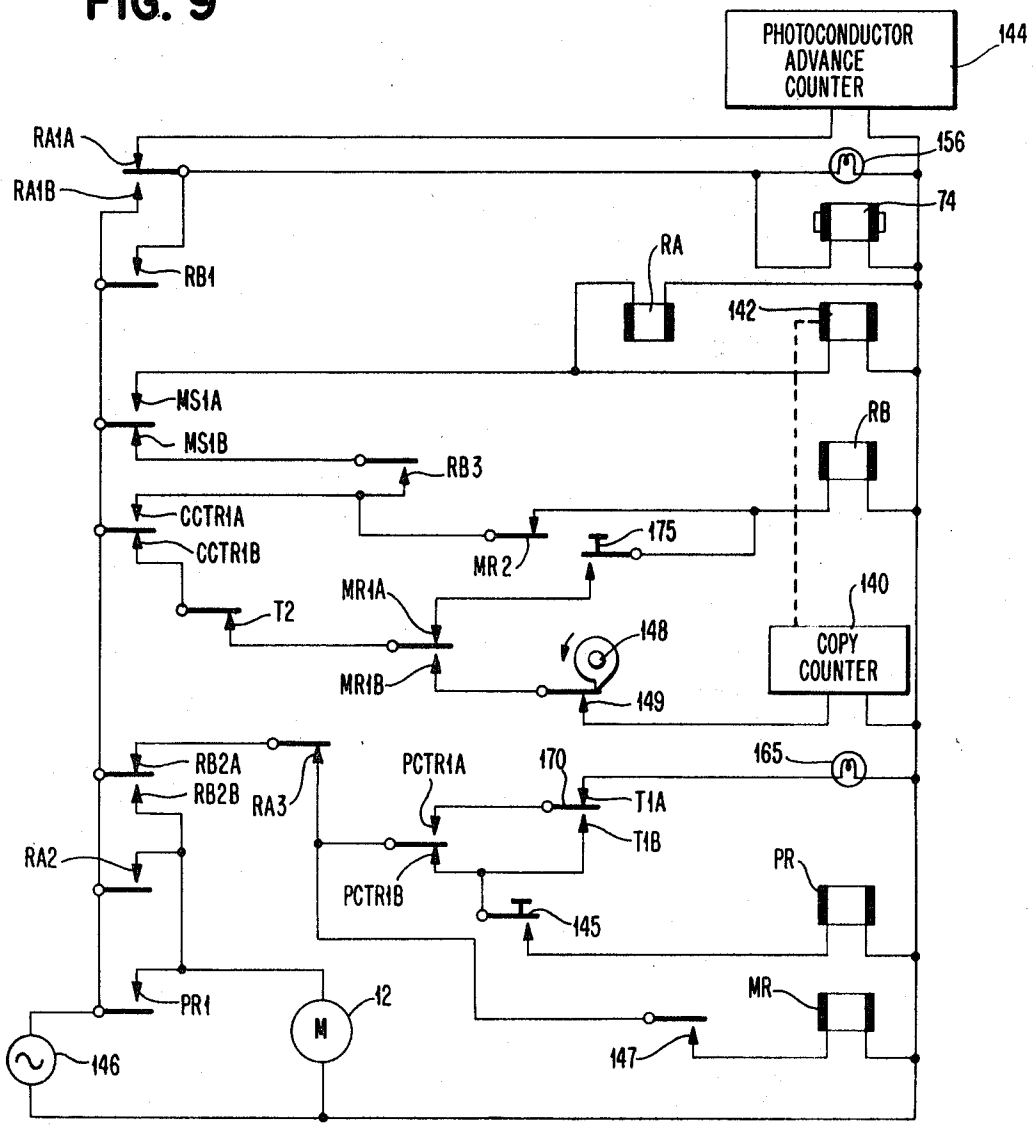
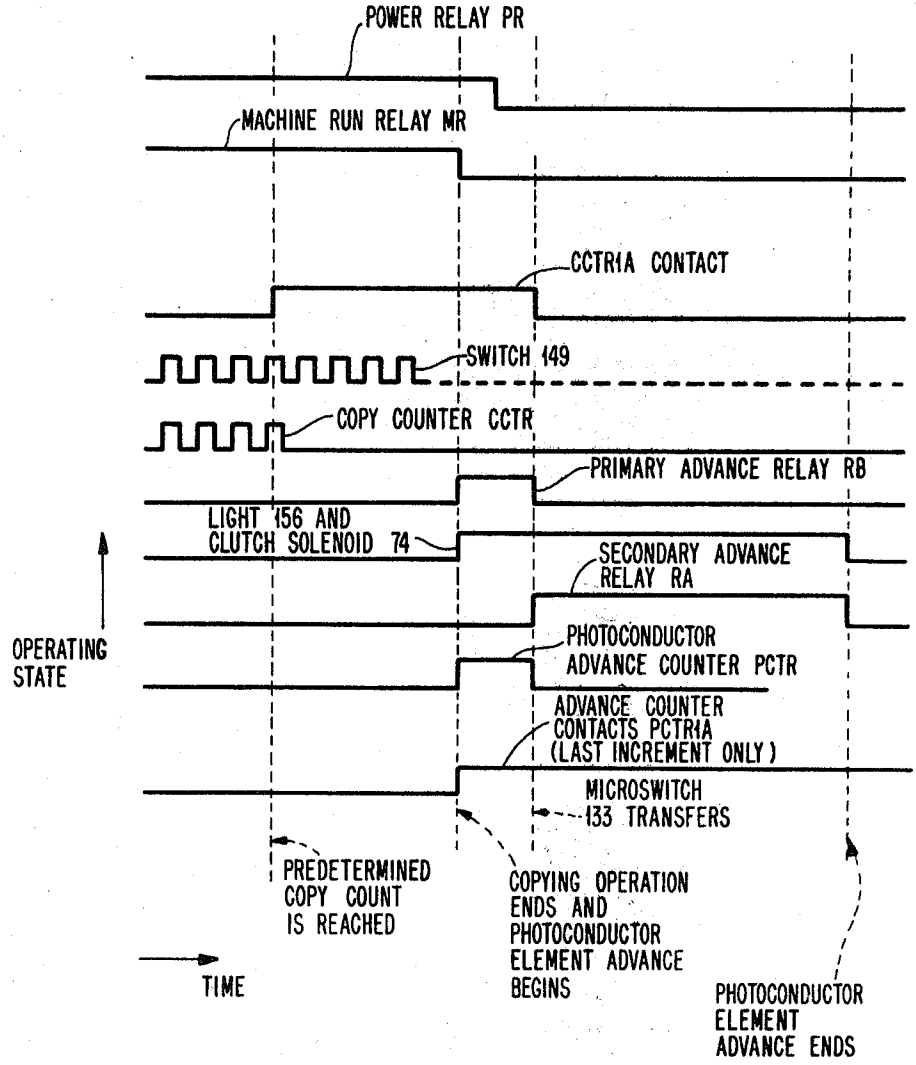

