United States Patent

Mielnikowski, Jr. et al.

[15] **3,653,756**

[45] **Apr. 4, 1972**

[54] MECHANICALLY ACTUATED PHOTOCOPY MACHINE

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[22] Filed: **July 15, 1968**

[21] Appl. No.: **745,019**

[52] **U.S. Cl.** **355/3**, 355/10, 355/14, 118/637

[51] **Int. Cl.** **G03g 15/00**

[58] **Field of Search** 355/3, 10, 11, 14; 101/41; 118/637

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[57] **ABSTRACT**

A photocopy machine having a plurality of stations performing a sequence of operations in a single copying cycle, the sequence of the operations being controlled by a series of cam mechanisms, all of which are actuated by a single drive means. A multiple station indexing means is provided for engaging the drive means from one to a finite number of times upon completion of each copy cycle.

14 Claims, 10 Drawing Figures

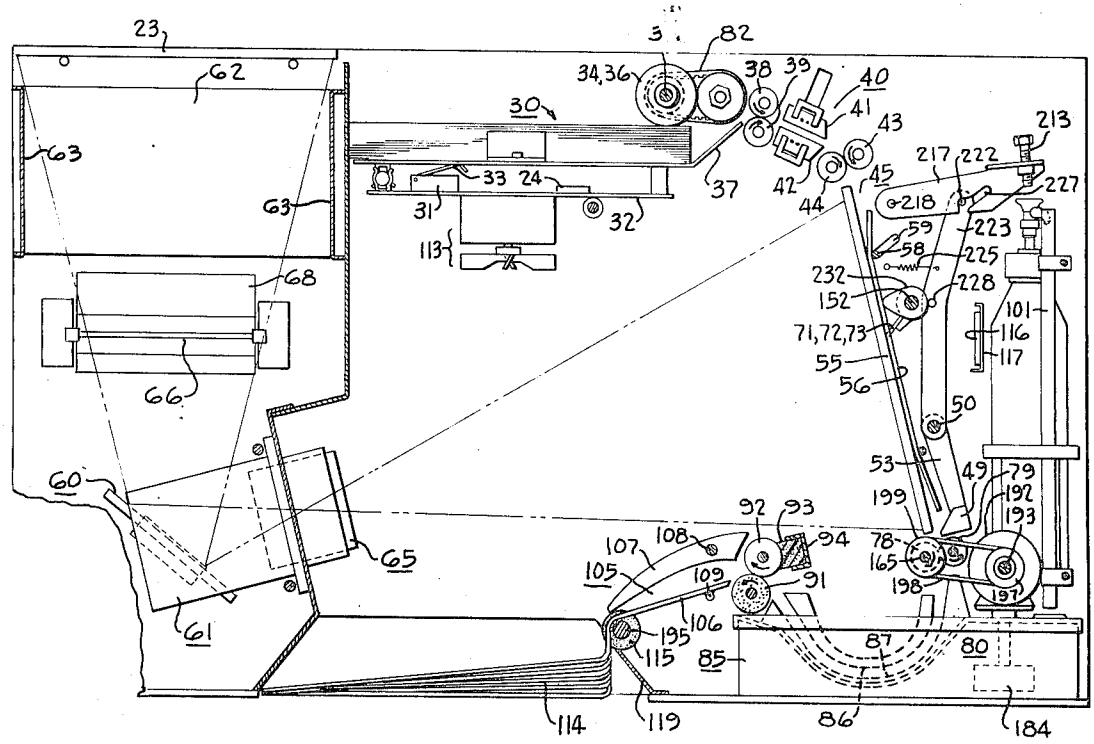


Fig. 1

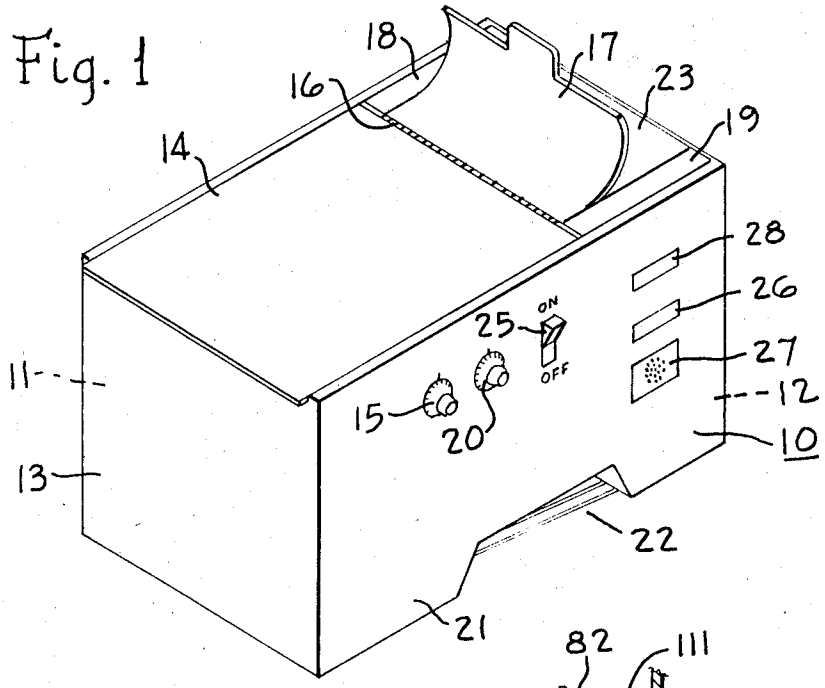
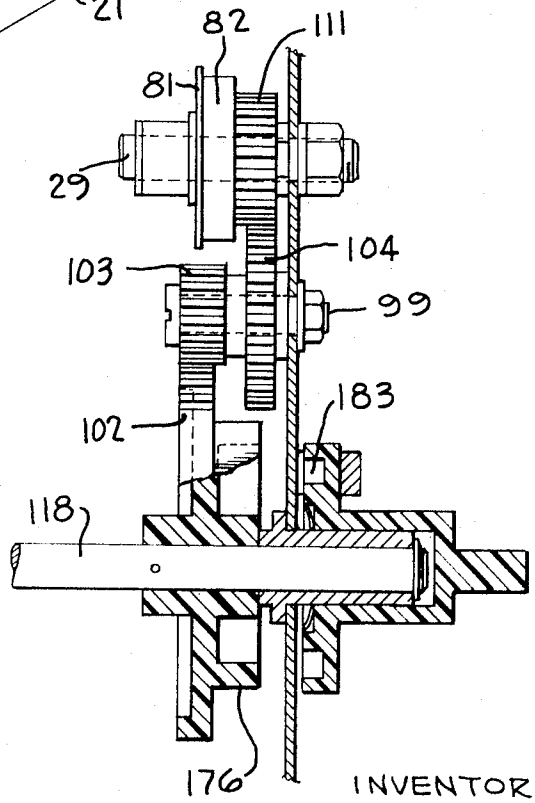


Fig. 9



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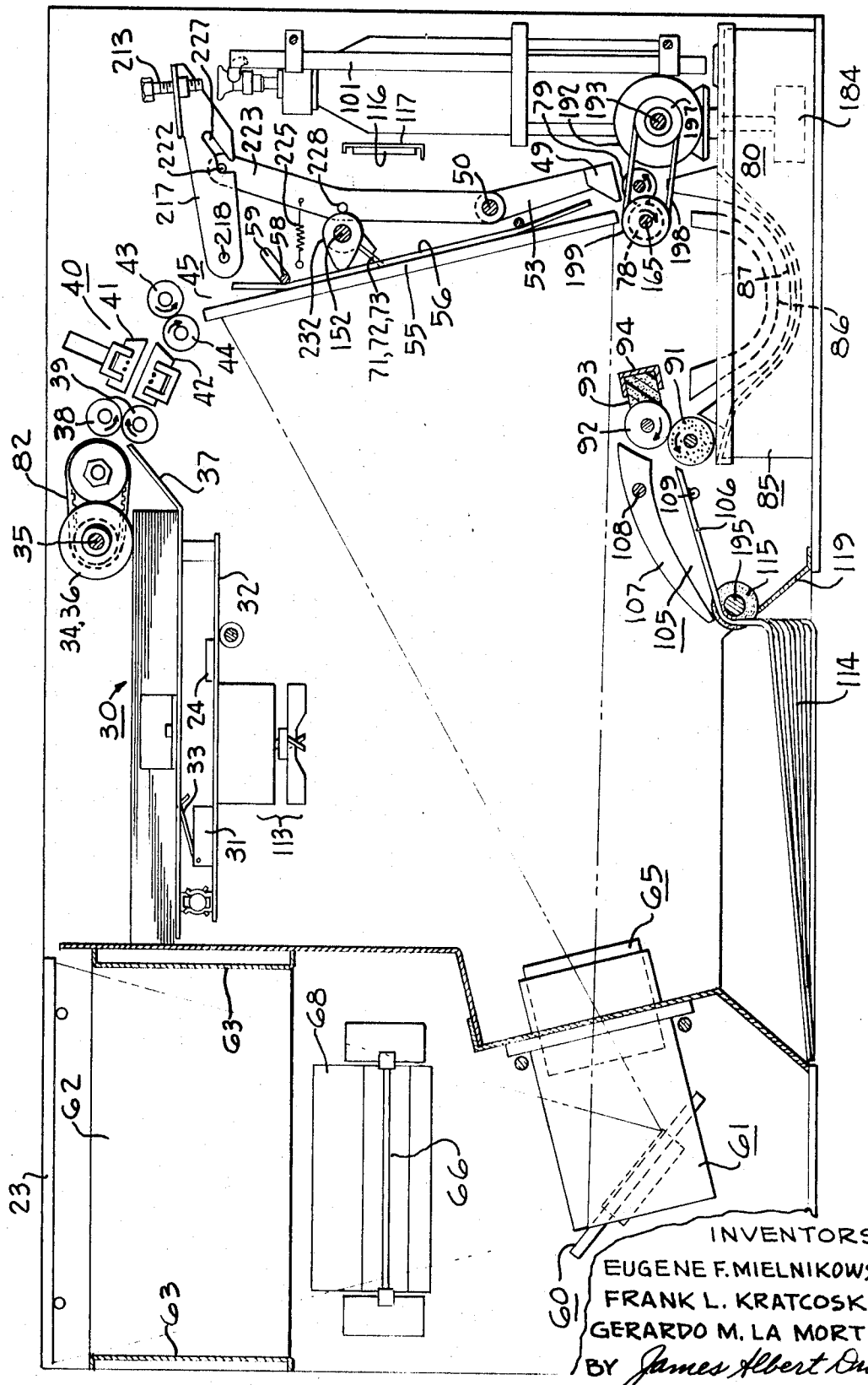