PHOTOCONDUCTOR ADVANCE COUNTER
144
RA1A
RA1B
RB1
156
74
RA
142
MS1A
MS1B
RB3
RB
CCTR1A
CCTR1B
MR2
175
T2
MR1A
MR1B
148
149
140
COPY COUNTER
RB2A
RB2B
RA3
PCTR1A
170
T1A
T1B
165
RA2
PCTR1B
145
PR
PR1
12
M
146
147
MR

FIG.10


POWER RELAY PR
MACHINE RUN RELAY MR
CCTR1A CONTACT
SWITCH 149
COPY COUNTER CCTR
PRIMARY ADVANCE RELAY RB
LIGHT 156 AND CLUTCH SOLENOID 74
SECONDARY ADVANCE RELAY RA
PHOTOCONDUCTOR ADVANCE COUNTER PCTR
ADVANCE COUNTER CONTACTS PCTR1A (LAST INCREMENT ONLY)
MICROSWITCH 133 TRANSFERS
OPERATING STATE
PREDETERMINED COPY COUNT IS REACHED
COPYING OPERATION ENDS AND PHOTOCONDUCTOR ELEMENT ADVANCE BEGINS
PHOTOCONDUCTOR ELEMENT ADVANCE ENDS
TIME

AUTOMATIC PHOTOCONDUCTOR ADVANCE MECHANISM FOR A XEROGRAPHIC COPYING MACHINE

The present invention relates generally to the copying arts. More particularly, the present invention is concerned with mechanisms for automatically replacing the reusable photoconductor element in a xerographic copying machine or the like.

In an application of Clifford E. Herrick, Jr. entitled "Electrophotographic Process," Ser. No. 649,162, filed June 27, 1967, now abandoned, and assigned to the assignee of the present invention, there is disclosed and claimed an arrangement which permits replacement or changing of the photoconductor element in a xerographic copying machine. The photoconductor material or layer is coated on a flexible conductive backing material and the resulting photoconductor element is stored in roll form on supply and takeup spindles within the interior of the copy drum. The photoconductor element extends from the supply roll to the exterior of the drum, about the exterior periphery of the drum, and then back into the interior of the drum to the takeup roll. To change the operative portion of the photoconductor element, a length of the photoconductor element is advanced from the supply roll to the takeup roll. Such an arrangement is extremely advantageous since it eliminates the necessity of removing the copy drum from the copying machine to clean or replace the photoconductor surface. This substantially reduces operator maintenance and service calls. In addition, it provides copies of consistently high quality throughout the life of the xerographic copying machine.

The present invention is concerned with the sequence circuits disclosed herein. The specific copy drum which is also disclosed forms the claimed subject matter of a concurrently filed and copending patent application entitled "Drum Structure for a Xerographic Copying Machine," Ser. No. 791,350, filed Jan. 15, 1969, in the names of Richard A Berlier and Russell W. Rice, and which is also assigned to the assignee of the present invention.

It is the primary or ultimate object of this invention to provide mechanism for automatically advancing or replacing the photoconductor element in a xerographic copying machine. Apparatus is provided for registering or counting each copy made by the copying machine and automatically advancing the striplike photoconductor element after a predetermined number of copies has been made. As will be hereinafter more fully explained, the wear or filming rate of a photoconductor surface is directly related to the number of copies which have been made using the photoconductor.

Another object of the invention is to provide mechanism for effecting automatic advance of the photoconductor element in a xerographic copying machine which provides an indication to the operator when the entire length of the photoconductor stored within the machine has been used. A second counter is actuated each time the photoconductor element is advanced and actuates a signal when a count corresponding to the number of usable operative portions of the photoconductor element stored within the machine has been reached.

Yet another object of the invention is the provision of mechanism for automatically advancing the photoconductor element in a xerographic copying machine which incorporates numerous safety features that prevent damage to the machine and the advance mechanism. Interlocks are provided so that a copying cycle cannot be initiated when the photoconductor element is being advanced. However, if the operator depresses the start switch during the time the photoconductor element is being advanced, the sequence circuits are conditioned and a copying cycle is automatically initiated when the advance operation is completed. The photoconductor advance mechanism is prevented from operating when the second counter indicates the supply of the photoconductor element has been exhausted.

A further object of the invention is to provide automatic photoconductor advance mechanism for a xerographic copying machine or the like which permits the operator and/or service personnel to initiate a photoconductor advance operation at any time. The arrangement is such that the photoconductor element can be advanced by the operator whenever a particularly high quality copy is desired, the surface of the operative portion of the photoconductor element is damaged, or a bad section of photoconductor element is encountered.

A still further object of the invention is to provide automatic photoconductor advance mechanism for a xerographic copying machine having the characteristics set forth above which is extremely simple in construction and operation. The mechanism is fabricated from standard components at a relatively low cost and is highly reliable in operation.

The foregoing and other objects and advantages of the invention will be apparent from the following more particular description of a preferred embodiment of the invention as illustrated in the accompanying drawings.

In the drawings:

FIG. 1 is a schematic side view of a xerographic copying machine employing automatic photoconductor advance mechanism constructed and operated in accordance with the teachings of the present invention;

FIG. 2 is an exploded end perspective view showing a portion of the drive arrangement employed to periodically rotate the takeup spindle to advance a new length of photoconductor element about the outer periphery of the copy drum;

FIG. 3 is a front end view of a part of the advance mechanism;

FIG. 4 is a side sectional view taken along the section line 4–4 of FIG. 3;

FIG. 5 is a back end view of a portion of the advance mechanism taken along section line 5–5 of FIG. 4;

FIG. 6 is a partial side sectional view depicting the takeup roll of photoconductor element and the measuring roll;

FIG. 7 is a partial side sectional view showing the lock associated with the supply roll of photoconductor element;

FIG. 8 is a back end view depicting the brake associated with the supply roll of photoconductor element;

FIG. 9 is a schematic circuit diagram of the sequence circuits controlling the photoconductor advance operation; and

FIG. 10 is a timing diagram depicting the operation relative to time of certain of the circuit elements employed in the circuit diagram of FIG. 9.

XEROGRAPHIC COPYING MACHINE

Referring now to the drawings, and initially to FIG. 1 thereof, there is shown a schematic representation of a xerographic copying machine embodying the automatic photoconductor advance mechanism of the present invention. The electrophotographic member of the copying machine comprises a copy drum **10** which is mounted for rotation in the direction indicated by arrow **11**. The copy drum is rotated about its axis by an electric motor **12** acting through a drive train schematically indicated by a broken line. This motor not only rotates the drum during copying cycles, but also during a photoconductor advance cycle.

Disposed on the outer periphery of the drum is a photoconductor element generally designated by the reference numeral **13**. The photoconductor element preferably comprises a layer of an organic photoconductor consisting essentially of a 1- to-1 molar ratio of polymerized vinylcarbazole and 2,4,7-trinitro-9-fluorenone. This photoconductor is disclosed and claimed in an application of Meredith D. Shattuck and Ulo Vahtra entitled "Organic Photoconductive Compositions and Their Use in Electrophotographic Processes," Ser. No. 556,982, filed June 13, 1966 and assigned to the assignee of this invention.

The photoconductor material is coated on a flexible conductive backing material, such as aluminized 3 mil Mylar plastic. The resulting photoconductor element **13** is thin and flexible and an extended length thereof is stored in roll form

within the interior of the copy drum. A supply roll **14** of unused photoconductor element **13** is removably supported on supply spindle **15** while a takeup roll **16** of the photoconductive element **13** is similarly supported on takeup spindle **17**. The center or operative portion **18** of the photoconductor element located between the supply and takeup rolls extends through an axial slot **19** in and about the outer periphery of the copy drum. A resilient seal **28** is located within and extends the length of the slot **19** to prevent toner and other material from entering the interior of the copy drum. This arrangement permits changing of the operative portion of photoconductor element without removing the copy drum from the copying machine as is fully disclosed and claimed in the above identified copending application Ser. No. 649,162.

Disposed about the periphery of the copy drum **10** are a number of processing stations which carry out the conventional steps of the xerographic copying process. An initial charging station is provided by a corona unit **20** which deposits a uniform charge on the surface of the photoconductor element while the same is maintained in the dark. The next station is exposure station **21** where a line image of the original document is projected onto the uniformly charged surface of the photoconductor element **13** as the copy drum rotates. A document **22** to be copied is supported face down on a movable and transparent copy bed **23** which moves back and forth past a scanning slit is indicated by the arrow **24**. The document **22** passing the scanning slit is illuminated by lights **25** and a line image of light and shadow is projected by stationary lens **26** onto the photoconductor element **13** carried by the copy drum.

The next station in the direction of rotation of the copy drum **10** is a cascade developer unit **27** where a two component developer composition is caused to flow across the surface of the drum. The developer composition comprises heat fixable marking particles or toner which is attracted to and deposited on the surface of the photoconductor element in accordance with the latent electrostatic image corresponding to the original. The result of the cascade development operation is the formation of a toner image on the surface of the photoconductor element. It is now necessary to transfer the toner image to a copy sheet and this is accomplished at the toner transfer station **29**.

The plain copy paper is stored within the copying machine in roll form as indicated by roll **31** and is fed along a path of travel **32** in the direction indicated by the arrows leading past knives **33**, the toner image transfer station **29**, fusing apparatus generally indicated by reference numeral **34** and then to an output copy hopper **35**. The copy paper is cut to the length selected by the operator and the cut copy sheet moves into contact with the drum. A transfer corona unit **36** assists in the transfer of the toner image to the copy sheet. The copy sheet is then separated from the drum, the toner image fused by heat and the final copy transported to the output hopper **35**.

Not all of the toner image is transferred to the copy sheet and it is necessary to remove the residual toner from the surface of the drum. This is accomplished by employing a preclean corona unit **37** whose corona discharge tends to loosen the remaining toner particles and a cleaning brush **38** which is rotated at high speed in the direction indicated by arrow **39**. The toner particles which are brushed from the surface of the photosensitive material are drawn by vacuum into a filter bag mounted within a housing **40**.