Fig. 2

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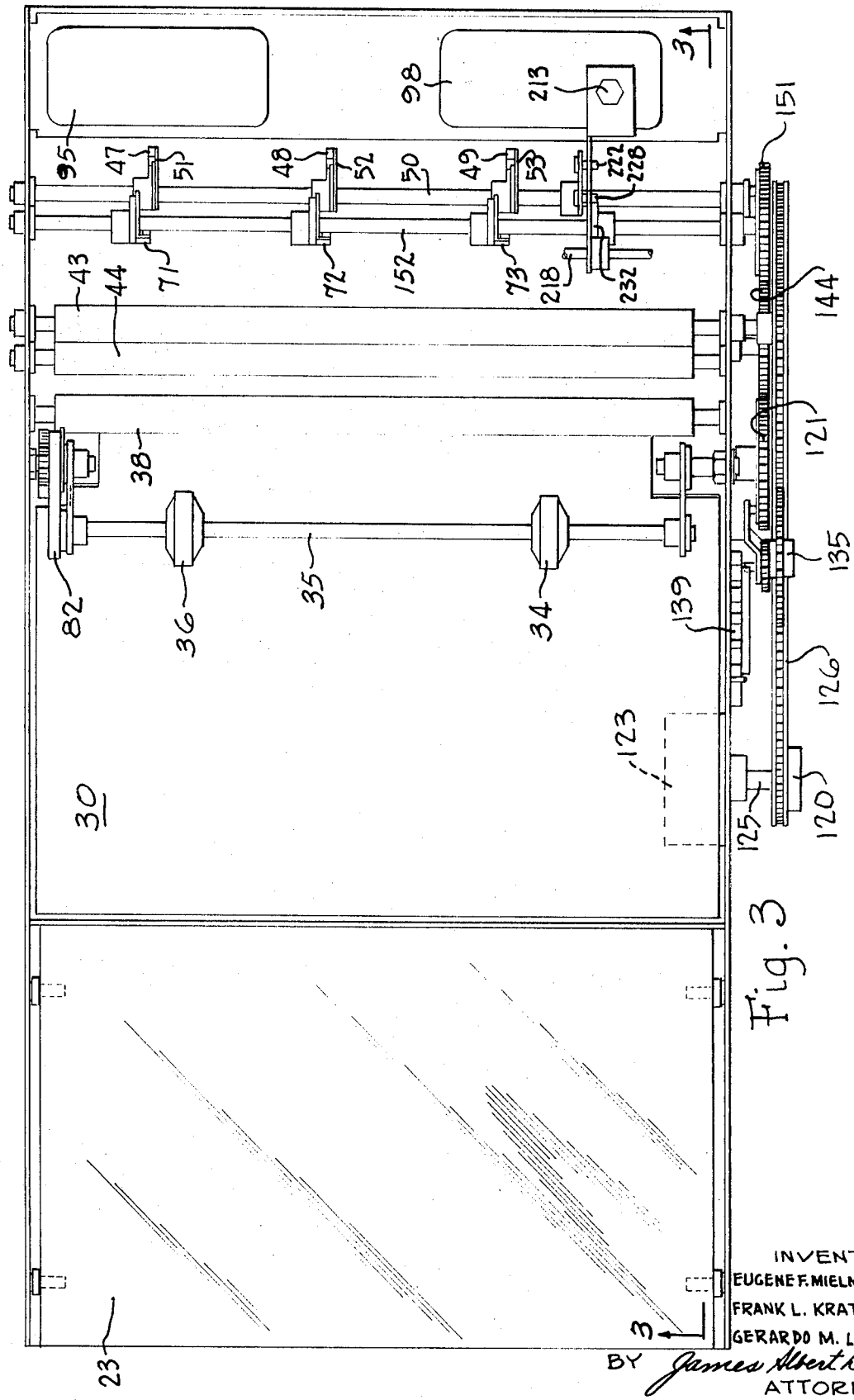


Fig. 3

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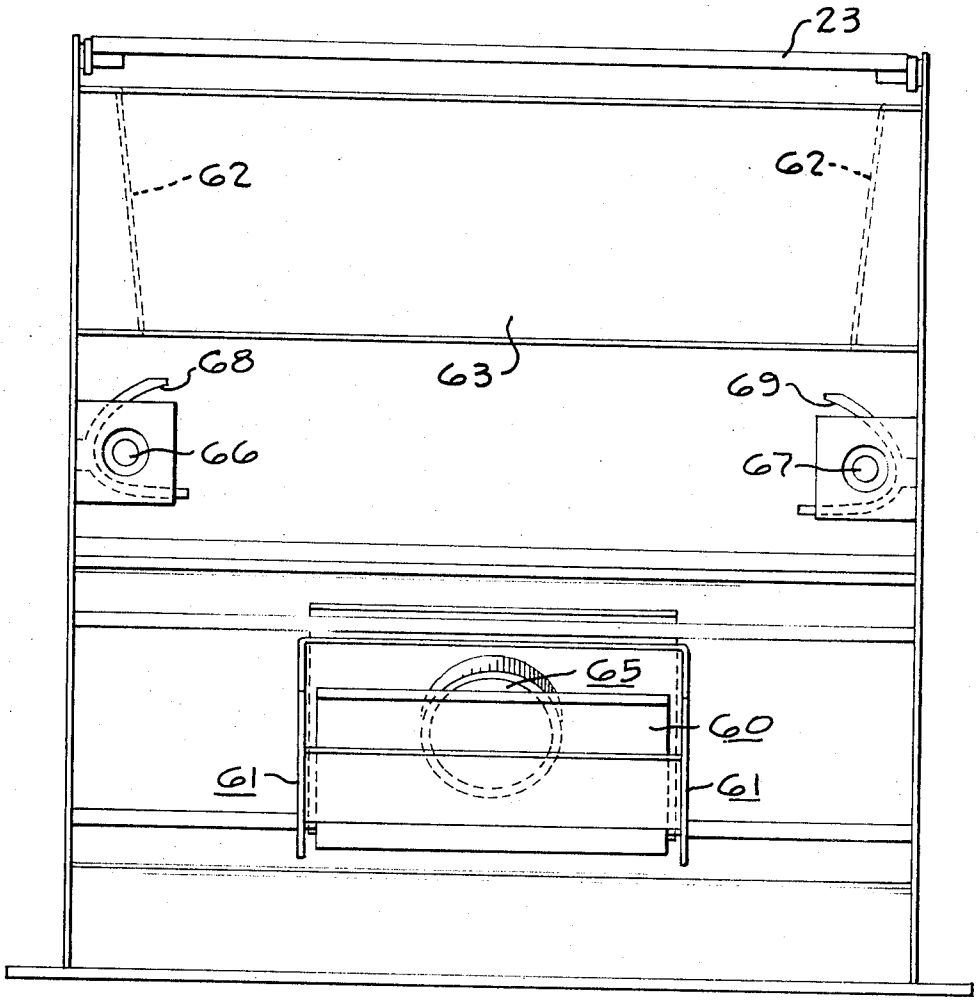