One of the problems which is apparently at least partially connected with the cleaning operation, the surface characteristics of the photoconductor layer, and the properties of the toner, is the gradual buildup of a film of toner on the surface of the photoconductor element as copies are made. In the absence of the internal storage of the photoconductor element within the interior of the machine, this buildup of toner film either may require very frequent removal and cleaning of the copy drum to maintain copy quality, or may result in copies of low quality having appreciable background and low contrast if the copy drum is removed and cleaned at less frequent intervals. For example, the manufacturer recommends that the copy drum be removed and washed with a solvent for the toner after about 7000 copy cycles for one commercially available xerographic copying machine having a permanent photoconductor surface. Another problem with a machine using a copy drum having a permanent photoconductor surface is that the entire drum must be removed and replaced if the photoconductor surface becomes heavily scratched or otherwise damaged, such as by inadvertant scratching by carrier beads for the toner in the developer composition. These limitations and difficulties with the prior art arrangements are eliminated when a supply of the reusable photoconductor element is stored within the interior of the copy drum and automatically advanced in accordance with the teachings of the present invention.

PHOTOCONDUCTOR ADVANCE MECHANISM

The mechanical portions of the photoconductor advance mechanism are shown in FIGS. **2—8** of the drawings and comprise various assemblies mounted at one end of the copy drum **10**. The general or overall operation of the mechanism in automatically advancing the photoconductor element **13** is that a solenoid is actuated to engage a clutch and release the locking means preventing movement of the photoconductor element. The engaged clutch drivingly couples a normally free wheeling drive train to the stationary frame of the xerographic copying machine. As the copy drum is rotated by motor **12**, the takeup roll **16** is driven to advance the photoconductor element **13**. A metering roll engages and is rotated by the takeup roll **16** of the photoconductor element. After a predetermined measured amount of the photoconductor element has been payed out, a switch is actuated which deenergizes the solenoid. The drive train is again permitted to free wheel so that there is no relative movement between the takeup roll **16** and the copy drum **10** as the drum is rotated by motor **12** during copying cycles.

Referring initially to FIGS. **2—4** of the drawings, the copy drum **10** comprises an end plate **45** that is removably attached by screws or other convenient attachment means to the machined cylinder forming the body portion of the copy drum. The end plate carries a pair of bearings **46** which journal the ends of supply and takeup spindles **15** and **17**, respectively. An elongated and flanged sleeve type bronze bearing **47** is rigidly mounted in the center of the end plate **45** and receives a T-shaped cylindrical stub **48** whose head end is rigidly attached to a stationary portion of the xerographic copying machine in a manner to be hereinafter more fully explained.

A similar end plate, not particularly shown, is attached to the other end of the machined cylinder forming the body portion of the copy drum **10** and mounts bearings supporting spindles extending from the opposite ends of the supply and takeup rolls **14** and **16** of photoconductor element. An elongated supporting rod, also not shown, extends from the other side of the xerographic copying machine and through the center of the end plate at the other end of the copy drum. The arrangement is such that the copy drum is supported for rotation about its axis by the elongated supporting rod and the T-shaped stub **48**. Also, the supply and takeup rolls **14** and **16** of photoconductor element are supported at their ends in the end plates for rotation relative to the copy drum. As shown in the various view of the drawings, the spindles for the takeup and supply rolls of photoconductor element mounted at the opposite ends of the copy drum have plug type fittings that extend within and functionally engage the ends of the tubular supporting cores of the takeup and supply rolls. This construction permits the photoconductor element to be changed after it has been completely used by removing it and inserting an unused photoconductor element within the copy drum.

Mounted on and freely rotatable with respect to the bronze sleeve bearing **47** adjacent the outer surface of end plate **45** is

an annular ring gear 50. Meshing with the ring gear 50 is a pinion gear 51 which is supported from the end plate 45 and, in turn, drivingly engages a gear 52. Gear 52 is carried by crossover shaft 53 that projects through the end plate 45 and also carries gear 55. This latter gear meshes with a spur gear 56 which is attached to the end of the takeup spindle 17. During normal copying operations when the main ring gear 50 is free to rotate relative to the stationary frame of the copying machine, the gear train comprising gears 51, 52, 55 and 56 operates in a planetary or free wheeling fashion as the copy drum is rotated by drive motor 12 so that the takeup roll 16 is not rotated about its axis and the photoconductor element is not advanced. However, if the ring gear 50 is held and prevented from turning while the drum is rotated by drum drive motor 12, then the takeup roll 16 will pull and wind the photoconductor element at a rate dependent on the speed of rotation of the copy drum and the overall ratio of the gear train. An important advantage of this arrangement is that the drive motor 12 which rotates the copy drum during normal copying operations is also employed to advance the photoconductor element from supply roll 14 to the takeup roll 16. This eliminates the need for a separate drive motor or other powering means mounted within or for movement with the copy drum to advance the photoconductor element.

A generally circular mounting plate 57 having a relatively large center is attached to threaded shafts extending from the machine frame 58 by a plurality of knoblike nuts 59. Pinned or otherwise attached to mounting plate 57 is an apertured cover plate 60 which, in turn, has the T-shaped cylindrical stub 48 mounted therefrom by bolts 61. In this manner the stub 48 is referenced to mechanical ground or the stationary frame of the xerographic copying machine.

The cylindrical sleeve type bearing 47 has a pair of slots 62 on the opposite sides thereof while the stub 48 has a cooperating outer peripheral groove 63. Received within the slots 62 and the groove 63 is a U-shaped spring clip 64 which maintains the apparatus in assembled relation. A helical coil spring 65 encircles the stub 48 and bears against the front edge of the sleeve bearing 47 to insure that the copy drum 10 is firmly seated on the elongated supporting rod at the other side of the copying machine. To obtain access to the copy drum for service or its removal from the machine, the knoblike nuts 59 are removed. The copy drum can then be pulled endwise from the copying machine. Removal of the spring clip 64 permits mounting plate 57 and all apparatus carried thereby to be lifted away from the copy drum itself.

Meshing with the ring gear 50 is the pinion gear portion 67 of a clutch ratchet 68 that is rotatably supported from the cover plate 60. The ratchet 68 has four teeth 69 spaced about its periphery which are, under certain conditions, adapted to engage a pin 70 defining a dog which is carried by a clutch pawl 71. The clutch pawl 71 is pivoted adjacent one end from the cover plate 60 by pivot pin 72 and its other end is pivotally connected to the plunger 73 of a clutch solenoid 74 which is secured to mounting plate 57. A spring 75 connected between the clutch pawl 71 and the mounting plate 57 normally maintains the clutch pawl in a raised position. To initiate a photoconductor advance operation, the clutch solenoid 74 is actuated to lower the clutch pawl 71 so that one of the teeth 69 of ratchet 68 engages pin 70 to stop the rotation of this ratchet. Since pinion gear portion 67 meshes with ring gear 50, the latter is held stationary relative to the frame of the copying machine under this condition and driving power is supplied to takeup roll 16 as the drive motor 12 turns the copy drum.

Pivotally attached to the free end of the clutch pawl 71 is a link 76 that is connected to one arm of a U-shaped pivoted transfer bracket 77. The other arm of the bracket provides a finger 78 which overlies the end of a tubular sleeve 79. This sleeve is slidably mounted concentrically within the stub 48 and extends through the end plate 45 to the interior of the copy drum. It is preferably formed of a hard plastic having a relatively low coefficient of friction and serves as a slidable actuator in a manner to be further described.

As best shown in FIGS. 4, 5 and 7 of the drawings, the inner end of the sleeve 79 is engaged by the rounded end 82 of a pivoted pawl 83. The other end of the pawl is formed with teeth 84 which engage the teeth of a face ratchet 85 attached to the supply spindle 15. A spring 86 is connected to the pawl 83 and biases the teeth 84 into engagement with the ratchet 85. The pawl 83 and ratchet 85 provide a locking means which prevents rotation of the supply roll 14 and locks the entire photoconductor advance mechanism during normal copying operations. However, when clutch solenoid 74 is energized, the link 76 rotates bracket 77 and finger 78 pushes actuator sleeve 79 towards the interior of the drum. The motion of sleeve 79 pivots pawl 83 against the biasing force of spring 86 and the teeth 84 are removed from locking engagement with the teeth of face ratchet 85. This allows the photoconductor element to be pulled from the supply roll 14 as the takeup roll 16 is rotated via the gear train coupling the now stationary ring gear 50 and the spur gear 56 on the takeup spindle 17.

As shown in FIG. 8 of the drawings, a folded pad 87 of a resilient material, such as polyurethane, is carried by pivoted lever 88 and engages the outer periphery of the supply roll 14 of photoconductor element. The pad 87 is biased into contact with the supply roll by a spring 89 which extends from the opposite end of lever 88 to a mounting bracket 90. This mechanism provides a drag brake which prevents free rotation of the supply roll 14 and piling up of unwound photoconductor element within the interior of the copy drum during photoconductor advance operations. The operation of the locking means and the braking means is to insure that the operative portion 18 of the photoconductor element is maintained in tight and firmly contacting relation with the outer periphery of the copy drum 10 during both normal copying and photoconductor advance operations and also when the drum is removed from the copying machine.

The apparatus for measuring and controlling the length of photoconductor element that is pulled from the supply roll 14 during a photoconductor advance operation is shown in FIGS. 4—6 of the drawings and comprises a metering roll 95 positioned within the interior of the copy drum and engaging the outer periphery of the takeup roll 16 of photoconductor element. The metering roll 95 has an outer peripheral surface formed of rubber or similar material having a high coefficient of friction and is spring biased into contact with the takeup roll 16 of photoconductor element so that there is no slippage between these two rolls. The rotation of the metering roll 95 accurately reflects or measures the length of photoconductor element advanced during a photoconductor advance operation.

The metering roll 95 is pinned to a shaft 96 which extends between the spaced arms 97 of a U-shaped portion or clevis located at one end of a metering arm 99. The metering arm carries the metering roll 95 and additional motion transmitting apparatus to be hereinafter more fully described. This arm has a relatively large aperture in its other end and pressed into this aperture is a mounting ring 101. The mounting ring 101 is rotatably supported on the end portion of sleeve bearing 47 that projects inwardly from the end plate 45 into the interior of the copy drum. An annular metering gear 100 is rotatably supported on the mounting ring 101 in side-by-side relation with respect to the metering arm. The metering arm 99 and the metering gear 100 are free to rotate relative to each other.

The outer end of a spring 103 is attached to a tab 104 projecting from the metering arm 95. The spring 103 is formed of spring steel wound about a pivotally mounted pin bracket 105 and provides a rotational biasing force that maintains the metering roll 95 in firm contact with the takeup roll 16 of photoconductor element. This firm contact is maintained under a relatively constant force even though the diameter of the takeup roll increases appreciably as the photoconductor element is used and transferred from the supply roll to the takeup roll.

The metering arm 99 is provided with an arrangement for stabilizing the metering roll 95 and the other apparatus movable therewith. This comprises a pair of outwardly projecting

tabs 106 that mount buttons 107 of material having a low coefficient of friction and an outrigger roller 108. The buttons 107 engage and ride against the inner surface of the end plate 45 while the roller 108 is mounted on a tab that projects through an arcuate slot 109 in the end wall 45 and rides against the outer surface thereof. This provides a three point outboard supporting arrangement which insures that there is no wobble or undesired play in the photoconductor element measuring apparatus.

Also pinned to the shaft 96 carrying the metering roll 95 is a gear 116. This gear, in turn, engages a pinion gear 117 which acts through pinion gear 118 to drive the metering gear 100. Both of the gears 117 and 118 are rotatably supported from the metering arm 99 and the arrangement is such that the metering gear 100 rotates through an angular distance directly proportional to the length of the photoconductor element being wound on the takeup roll.