Fig. 4

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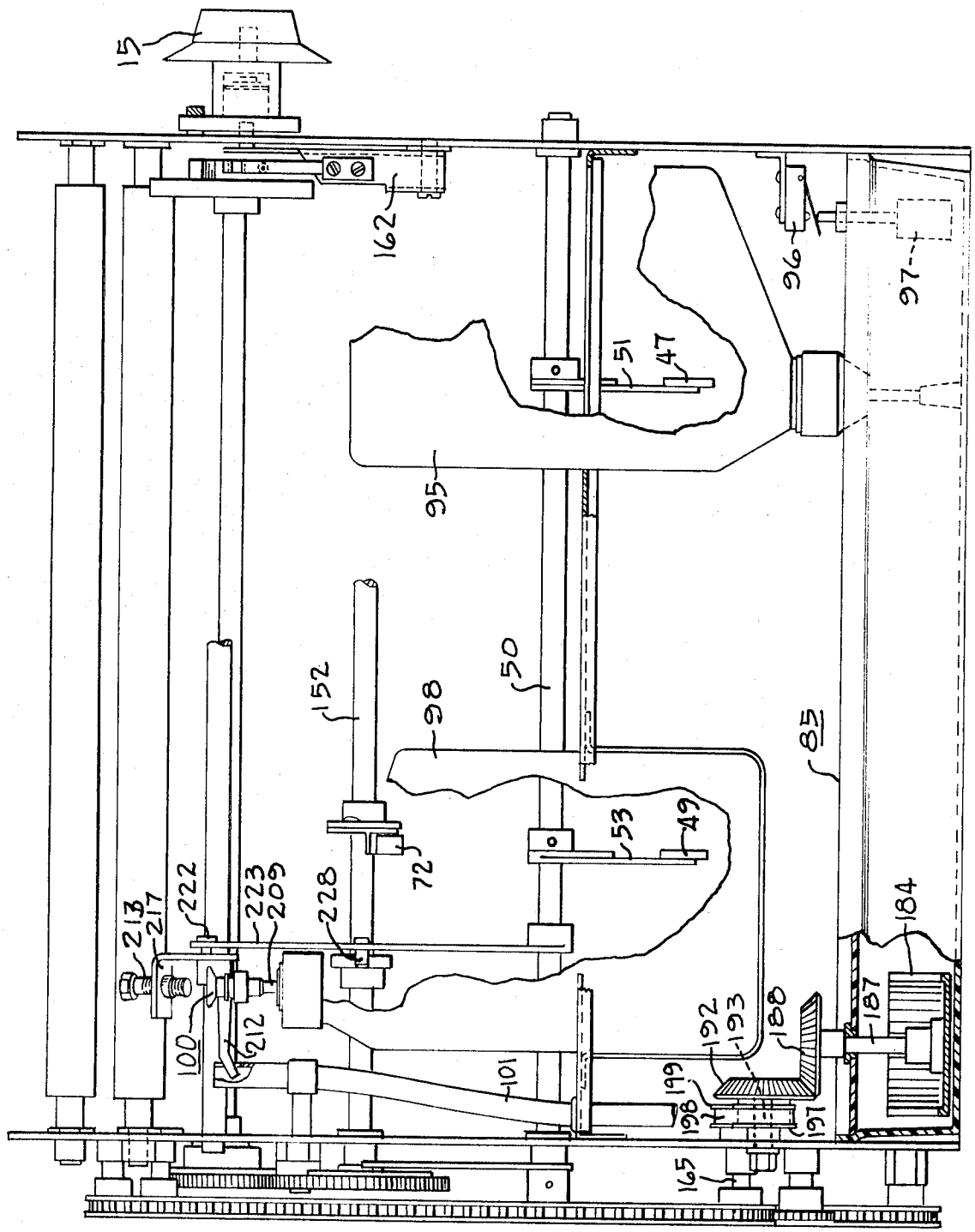


Fig. 5

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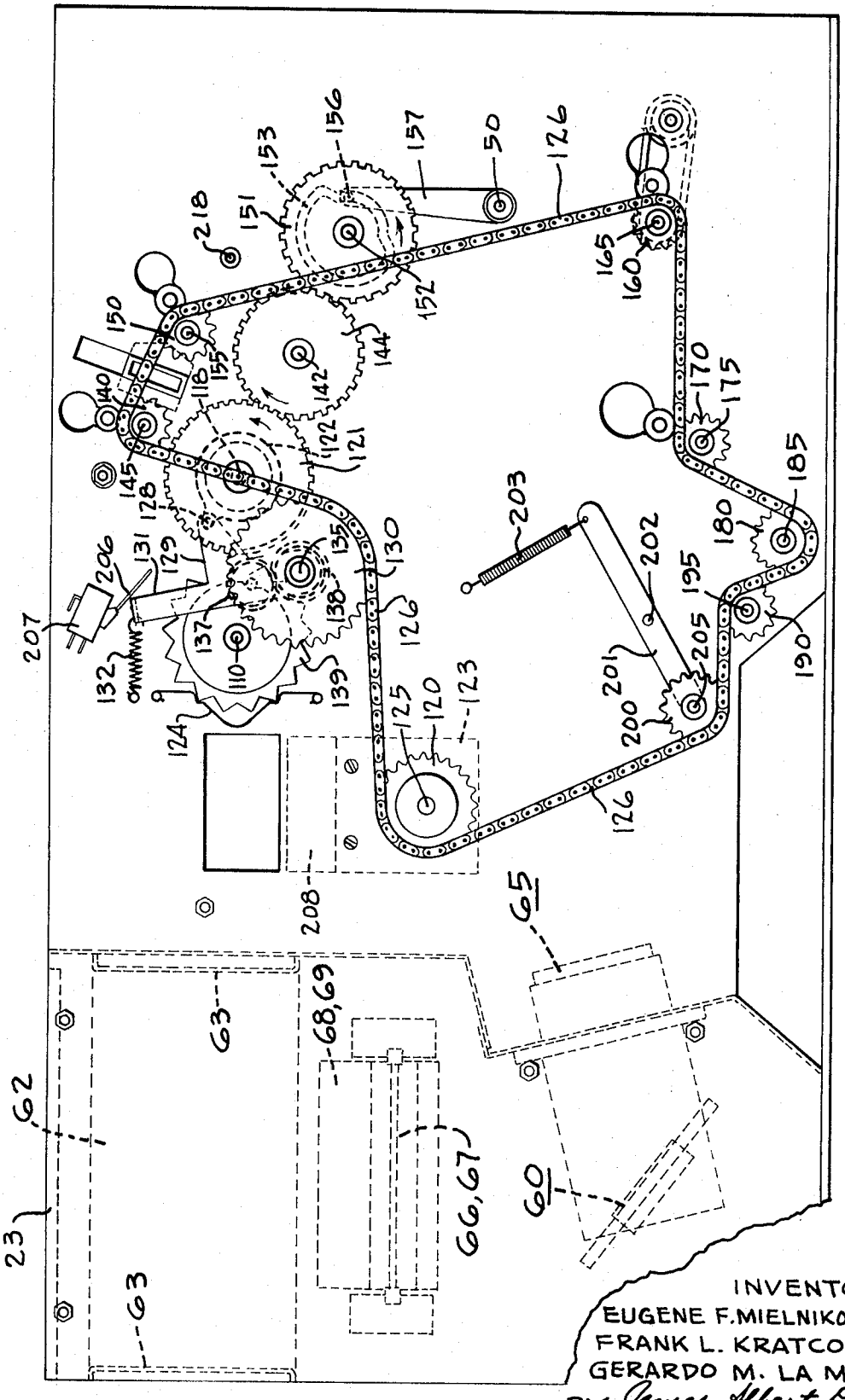
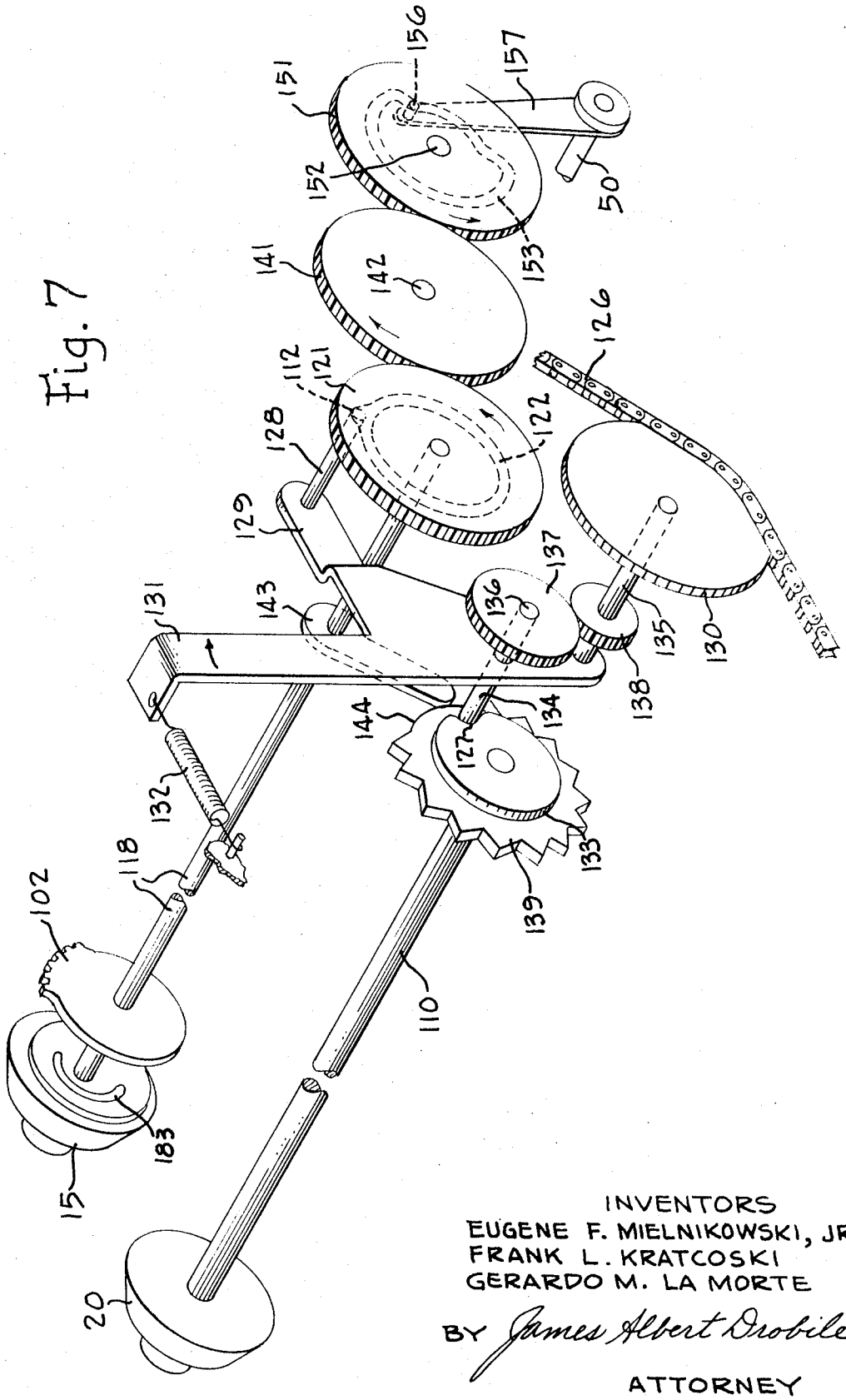