The annular inner face 119 of the metering gear 100 and a cam element 120 extending from this face define an annular face cam which is engaged by a cam follower roll 121. The roll 121 is rotatably supported from an L-shaped cam follower lever 122 that is, in turn, pivotally mounted from the metering arm 99 by mounting clevis 123. The radially projecting leg 124 of the cam follower lever 122 extends toward the axis of the copy drum and overlies the inner end of a plunger 125. An L-shaped spring member 126 formed from strip steel is mounted from the metering arm 99 by bracket 127 and serves to bias the cam follower roll 121 into firm contact with the face cam.

The plunger 125 is slidable along the axis of the copy drum and is received within the center opening of tubular actuating sleeve 79. It extends from the interior of the copy drum through the end wall 45 and its outer end engages the end of a switch actuating lever 130. This lever is pivoted about pin 131 and its other end overlies the actuating button 132 of a microswitch 133 that is suitably mounted from the cover plate 57.

The ratio of the gearing between the metering roll 95 and the metering gear 100 is designed so that one complete revolution of the metering gear represents the length of photoconductor element which must be advanced to provide a clean or new photoconductor surface on the exterior of the copy drum. In operation, the clutch solenoid 74 is energized to initiate the photoconductor advance operation. The cam follower roll 121 will be resting on the cam element 120 when the clutch solenoid 74 is initially energized. Under these conditions the microswitch 133 will be open and the plunger will be in its retracted position within the interior of the copy drum. Within several revolutions of the copy drum during the photoconductor advance operation the metering gear 100 will have rotated sufficiently so that the cam follower roll 121 no longer engages the cam element 120. Plunger 125 will move outwardly of the drum under the force imparted by spring member 126 to pivot actuating lever 130 which, in turn, depresses button 132 to close microswitch 133.

The photoconductor element is wound on the takeup roll 16 until the metering roll 95 has rotated sufficiently to turn the metering gear 100 through one revolution. The cam element 120 then engages the cam follower roll 121 to pivot the cam follower lever 122 outwardly against the force exerted by spring member 126. As a result of the movement of the cam follower lever 122, the spring force tending to move button 132 from the interior of the microswitch 133 is now sufficient to open the switch. This motion is reflected in pivoting motion of the actuating lever 130 and sliding movement of the plunger 125 along the axis of the copy drum. The opening of the microswitch 133 opens an electrical circuit to be later described which results in the deenergization of the clutch solenoid 74. The clutch pawl 71 is removed from clutching relation with the teeth 69 of the clutch ratchet and ring gear 50 is again free to rotate relative to the stationary frame of the xerographic copying machine. The deenergization of the clutch solenoid 74 also permits the movement of actuator sleeve 79 under the biasing force of spring 86 and the locking means provided by teeth 84 of pawl 83 and face ratchet 85 is reengaged.

Considerable force is required to advance the photoconductor element about the outer periphery of the copy drum and the gearing interconnecting the drive gear 50 with the takeup roll 16 is selected in accordance with the torque required. For example, in one constructed xerographic copying machine, the copy drum has a diameter of approximately 7 inches and gearing designed to advance about one inch of photoconductor element for each revolution of the copy drum during a photoconductor advance operation. Since the copy drum is rotated at a speed of slightly less than 4 inches per second by drum drive motor 12, a complete photoconductor advance operation requires on the order of 2½ to 3½ minutes, depending on the amount of used photoconductor element wound on the takeup roll at the beginning of any photoconductor advance operation.

AUTOMATIC SEQUENCE CIRCUITS

The sequence circuits which control automatic advancement of the photoconductor element and incorporate interlocks to prevent damage to the copying machine under various operating conditions are shown in FIG. 9 of the drawings.

In addition to the clutch solenoid 74 and the microswitch 133, the sequence circuits comprise a copy counter 140 which is a predetermined counter with an electrical reset. Its characteristics are that a predetermined number can be set into the counter manually and its counting elements advance by one each time an electrical pulse representing a copy cycle is supplied thereto. Various contacts associated with the copy counter are transferred when the accumulated count reaches the predetermined count previously set into the counter. This counter is also provided with a reset winding 142 that is energized to reset the counter to zero after the predetermined count has been reached. A preferred counter employed in one constructed embodiment of the invention is marketed by International Telephone and Telegraph, Controls and Instruments, 200 South Wolf Road, Des Plains, Illinois 60016 under model number CE62BE402.

Another counter, photoconductor advance counter 144, is employed to record the number of times the photoconductor element is advanced. It is responsive to counting pulses and upon reaching a preset count closes associated contacts which perform other control functions. This counter is reset manually and is preferably of the type available from Durant Manufacturing Company, 622 North Cass Street, Milwaukee, Wisconsin 53201 under model number 2-Y-41092-402-T. Since the construction of copy counter 140 and photoconductor advance counter 144 is well understood by those skilled in the counter art and does not form a portion of the present invention, these counters will not be further described.

The remaining components of the sequence circuits shown in FIG. 9 of the drawings will be explained in relation to the overall operation of the circuits. It will be assumed that a predetermined number corresponding to the number of copies which is to be produced on each operative length of the photoconductor element has been manually set into the copy counter 140. It will also be assumed that the photoconductor advance counter 144 is arranged to transfer its associated contacts when a predetermined count corresponding to the number of operative lengths of photoconductor element stored within the interior of the copy drum is achieved and that the copying machine is in a normal copy producing mode.

The operator depresses the power switch 145 and power relay PR is actuated through a circuit comprising the series connected and normally closed relay contacts RB2A, RA3 and PCTR1B. Energization of the power relay PR results in closure of relay contacts PR1 so that the drum drive motor 12 is connected with a source of supply voltage indicated schematically at 146 and the copy drum is rotated at a constant speed. Next, the operator places the document to be copied

on the copy bed and sets a mechanical counter, not shown, to the number of copies of the document which are required. A start switch **147** is closed during the revolution of the copy drum when the first copy is being produced and remains closed until the revolution of the copy drum during which the last copy of a copying drum is completed. In a constructed embodiment of the invention, the start switch is manually closed by the operator and is opened after the copy bed returns to its home position after making the last copy in a copy run. The mechanical counter and the mounting of the switch **147** is disclosed on page 767 of the Dec. 1968 issue of the IBM Technical Disclosure Bulletin which is incorporated by reference herein. This Bulletin is published by International Business Machines Corporation, Box 218, Yorktown Heights, N.Y. 10598. The mechanical step down counter will not be further described since its construction forms no portion of the present invention. It is only required that the switch **147** remain closed during the revolutions of the drum during which copies are being produced.

Closure of the start switch **147** results in the energization of machine run relay MR and the transfer of relay contacts MR1A and MR1B. A cam **148** is coupled for rotation with the copy drum and has a lobe which closes switch **149** once each revolution of the copy drum. The arrangement is such that a counting pulse is supplied to copy counter **140** each time a copy is produced over the circuit comprising normally closed relay contacts CCTR1B, normally closed toggle switch contacts T2, transferred relay contacts MR1B and switch **149**. Since the switch **147** is closed and relay MR is energized only when copies are being made and one copy is provided for each revolution of the drum as represented by the closure of cam operated switch **149**, the count in the counter **140** represents the actual number of copies produced since the last time the reset winding **142** was energized.

Copies continue to be made and in the normal course of events a count corresponding to the predetermined count set in the copy counter **140** is registered by this counter. The contacts CCTR1A and CCTR1B transfer immediately when this condition occurs. The opening of contacts CCTR1B prevents any further pulses from being supplied to the copy counter **140** as the copy drum rotates to produce the remaining number of copies required for the copying operation then in process.

As soon as the remaining copies in the copying operation have been made, the switch **147** is opened and machine run relay MR drops to close the contacts MR2. Since the copy counter contacts CCTR1A had previously been closed when the predetermined count has reached, the advance relay RB is energized. Energization of this relay transfers the RB contacts to perform a multiplicity of functions. The closure of contact RB1 energizes clutch advance solenoid **74** to being a photoconductor advance operation as fully explained in the preceding section of the specification. The closure of relay contacts RB1 also energizes advance light **156** which indicates to the operator that the machine has been cycled into and is undergoing a photoconductor advance operation. In addition, a counting signal is supplied over closed relay contacts RB1 and RA1A to step the photoconductor advance counter by a count of one. The drive motor **12** for the copy drum is maintained in an energized state during the photoconductor advance operation via closed relay contacts RB2B even if the power switch **145** is opened. The now closed relay contacts RB3 provide a holding circuit through the normally closed contacts MS1B of microswitch **133** mounted at the end of the copy drum during the initial phase of a photoconductor advance operation.

As soon as a photoconductor advance operation is initiated by energization of clutch actuating solenoid **74**, the ring gear **100** begins to rotate. After a number of revolutions of the copy drum the cam element **120** has moved from beneath the cam follower roll **121** to such an extent that microswitch **133** is switched so that contacts MS1A are closed and contacts MS1B are opened. The secondary advance relay RA and the reset winding **142** for the copy counter **140** are energized via the closed contacts MS1A. Resetting of the copy counter **140** will switch the contacts CCTR1A and CCTR1B back to their original states and the primary advance relay RB will be deenergized. All of the RB relay contacts will transfer, but it should be noted that all of the loads previously carried by the RB contacts are now carried by RA contacts with the exception of the photoconductor advance counter **144** which has already registered the advance operation. For example, the closed contacts RA1B provide a path to energize the advance light **156** and the clutch solenoid **74** while closed contacts RA2 insure continued energization of the copy drum drive motor **12**.

The photoconductor advance operation continues until the cam element **120** on the metering cam **100** has pivoted the cam follower roll to the extend required to operate the microswitch **133**. The transfer of the contacts MS1A and MS1B for the microswitch **133** opens the energizing circuit for the secondary advance relay RA and the RA contacts return to their initial states. The advance solenoid **74** is deenergized to end the photoconductor advance operation, the advance light **156** is extinguished and the drive motor **12** is turned off.

As is shown in the timing diagram of FIG. **10** of the drawings, the primary and secondary advance relays RB and RA are not simultaneously deenergized at any time during a photoconductor advance operation. Due to this condition as indicated by the relay contacts RB2A, RB2B and RA3, the machine is interlocked during the photoconductor advance operation so that even if the power switch **145** is closed, the power relay PR will not be energized. This prevents the operator from inadvertently initiating a copying operation while the photoconductor advance operation is in progress. It is noted that if the switch **147** is closed during a photoconductor advance operation, the machine will automatically begin making copies as soon as the secondary advance relay RA has been deenergized.

After a predetermined number of photoconductor advance operations corresponding to the number of lengths of usable portions in the photoconductor element have occurred, the count accumulated in photoconductor advance counter **144** will cause the transfer of contacts PCTR1A and PCTR1B. This energizes an end of photoconductor element light **165** to indicate to the operator that the entire length of photoconductor element has been used. Also, the energizing circuit for the power relay PR is opened so that in the absence of further manual conditioning of the sequence circuits the copying machine cannot be used to produce additional copies. The power circuit to the drum drive motor **12** will be opened once the photoconductor operation then in progress is completed and cannot be reestablished through relay contacts PR1 under these conditions. The arrangement is such that the operator is positively informed by energization of light **165** and stopping of the machine that the last usable portion of the photoconductor element has been advanced into operative position about the outer periphery of the copy drum and steps must be taken to call service personnel or otherwise secure the replacement of the photoconductor element.