Fig. 6

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Fig. 7

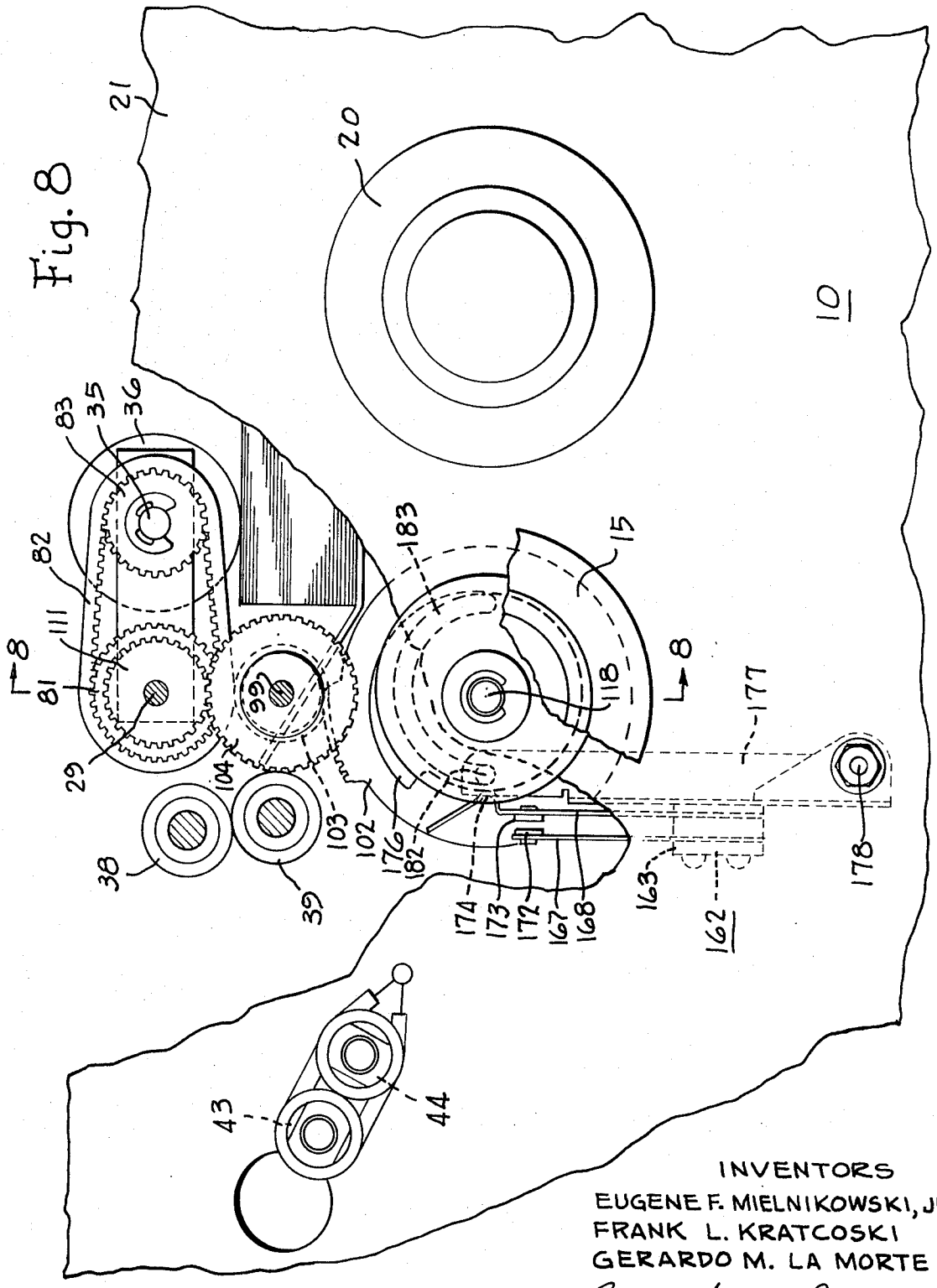


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Fig. 8



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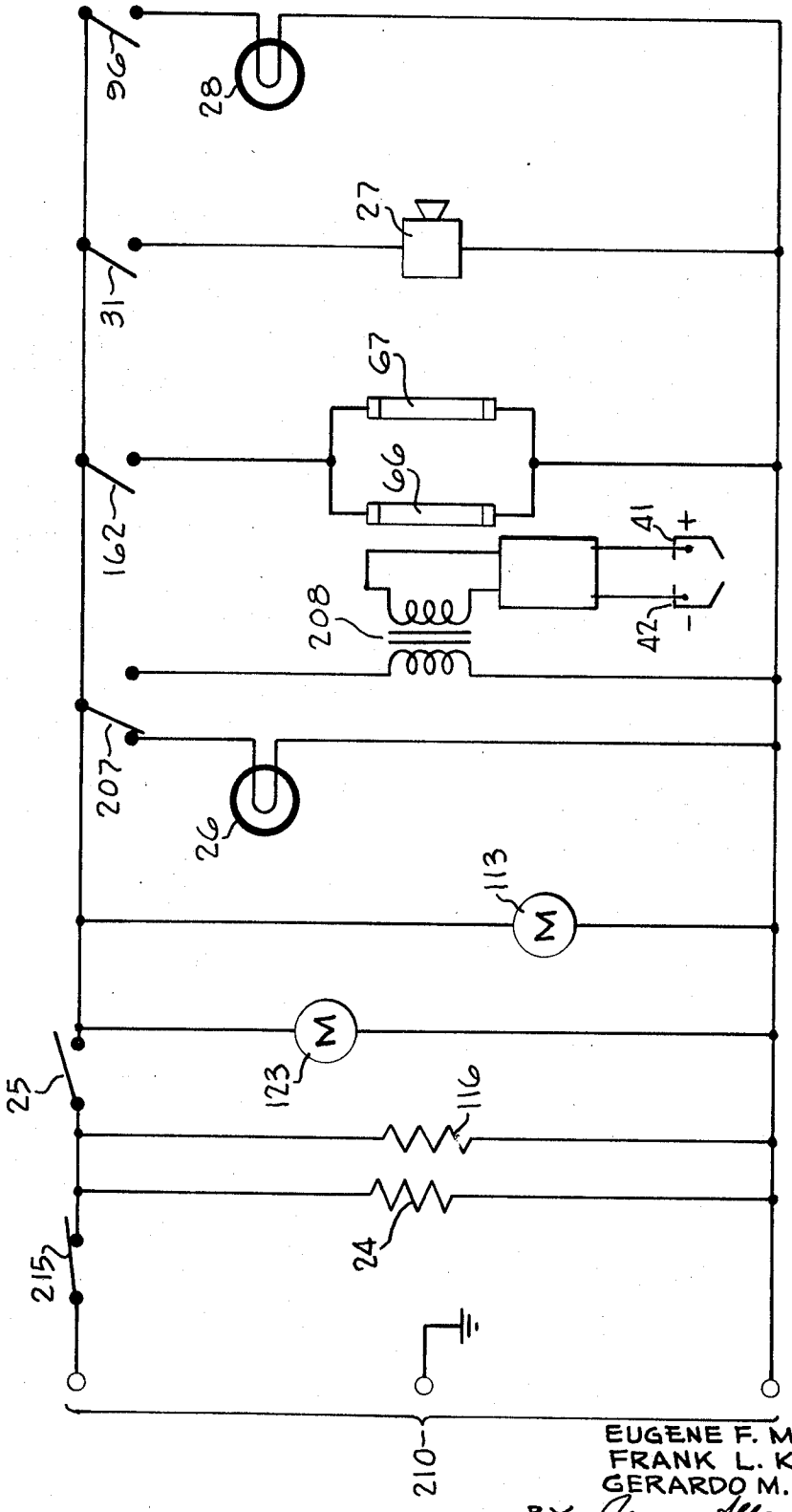


Fig. 10

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MECHANICALLY ACTUATED PHOTOCOPY MACHINE

CROSS-REFERENCE TO RELATED APPLICATION

The new, original and ornamental design for the copy-making apparatus herein disclosed also is disclosed, and is claimed, in co-pending design application filed of even date herewith by Bruce R. Hannah, Francis G. LaMorte and Frank L. Kratcoski, Ser. No. D–12,772, now abandoned in favor of Ser. No. D–16,559.

BACKGROUND OF THE INVENTION

This invention relates to a new and improved apparatus for reproducing on an electrophotosensitive member an image of an object. More specifically, the invention is directed to a new and improved compact copying apparatus employing an electrostatic process wherein an electrostatic image of the original is formed on an electrophotosensitive sheet material such as paper, and is developed by a developing agent comprising a suspension of charged solid marking particles dispersed in an electrically insulating liquid, the dispersed particles being attracted and adhered to the electrostatic image on the sheet material to form thereon a copy of the original object.

Apparatus suitable for reproducing the image from an object such as a document, book or the like, through an electrostatic process employing an electrophotosensitive paper heretofore has been known and used. However, conventional apparatus of this type has suffered from one or more serious disadvantages. For example, apparatus of this type often has been unduly expensive to construct, and expensive and inconvenient to service. Furthermore, much conventional apparatus of this type has limited usefulness and flexibility in that it often is not suited for copying three-dimensional objects such as books and the like. Finally, much conventional apparatus of this type requires that each sheet of paper be fed into the apparatus by hand, and that such manual steps be repeated until the desired number of copies has been prepared.

SUMMARY OF THE INVENTION

In view of the above, it is an object of the present invention to provide a new and improved compact copying apparatus employing an electrostatic process, a coated non-conductive paper adapted to be rendered electrophotosensitive by an electrostatic potential, means for applying an electrostatic potential to such paper, means for exposing a sheet of paper so sensitized and charged to a reflected image of the object to be copied whereby such image is reproduced electrostatically on the paper, means for developing the electrostatic image by depositing charged marking solids thereon, and means for fixing the deposited electrostatic image on the paper to provide a final copy. Another and more specific object of the present invention is to provide a copying apparatus in which the electrophotosensitive coated paper is fed automatically and not by hand, after selecting the number of copies to be produced, until the selected number of copies is produced and the apparatus automatically stops.

The apparatus of the present invention preferably includes a storage compartment or magazine located in an upper middle region of the apparatus, for storing coated copy paper; synchronized means for automatically initiating the advancement of such paper, one sheet at a time, from one side of the magazine; plural means for continuously advancing the single sheet, first in a generally lateral and downward direction into and through a corona charging zone shielded from light, and thereafter in a generally downward direction into a generally vertical exposure zone, located generally below the corona charging zone, wherein such sheet is held in a fixed position by synchronized holding means and shielded from light until exposed; synchronizing means for energizing the corona units in the charging zone during the passage of such sheet therethrough, whereby an electrostatic potential is applied across the sheet rendering it electrophotosensitive; exposure means including a source of illumination, a reflector mirror and lens, for projecting on said electrophotosensitive sheet a

reflected image of an object positioned on a scanning area located in the upper region of the apparatus adjacent the opposite side of the magazine; means for synchronizing the projection of said image with the positioning of the paper in the exposure zone and for controlling automatically the period of time during which the paper is exposed to such image; synchronized plural means for releasing automatically the sheet of copy paper after exposure, and for positively ejecting the exposed sheet of copy paper from the exposure zone; means for continuously receiving and advancing the exposed sheet of copy paper in a generally downward direction and into a developing zone located in the lower region of the apparatus generally below the exposure zone, and through which such paper travels in a generally lateral direction opposite its direction of travel through the charging zone; developing means in such developing zone including a dispersion of charged marking particles suspended in a clear, non-conductive liquid medium; plural means for continuously receiving the paper containing the developed image, for removing excess liquid from such paper, and for continuously advancing such paper containing the developed image in the same generally lateral direction through a drying zone and into an accumulating zone for finished copies located in a lower middle region of the apparatus generally below the copy paper magazine; and means for drying the developed image to produce a copy containing a fixed image of the object to be copied.

The apparatus of the invention preferably also includes a continuous drive means or mechanism, for continuously driving certain elements such as paper transfer means while the apparatus is energized, and a one-cycle drive means or train mechanism which drives and synchronizes elements essential to the production of a single copy of the object to be reproduced. Also preferably included in the apparatus are manually initiated camming means, for engaging and disengaging the continuous drive mechanism from the one-cycle drive train mechanism, and additional camming means associated with the one-cycle drive train mechanism, for preventing the disengagement of the continuous drive mechanism from the one-cycle drive train mechanism until the completion of a full cycle of operation. Associated with the manually initiated camming means is switching means for energizing the corona units in the charging zone.

Also preferably associated with the one-cycle drive train mechanism are: means including a segmental torque-transfer means such as a segmental gear, proportioned so as to initiate the advancement of only a single sheet of copy paper per cycle from the magazine to the charging zone; camming means for actuating the switching means controlling exposure illumination; camming means for operating the stop members intended to retain and properly position the charged copy paper in the exposure zone until exposure and thereafter to release same; ejecting members for positively advancing the sheet of copy paper from the exposure zone after exposure; camming means operating adjustable pumping means for introducing from a reservoir into the developing zone a quantity of charged marking particles sufficient to replace that depleted in making a copy. Also associated with the one-cycle drive train mechanism, but manually adjustable independent thereof, is additional camming means controlling the exposure time.

The apparatus of the invention preferably also includes means for repeating automatically the one-copy cycle until a predetermined number of copies, either unlimited or selected from a specified range, is produced. Included in the cycle-repeat means or mechanism is a multiple-station member associated with the manually initiated camming means which engages and disengages the continuous drive mechanism with the one-cycle drive train mechanism. This multiple-station member is manually prepositioned, and is restored by pawl means associated with the one-cycle drive train mechanism, one station for each full cycle thereof, until the manually initiated camming means ultimately is restored to the disengaging position.

The foregoing and other objects and advantages of the present invention will become more readily apparent from an examination of the following description in the light of the accompanying drawings and claims.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a view in perspective, showing in general outline the exterior arrangement of the apparatus of the present invention;

FIG. 2 is a view partly in elevation and partly in section along the line 3—3 of FIG. 3, showing the interior arrangement of a preferred embodiment of the apparatus of the invention;

FIG. 3 is a plan view of the same embodiment, with the hinged top access panel and the scanning area cover removed;

FIG. 4 is an end view of the same embodiment, as seen from the left in FIGS. 2 and 3, showing the illumination sources, the reflector and (in broken outline) the lens assembly;

FIG. 5 is an end view of the same embodiment, as seen from the right in FIGS. 2 and 3, with portions thereof broken away, and showing among other elements the developer tank and agitator, the developer reservoir and concentrate bottles, and the automatic paper stop and paper advance mechanisms of the exposure zone;

FIG. 6 is an elevation view of the same embodiment, as viewed from the bottom in FIG. 3 and the left in FIG. 5, showing among other elements the continuous drive mechanism, the one-cycle drive train and associated mechanisms, and the automatic cycle-repeat mechanism;

FIG. 7 is an expanded view in perspective of parts of the continuous and one-cycle drive mechanisms, of the manually initiated camming means for engaging and disengaging same, and of the automatic cycle-repeat mechanism;

FIG. 8 is a fragmentary view from the right in FIG. 5, showing the front of the automatic exposure synchronizing and exposure time mechanisms with portions thereof broken away;

FIG. 9 is a view in section along the line 8—8 of FIG. 8;

FIG. 10 is a schematic diagram for the various electrical components of the same embodiment of the apparatus of this invention.

DETAILED DESCRIPTION OF THE INVENTION

As noted above, FIGS. 1 and 2 show the general arrangement of a specific and preferred embodiment of the apparatus of the present invention, FIG. 1 illustrating its external appearance, and FIG. 2 its general internal arrangement. As illustrated in FIG 1, the apparatus includes casing 10 comprising back panel 11 (not visible), side panels 12 (not visible) and 13, top panel portion 14 hinged at 16 to provide access to the interior working parts of the apparatus, flexible cover 17 also hinged at 16 for scanning area 23, fixed top panel portions 18 and 19 forming guides adjacent scanning area 23 for aligning the object to be copied, and front panel 21.

In the embodiment illustrated in FIG. 1, front panel 21 includes hand access opening 22 for removal of finished copies, selector knob 15 connected to control means for varying exposure time in the apparatus, selector knob 20 connected to means for pre-setting the number of copies desired to be made, on-off main power switch 25, and audible or visual signal means 26, 27 and 28 indicating, respectively, readiness of apparatus, lack of copy paper and lack of developer solution.

Referring now to FIG. 2, which illustrates the interior arrangement of a specific and preferred embodiment of the apparatus of the invention, the coated copy paper is stored in magazine or storage compartment 30. Switch 31, connected (not visible) to lack-of-paper signal means 27, is mounted on platform 32 supported below compartment 30, and includes pivoted actuating arm 33 which projects through the bottom of compartment 30 and into actuating contact with any paper stored therein. Also mounted on platform 32 are one or more heaters 24, in order to maintain the supply of copy paper at an optimum temperature.

Upon energization of the main drive motor 123 and actuation of the drive mechanisms as hereinafter described, a single sheet of coated copy paper is advanced by paper transfer rollers 34 and 36 (see also FIG. 3) mounted on belt-driven floating shaft 35, up inclined panel 37 and into the nip of power-driven paper transfer rolls 38 and 39 which are rotating continuously in the directions indicated by the directional arrows. Paper transfer rolls 38 and 39 feed the sheet downwardly into charging zone 40, located adjacent and slightly below, which zone includes spaced corona charging units 41 and 42. These corona units previously have been energized from combination rectifier and voltage step-up transformer 208 (not visible in FIG. 2; see FIG. 6) through actuation of switch 207 (not visible in FIG. 2; see FIG. 6) by a synchronized charger actuating mechanism to be described hereinafter. After traveling through the charging zone 40, the leading edge of the paper sheet is advanced, by the action of rolls 38 and 39 on the trailing portion of the sheet, into the nip of power-driven paper transfer rolls 43 and 44 which are rotating continuously in the directions indicated by the directional arrows.

The paper sheet is advanced downwardly by transfer rolls 43 and 44 into an exposure zone 45, which is positioned generally below charging station 40. Downward travel of the sheet is stopped, after the trailing edge of the sheet is discharged from rolls 43 and 44, by paper stop fingers 47, 48 and 49 (see also FIG. 3) attached to arms 51, 52 and 53 which are fixed to rotatable shaft 50. By operation of the synchronized one-cycle drive train timing mechanism to be hereinafter described, the paper stop fingers 47, 48 and 49 are positioned in contact with the surface of transparent exposure window 55 forming the exposure plane of exposure zone 45 during introduction of the paper sheet so as to stop and retain the sheet in the correct position for exposure. The paper sheet is generally held against the surface of window 55 by restraining means 56 consisting of a grille made from metal or other suitable material and pivoted loosely at rod 58 which rests in support slots 59 in the inner casing.