To permit the making of copies using the last section of the photoconductor element, the operator manually actuates toggle switch **170** which transfers contacts T1A, T1B and T2. This performs several functions. The closed contacts T1B provide a circuit through the closed relay contacts PCTR1A of the photoconductor advance counter, relay contacts RA3, and relay contacts RB2A to permit energization of the power relay PR when the power switch **145** is closed. The opening of contacts T1A also extinguishes the end of photoconductor element light **165**. The opening of contacts T2 prevents counting pulses from being supplied to the copy counter **140** so that the copying machine is not thereafter cycled into a photoconductor advance mode of operation and an unlimited number of copies can be made on the last length of the photoconductor element. It is noted that the indication relative to the need to replace the photoconductor element is provided before the

last length is used. This is important since it permits the service personnel to replace the photoconductor element at a convenient time and the use of the copying machine is not interrupted. The operator is informed of the need to replace the photoconductor and simply closes the toggle switch **170** to continue copy operations.

At certain times it is desirable to advance the photoconductor element before the copy counter has accumulated the count set into this counter corresponding to a predetermined number of copies. This might occur if the photoconductor becomes damaged by carried bead scratches, a bad section of the photoconductor element is encountered, or particularly high quality copies are desired. At any time the copying machine is not making copies and prior to the advance cycle for the last length of photoconductor element, push button switch **175** can be depressed. Primary advance relay RB will be energized through normally closed relay contacts CCTR1B, T2 and MR1A and the now closed push button switch **175** to initiate a photoconductor advance operation. The primary advance relay RB will be held through its contacts RB3 and closed metering switch contacts MS1B if the push button is released. The photoconductor advance operation then proceeds in the manner outlined above until the metering gear **100** rotates sufficiently to actuate microswitch **133** and deenergizes the secondary advance relay RA to end the operation.

It should now be apparent that the objects initially set forth have been accomplished. Of particularly importance is the provision of photoconductor advance mechanism which is operative to automatically cycle a xerographic copying machine into a photoconductor advance or replacing mode to change the operative photoconductor element. The sequence circuits provide various interlocks which prevent damage to the copying machine and insure the advance operations are completed in a fast and efficient manner.

While the invention has been particularly shown and described with reference to a preferred embodiment thereof, it will be understood by those skilled in the art that changes in form and details may be made therein without departing from the spirit and scope of the invention.

What we claim is:

1. Apparatus for providing xerographic copies wherein a latent electrostatic image is formed on a reusable photoconductor element, the photoconductor element is contacted with electrostatically attractable marking material to form a toner image, the toner image is transferred to a supporting surface, and the photoconductor element is cleaned of remaining marking material for reuse by repeating the above steps to provide other copies comprising:

a cylindrical copy drum having an axial slit in its outer periphery;

means rotatably supporting said copy drum for rotation about its axis;

a drive motor for rotating said copy drum;

a supply roll and a takeup roll of said photoconductor element rotatably supported within the interior of said copy drum;

said photoconductor element extending from said supply roll through said slot, about the outer periphery of said copy drum, and back through said slit to said takeup roll;

means for rotating said takeup roll to advance a predetermined length of said photoconductor element and replace the portion of said photoconductor element extending about the outer periphery of said copy drum;

copy counting means for recording the number of copies produced on said photoconductor element; and control circuit means for actuating said means for rotating said takeup roll each time said copy counting means of copies having been produced on the portion of said photoconductor element extending about the outer periphery of said copy drum;

a photoconductor element advance counter;

means to actuate said control circuit means, advance said photoconductor element advance counter and reset said copy counter each time said count corresponding to said predetermined number of copies is registered by said copy counter;

indicator means; and

means actuating said indicator means when said photoconductor element advance counter registers a predetermined count corresponding to the number of usable lengths of photoconductor element stored within said interior of said copy drum.

2. Apparatus according to claim **1**, further characterized by:

means responsive to the registering of said predetermined count corresponding to said number of usable lengths of photoconductor element stored within said copy drum by said photoconductor advance counter to prevent further actuation of said copy counter as additional copies are made.

3. Apparatus according to claim **1**, further characterized by:

output means;

second control circuit means for activating said output means each time said photoconductor element advance counter records a predetermined count;

said output means comprising means to stop operations of said apparatus for producing copies; and

manual activated means to override said output means to permit copies to be produced on the portion of said copy element last advanced about the outer periphery of said copy drum.

4. Apparatus for producing copies wherein an image is formed on a copy element comprising:

a copy element supporting member having an opening in its outer periphery;

means supporting said copy element supporting member for movement;

a drive motor for moving said copy element supporting member;

a supply of said copy element stored within the interior of said copy element supporting member;

said copy element extending from said supply copy element supporting member, and back through said opening to said supply;

means within said copy element supporting member for advancing said copy element to replace the portion of said copy element extending about the outer periphery of said copy element supporting member;

copy counting means for recording the number of copies produced on said copy element;

control circuit means for activating said means for advancing each time said copy counting means records a count corresponding to a predetermined number of copies having been produced on the portion of said copy element extending about the outer periphery of said copy element supporting member;

engageable drive coupling means for transmitting the movement of said copy element supporting member by said drive motor to said means for advancing said copy element;

means to selectively engage said drive coupling means to cause said copy element to advance about the periphery of said copy element supporting member; and

means for detecting when an advance operation is completed;

said means for detecting comprising a switch in a first state at the beginning of a copy element advance operation, said switch switching to a second state during said copy element advance operation, and said switch returning to said first state at the end of said copy element advance operation;

control circuit means comprising primary and secondary copy element advance relays;

said primary relay being actuated when said control circuit means records a count corresponding to said predetermined number to activate said means for advancing;

said secondary relay being energized and said primary relay being deenergized to maintain actuation of said means for advancing when said switch switches to said second state; and

said secondary relay being deenergized to deenergize said means for advancing when said switch means returns to said first state.

5. Apparatus according to claim 4, further characterized by:

manual operated switch means for energizing said drive motor; and

auxiliary circuit means for energizing said drive motor from when said copy counting means records said count corresponding to a predetermined number until said means for detecting that an advance operation is completed to prevent deenergization of said drive motor during an advance operation.