While in exposure station 45, the electrophotosensitized surface of the sheet, which is against window 55, is exposed to a reflected image of the object being copied. This object image is conveyed by reflected light from the object mounted on the object plane in scanning area 23, past reflecting mirror 60, resting in assembly 61 (see FIG. 4), through lens 65 and transparent exposure window 55 and onto the electrophotosensitized surface of the paper sheet. The exposure light source preferably consists of quartz-iodide lamps 66 and 67, individually mounted in modified parabolic aluminum reflectors 68 and 69 (see FIG. 4). Two additional pairs of mirrors or other light-reflecting surfaces are installed below the scanning area at 62 and 63. The time of exposure is determined by the manually preset exposure timing mechanism to be described hereinafter, which mechanism is associated with the exposure illumination switch 162 (not visible) and consequently controls the length of time during which lamps 66 and 67 are energized.

After exposure for the predetermined time, the lamps 66 and 67 are de-energized by exposure illumination switch 162, associated with the one-cycle drive train mechanism referred to above. Momentarily thereafter, the paper stop fingers 47, 48 and 49 are withdrawn by a synchronized, automatic timing mechanism associated with the one-cycle drive train, from contact with the surface of exposure window 55, thus rendering the paper sheet free to travel downwardly from the exposure station 45. Forward progress of the paper sheet is ensured by paper advance fingers 71, 72 and 73 (see FIG. 3) mounted on rotatable shaft 152, which also is actuated by a synchronized timing mechanism associated with the one-cycle drive train mechanism to be described hereinafter. Upon leaving the exposure station 45, the paper sheet is advanced into the nip of power-driven paper transfer rolls 78 and 79 which are continuously rotating in the directions indicated by the directional arrows.

Transfer rolls 78 and 79 advance the paper sheet into developing station 80, located at the bottom of the apparatus generally below exposure area 45. Developing station 80 includes a tank 85 containing an agent suitable for developing the electrostatic latent image formed on the electrophotosensitized paper sheet. The paper sheet is advanced by rolls 78 and 79 through the bath of developing agent in a submerged curvilinear path defined by guide surfaces 86 and 87, and into the nip of power-driven paper transfer rolls 91 and 92 which are rotating continuously as shown by the directional arrows. Roll 91 is constructed of a slightly compressible and resilient material, such as rubber or other similar material, so as to exert a "squeegee" action in order to remove excess liquid from the developing agent from the paper. Solids, i.e., marking particles from the developing agent, which are deposited on smooth roll 92 are removed by wiper 93 which is composed of a resilient and absorbent material, such as polystyrene foam or the like, and is held in compressed contact with roll 92 by holder 94.

The desired upper level of the developing agent in tank 85 is maintained at the desired point by inverted bottle 95 containing a supply of such agent, the mouth of such bottle being positioned at the desired liquid level so that any drop in actual level induces replenishment from the bottle. Switch 96, connected to signal means 28, is actuated by float 97 and indicates that the level of the developing agent has fallen too low (see FIG. 5). The solids (i.e., the charged marking particles) in the developing agent are maintained at the desired concentration by introducing a much more highly concentrated suspension thereof, from reservoir bottle 98, to replace solids lost by depletion. The more highly concentrated suspension of solids is introduced periodically through tube 101 by pump mechanism 100 associated with the one-cycle drive train mechanism to be hereinafter described.

Upon emerging from rolls 91 and 92 the still-wet paper sheet is advanced laterally through drying zone 105 defined by upper and lower guide surfaces 107 and 106 and located adjacent to developing station 80. Upper guide surface 107 comprises a plurality (not shown) of individual fingers pivotally mounted on transverse rod 108 and adapted to depress and guide the leading edge of the paper sheet after it emerges from rolls 91 and 92 and to maintain the sheet in driving contact with paper discharge roll 115. Lower guide surface 106 comprises a grille structure supported at one end by transverse rod 109 and at its middle by suitable means not in conflict with the paper discharge roll 115. At its other end this same grille forms discharge receptacle 114 for receiving finished copies. In drying area 105, the wet paper sheet is subjected to a gradual flow of heated air, which has been circulated by motor-driven fan 113 across one or more strip heaters 116 mounted transversely in holder 117. The dried paper sheet emerges from drying area 105 over paper discharge roll 115 made of a resilient outer layer mounted on core shaft 195, and into delivery compartment 114. Interference by air drafts with the proper laying and stacking of finished copies is prevented by air-baffle 119.

In order to describe the continuous drive mechanism as referred to above, reference now is made initially to FIG. 6. In FIG. 6, main drive sprocket 120 is mounted on shaft 125 of main drive motor 123. When motor 123 is energized, drive sprocket 120 continuously drives endless chain 126 over continuous drive mechanism drive sprocket 130 mounted on stub shaft 135; roll drive sprocket 140 mounted on shaft 145 in common with paper transfer roll 39; roll drive sprocket 150 mounted on shaft 155 in common with paper transfer roll 44; roll drive sprocket 160 mounted on shaft 165 in common with paper transfer roll 78; roll drive sprocket 170 mounted on shaft 175 in common with paper transfer roll 91; idler sprocket 180 mounted on shaft 185; roll drive sprocket 190 mounted on shaft 195 in common with paper discharge roll 115; spring-loaded idler sprocket 200; and back to main drive sprocket 120. Idler sprocket 200 is rotatably mounted by pin 205 to one end of arm 201, which is pivotally mounted by pin 202 at a point intermediate its ends to the casing and loaded at its other end by spring 203 attached to the casing. Idler sprocket 200 takes up any slack in chain 126 and maintains the proper degree of tension in the chain.

Reference is now made to FIGS. 6 and 7 for a description of the one-cycle drive train and associated timing mechanisms. Rotationally mounted on stub shaft 135, behind drive sprocket 130, is arm 131, which is connected at its free end by spring 132 to a fixed point on the casing. Mounted perpendicular to arm 131 is a cylindrical member which extends through arm 131, to form cam follower pin 134 on the rear side of arm 131, and stub shaft 136 on the front side of arm 131. Rotatably mounted on said stub shaft 136 is drive gear 137 in constant engagement with mating gear 138 preferably formed integral with the rearward hub of drive sprocket 130, so that said gear 137 is continuously rotating while the continuous drive mechanism is in operation.

As noted, arm 131 is adapted for free rotation on stub shaft 135, but is normally restrained from clockwise rotation by spring 132. Arm 131 is limited in counterclockwise rotation by cam surface 133, cooperating with cam follower pin 134, and formed on the front face of cycle-repeat selector star wheel 139. Arm 131 is limited in its clockwise rotation by gear 121, constituting part of the one-cycle gear train, which is coplanar with drive gear 137 and adapted for operative engagement therewith. Arm 131 also includes side projection 129 which carries on the front face at its extremity cam follower pin 128. Cam follower pin 128 is adapted to ride in the path defined by internal cam track 122 integral with the rear surface of gear 121. Gear 121 is fixed on rotatable shaft 118, and is at all times in operative engagement with coplanar intermediate gear 141 fixed on rotatable shaft 142, and intermediate gear 141 is at all times in operative engagement with coplanar control gear 151 mounted on rotatable shaft 152. Gears 121, 141 and 151 are of equal size and are the principal elements in the one-cycle gear train mechanism. Control gear 151 is provided integrally on its rear face with internal paper control cam track 153.

In order to describe the one-cycle drive train mechanism, as heretofore referred to, and the means for engaging and disengaging same with the continuous drive mechanism, reference again is made to FIGS. 6 and 7. In FIG. 7, copy number selector knob 20 is shown mounted on rotatable shaft 110 which extends laterally and transversely through the apparatus to the far side where the cycle-repeat selector star wheel 139 is fixed thereon. Copy number selector knob 20 is adapted for manual rotation in order to select the number of copies (unlimited, or from one to 15) which it is desired to produce. The rotational movement imparted to knob 20 is translated by means of shaft 110 to cycle-repeat selector star wheel 139, which is in contact with resilient indexing detent spring 124 (see FIG. 6). The indexing detent spring 124 is adapted to convey to the operator a positive feeling of a stepping motion in going through the various positions corresponding to the available copy number stations, and to retard any tendency of the copy selector star wheel 139 to creep once in the desired position. Spring 124 preferably is designed so as to span at least four points, so as to allow for the two missing points, hereinafter described, and yet maintain operative contact with two points of the star wheel 139.

As apparent in FIG. 7, the raised cam surface 133 formed on the face of cycle-repeat selector star wheel 139 includes indented detent position indicated at 127. When the copy selector knob 20 is in neutral position, so that no copies are being produced even though the main drive motor 123 is energized and the continuous drive mechanism is in operation, cam follower pin 134 is urged into the detent position 127 of cam 133 by the tensile force of spring 132 on arm 131. In such position, cam follower pin 128 on projection 129 of arm 131 is in the protruding detent position 112 of internal cam track 122, and continuously rotating drive gear 137 is not in operative engagement with one-cycle gear train gear 121. Thus, gear 121 is "locked" in a fixed position although drive gear 137 is continuously rotating.

When copy selector knob 20 is manually rotated in a direction such as to rotate the copy selector star wheel 139 in a counterclockwise direction as shown in FIG. 7, the cam follower pin 134 is urged outwardly from detent position 127 by the corresponding rotation of cam 133, and arm 131 is moved a corresponding distance against the resistance of spring 132 so that continuously rotating drive gear 137 is moved into operative engagement with one-cycle gear train gear 121 at the same time that cam follower pin 128 is moved out of detent position 112 in internal cam track 122. In this manner, gear 121 and internal cam track 122, intermediate gear 141, and control gear 151 and internal cam track 153 are put into rotary motion as shown by the directional arrows. At the same time, the movement of the free end of arm 131 moves actuating arm 206 (see FIG. 6) of double-throw switch 207, thus energizing the corona charging units 41 and 42 through rectifier-transformer 208 and, at the same time, de-energizing signal means 26 to indicate that the apparatus is in use.

Simultaneously with the above, the rotational motion of gear 121 is partially translated through shaft 118 to segmental gear 102 mounted thereon at the opposite side of the apparatus. The toothed segment of gear 102 is adapted for operative engagement with gear 103 mounted on stub shaft 99 in common with gear 104 (see FIGS. 8 and 9). Gear 104 is in operative engagement with gear 111, mounted on stub shaft 29 in common with pulleys 81, which is connected by endless belt 82 to pulley 83 mounted on shaft 35 carrying paper transfer rollers 34 and 36. By means of segmental gear 102, only sufficient movement is imparted to paper transfer rollers 34 and 36 to advance a single sheet of copy paper into paper transfer rolls 38 and 39. Simultaneously, through rotational movement of control gear 151 and internal cam track 153 integral therewith (see FIG. 6), cam follower pin 156 is moved in a direction such that arm 157, to which said pin 156 is are removed from contact with glass exposure plane 55, thus permitting egress of the exposed paper sheet. At the same time, through rotation of shaft 152 carrying resilient paper advance fingers 71, 72 and 73, the paper is positively urged, by contact with such fingers, from the exposure area.

As noted above, exposure lamps 66 and 67 are energized by normally open on-off switch 162, shown in FIG. 8. Switch 162 includes insulated terminal base 163, which supports resilient and conductive arms 167 and 168 and their respective contact points 172 and 173. Switch 162 is mounted through base 163 onto rigid arm 177, which is pivotally mounted on the inside of the front casing by means of pin 178. Formed at the outer extremity of conductive arm 168, beyond contact point 173, is cam follower surface 174, which is adapted for sliding engagement on the surface of spiral exposure illumination cam 176 (see FIG. 9). Cam 176 is formed integral with the hub of segmental gear 102, mounted on shaft 118. With each revolution of shaft 118, the points 172 and 173 are first urged into contact and then separated by the movement of cam follower 174 on exposure illumination cam 176.

The period of time during which points 172 and 173 remain in contact, and consequently the time of exposure, are determined by a prepositioning of cam follower 174 in relation to spiral cam surface 176, so that the initial contact between points 172 and 173 will be effected either earlier or later in the cycle, respectively to extend or reduce the exposure time. This prepositioning of points 172 and 173 is effected by the rotational movement of arm 177 about pin 178 in response to the movement of a cam follower pin 182 mounted on the end of arm 177. Cam follower pin 182 projects through a slot in the front casing of the apparatus and into operative engagement with segmental spiral internal exposure timing cam track 183. Cam track 183 is formed integral with the rear hub of control knob 15, which is mounted on the front panel 21. Knob 15 is adapted for manual adjustment, so as to preposition the cam follower 174 with respect to cam surface 176 and thus predetermine the exposure time at the desired value.

The automatic cycle-repeat mechanism for reproducing a predetermined number of copies will now be described with reference to FIGS. 6 and 7. Mounted on shaft 118, coplanar with cycle-repeat selector star wheel 139, is pawl 143 adapted cooperatively to engage the projections of said star wheel. Consequently, provided the pawl 143 contacts a projection, the star wheel 139 will be advanced rotationally a distance equivalent to one tooth upon each revolution of the pawl 143. Depending upon the number of positions through which the cycle-repeat selector star wheel 139 preliminarily has been advanced counterclockwise (looking at FIGS. 6 and 7) by manual operation of control knob 20, an equivalent number of copies will be produced, each such copy corresponding to a single revolution of pawl 143. It should be noted that the number of copies which can automatically be made is determined by the configuration of star wheel 139, and particularly by the number of points thereon. Consequently, by varying the design of star wheel 139 from that shown, other ranges can be provided.

Star wheel 139 is missing two adjacent projections at 144, the one farthest clockwise providing a "neutral" position when in the path of pawl 143 and the other providing for "continuous" copying when so situated. When the cycle-repeat selector star wheel 139 is retraced the appropriate number of positions by pawl 143, it ultimately will arrive in the neutral position. At such time cam follower pin 134 will be urged by spring 132 applied to arm 131 to enter detent position 127 in cam 133. Simultaneously, cam follower pin 128 in arm extension 129 will move into "locking" position 112 in cam track 122, thus preventing further movement of the gear train. By moving the copy selector star wheel 139 one position clockwise from "neutral," rather than counterclockwise, a position is reached where copies will be produced continuously, since by virtue of the configuration of the star wheel 139 the pawl during its successive rotations fails in each case to contact any projection on the star wheel. Consequently, the one-cycle drive train mechanism remains in continuous operation.

As referred to above and as shown in FIGS. 2 and 5, developer tank 85 contains an agitator 184 mounted on vertical shaft 187 which is continuously rotated through contact between friction disc or bevel gear 188 mounted on shaft 187 and cooperating friction disc or bevel gear 192 mounted on spur shaft 193 through back casing. Spur shaft 193 also carries pulley 197 being driven by endless belt 198 from driving pulley 199 located on shaft 165.

As shown in FIGS. 2 and 5, solids dispenser pump 100 consists of reciprocating plunger pump 209 mounted in bottle 98 containing charged marking particles in relatively concentrated suspension, and discharging through tubes 212 and 101 into tank 85. Plunger 209 can be actuated manually or, as will normally be the case, automatically by contact with end of screw 213 threaded through arm 217 which is rotatably mounted about shaft 218. Movement of arm 217 in a clockwise direction (FIGS. 2 and 6) is effected by pin 222 mounted on arm 223 and riding in slot 227 of arm 217. Arm 223 is rotatably mounted on shaft 50 and carries cam follower pin 228 which follows cam 232 mounted on shaft 152. Arm 223 is urged in a counterclockwise direction by spring 225 attached at its other end to the casing. During each rotation of shaft 152 and cam 232, the arm 223 is moved clockwise around shaft 50 so as to effect a lateral movement of pin 222 in slot 227 of arm 217. Such movement of pin 222 causes a downward movement of arm 217 around shaft 218 and against the tensile force of spring 225. Such downward movement effects moving contact between the bottom of screw 213 and the plunger of pump 209, so as to produce the desired pumping action. The stroke of such pump can be varied by adjusting the position of screw 213 in arm 217.

The electrical circuitry and controls for operation of the apparatus of the present invention may be understood by reference to FIG. 10, wherein consistent reference numerals are used wherever possible. In-put power is supplied from a 120-volt, alternating-current, 60-cycle power source, indicated at 210. The switch designated 215 (not visible in the other drawings) is a normally open safety switch, which is

maintained in the closed position so long as the hinged top panel 14 (FIG. 1) is not opened. When panel 14 is opened for access to the interior, switch 215 is permitted to open so as to disconnect the power source from the rest of the apparatus circuit. So long as switch 215 is in the closed position (i.e., so long as access panel 14 is closed), the electrical circuit is completed to heaters 116 and 24, so that typically such heaters are energized continuously. When the main on-off switch 25, located on front panel 21 of the apparatus (see FIG. 1), is closed at the same time that safety switch 215 remains closed, electrical circuits are completed through main drive motor 123 and motor-driven fan 113, as well as up to switch 207 in the charger and feed circuit, switch 162 in the circuit including exposure lamps 66 and 67, switch 31 in the circuit including out-of-paper signal means 27, and switch 96 in the circuit including out-of-developer signal means 28.

When both switches 215 and 25 are in the closed position, as indicated above, and no copy paper is in progress through the apparatus, the circuit to machine-readiness signal means 26, located on front panel 21, will be closed by the switch 207 in its normal position. However, once the apparatus is actuated by manually rotating the copy selector control knob 15 on front panel 21 to a predetermined position away from "neutral," the circuit to signal means 26 is interrupted as a result of the mechanical action of arm 131 (FIG. 6) on switch 207, while at the same time the circuit is closed to charging units 41 and 42 through combination rectifier and step-up transformer 208. Normally open switch 162 is connected to exposure lamps 66 and 67, and is actuated automatically by the contact of rotating exposure illumination cam 176 on cam follower 174 (FIGS. 8 and 9) with the rotation of shaft 118.

Normally closed switch 31 is connected to the out-of-paper signal means 27 located on front panel 21 and illustrated in FIG. 10 as an audible signal means. Switch 31 is mounted on platform 32 below the bottom panel of paper storage compartment 30, with its actuating arm 33 extending upwardly through such bottom panel for contact with any paper therein. The absence of paper causes switch 31 to close, thus completing the circuit to signal means 27.

Normally open switch 96, mounted adjacent the developer tank 85, is connected to the out-of-developer signal means 28 mounted on front panel 21. Switch 96 is actuated by float 97, positioned in tank 85, so as to close switch 96 in the event the level of developer in tank 85 falls below a certain level. Actuation of switch 96 completes the circuit to signal means 28.

The novel and improved copy-making apparatus of the present invention offers the advantages of inexpensive construction, economy and ease of maintenance, and substantial flexibility in that it is suitable for making copies of a wide variety of objects including books and other three-dimensional objects.

The copy paper which is suitable for use with the apparatus of the present invention is a paper which has been surface-coated with a suitable material, such as zinc oxide and the like, to render the paper electrophotosensitive, i.e., sensitive to light after exposure to an electrostatic charge. When such electrostatically charged papers are exposed to light, they become conductive to the extent of such exposure and generally in proportion to its intensity. As a result of the light-induced conductivity, the electrostatic charge within the areas of light exposure is dissipated, again generally in proportion to the degree of light intensity. By way of example, copy papers suitable for use with the apparatus of the present invention are described in U.S. Pat. Nos. 2,922,883; 3,052,539; and 3,121,006. Many suitable copy papers are commercially available.

In the apparatus of the present invention, the surface-coated paper is rendered electrophotosensitive by means of an electrostatic potential applied to the paper in the absence of light while the paper is passing through the corona charging units. In the corona charging units, an electrostatic charge is applied to the paper, consisting typically of a negative charge accumulated on the coated surface of the paper and a resultant positive charge accumulated on the other surface. After charging, the paper is exposed to a high-intensity light reflection of the image of the object to be copied. The electrophotosensitive coating directly in line with the reflected image is shaded from light exposure to a degree depending upon the color and density of the reflected image, and to such extent remains non-conductive and consequently electrostatically charged, while the electrostatic charge on the exposed areas of the paper is more or less dissipated by conduction depending upon the intensity of the light exposure.

The exposed paper containing the electrostatically charged image is then subjected to a developing agent, comprising a suspension of positively charged marking particles, typically carbon, dispersed in a clear and non-conductive liquid medium, typically a petroleum-like base. The positively charged carbon particles typically constitute about 2 percent of the developer, and they remain dispersed throughout the dispersing medium by virtue of the repellent effect of their like positive charges and with the aid of agitation. When the exposed paper containing the charged image is contacted with such a developer, the positively charged carbon particles are attracted to the negatively charged image generally in proportion to the varying intensity of the accumulated charge on the image. In this manner, the image of the object is reproduced on the coated paper in varying intensity corresponding to the colors and shadings of the object. After developing, the excess liquid dispersing medium is removed from the paper, leaving the image formed by the deposited carbon particles which conveniently is fixed by drying.

It will be apparent that, as copies are produced, the concentration of the charged marking particles in the dispersing medium will diminish. Accordingly, it is necessary to replenish the charged carbon particles from time to time by introducing a more concentrated dispersion of such particles.

While the description and drawings herein presented pertain to specific and preferred embodiments of the invention, it is to be understood that the invention is not so limited and extends to any and all embodiments of the invention defined by the appended claims. For example, it should be noted that the apparatus of the invention could readily be modified to accommodate copy paper in the form of rolls rather than sheets. Also, by elimination of the corona charging units, the apparatus could readily be adapted to other processes, e.g., photographic.

The invention claimed is:

1. An apparatus for reproducing the image of an object on an electrophotosensitive sheet material, said apparatus comprising:

a. first transfer means to advance said sheet material into and through a charger zone disposed generally adjacent and below one side of said first transfer means;

b. charger means in said charger zone including spaced corona charging units to deposit an electrostatic charge of opposite polarity on each side of said sheet material;

c. second transfer means to receive said sheet material after charging and advance same into an exposure zone disposed generally below said charger zone;

d. exposure plane means in said exposure zone for positioning the charged sheet material during exposure;

e. object plane means disposed generally in horizontally spaced relation to the opposite side of said first transfer means and in laterally and vertically spaced relation to said exposure plane means;

f. means defining a light path between said object plane means and said exposure plane means for exposing the charged sheet material to a reflected light image of the object to be reproduced;

g. third transfer means to receive said sheet material after exposure and advance same into and laterally through a developing zone disposed generally below said exposure zone;

h. developing means in said developing zone, including charged marking particles suspended in liquid medium, to

develop the electrostatic latent image on said sheet material after exposure;

i. means disposed in horizontally spaced relation to said developing zone, for receiving the developed sheet material and advancing same in a generally lateral path of travel opposite in direction to its path of travel through said charger zone, and for removing the liquid portion of said developing means;

j. continuous drive means;

k. one-cycle drive train means for operating in synchronization elements to produce a single copy of the object to be reproduced;

l. manually initiated first camming means adapted to engage and disengage said continuous drive means with said one-cycle drive train means;

m. multiple-station member associated with said first camming means, said member being manually prepositioned and responsive to pawl means associated with said one-cycle drive train means to restore said member one station for each cycle completed until said first camming means is restored to the disengaging position;

n. first switching means associated with said first camming means for energizing said corona charging units;

o. feed means associated with said one-cycle drive train means to initiate feed of electrophotosensitive sheet material from a magazine to said first transfer means;

p. exposure illuminating means;

q. second switching means to energize said exposure illuminating means;

r. first spiral camming means associated with said one-cycle drive train means and adapted to actuate said second switching means;

s. second spiral camming means for manually and adjustably prepositioning said second switching means in relation to said first spiral camming means in order to control the exposure time;

t. stop means adapted for properly positioning and retaining said electrophotosensitive sheet material in said exposure zone;

u. second camming means associated with said one-cycle drive train means and adapted to move said stop means so as to maintain said sheet material in said exposure zone during exposure and to release said sheet material thereafter;

v. ejecting means associated with said one-cycle drive train means and adapted positively to advance the exposed sheet material from said exposure zone and into said third transfer means;

w. reservoir containing a relatively concentrated dispersion of charged marking particles in a liquid medium for replenishing such particles in said developing means;

x. manually adjustable pumping means connecting said reservoir with said developing zone; and

y. third camming means associated with said one-cycle drive train means and adapted to actuate said pumping means in order to introduce into said developing zone a predetermined quantity of said relatively concentrated dispersion.

2. Apparatus according to claim 1 and including a fourth camming means adapted to prevent disengagement of said continuous drive means from said one-cycle drive train means until completion of a full cycle of operation.

3. Apparatus according to claim 1 wherein said multiple station member is in the form of a star wheel.

4. Apparatus according to claim 1 wherein said continuous drive means is mounted on a pivoted member acted upon by said first camming means.

5. Apparatus according to claim 4 wherein said pivoted member includes cam follower means adapted for cooperation with a cam surface associated with said one-cycle drive train means to ensure full cycle operation.

6. Apparatus according to claim 4 wherein said first switching means is actuated by said pivoted member for energizing said corona charging units.

7. Apparatus according to claim 1 wherein said feed means includes a segmental gear adapted to introduce a single sheet of electrophotosensitive sheet material during each complete cycle.

8. A photocopying apparatus comprising: first gear means, support means rotatably, translatably mounting said first gear means and including a detent member, second gear means including a substantially circular cam track concentric therewith and defining along its periphery a detent section, said detent being mounted for travel in said track, mounting means mounting said support means for movement between a first position wherein said first gear means is unengaged from said second gear means and said detent member is located in said detent aperture and a second position wherein said first gear means is in driving engagement with said second gear means and said detent is located in the circular portion of said cam track, spring means biasing said support means to the first position, drive means, means interconnecting said drive means and said first gear means, whereby said cam track defines a single cycle cam whereby said detent can move to its rest position with disengagement of said first gear means upon completion of a rotation of said second gear means.

9. Apparatus as set forth in claim 8, wherein said support means comprises a substantially vertically extending bracket member having a forwardly extending arm mounting said detent member, said bracket having a leg portion extending below said arm, a shaft mounting said first gear means and rotatably mounted in said leg portion.

10. Photocopy apparatus comprising:

a. feed means to feed a sheet of copy paper from a first station;

b. corona charging means spaced downstream of said first-named means and adapted to charge one surface of said sheet;

c. means for feeding said sheet into a toner bath;

d. means for feeding said sheet into a planar position for exposure to an image;

e. means for discharging said sheet from said toner bath;

f. drive means;

g. mechanical means interconnecting said drive means and each of the aforesaid means;

h. cam means operatively connected to said drive means to effect a sequential feed of a paper sheet, charging by said corona charge means, immobilizing of said sheet in a planar position, exposing the immobilized sheet to a light image, and driving said exposed sheet through a toner bath to a discharge position;

i. means for engaging and disengaging said drive means from said mechanical means upon respective initiation and completion of a single cycle of operation of said photocopy machine; and

j. a multiple station member connected to said means for engaging and disengaging said drive means, said member being manually positioned and responsive to pawl means operatively connected to said engaging and disengaging means to restore said multiple station member one station for each completed cycle until said means for engaging and disengaging is restored to the disengaging position.

11. Apparatus as set forth in claim 10, wherein said multiple station member is a wheel.

12. Photocopy apparatus comprising:

a. feed means to feed a sheet of copy paper from a first station;

b. corona charging means spaced downstream of said first-named means and adapted to charge one surface of said sheet;

c. means for immobilizing said sheet in a planar position for exposure to an image;

d. means for feeding said sheet into a toner bath;

e. means for discharging said sheet from said toner bath;

f. drive means;

g. mechanical means interconnecting said drive means and each of the aforesaid means;

h. cam means operatively connected to said drive means to effect a sequential feed of a paper sheet, charging by said corona charge means, immobilizing of said sheet in a planar position, exposing the immobilized sheet to a light image, and driving said exposed sheet through a toner bath to a discharge position;

i. means for engaging and disengaging said drive means from said mechanical means upon respective initiation and completion of a single cycle of operation of said photocopy machine; and

j. a pivoted member mounting said drive means and acted upon by said cam means.

13. Apparatus as set forth in claim **12**, wherein said pivoted member includes cam follower means operatively connected to follow a cam surface associated with said mechanical means to insure full cycle operation thereof.

14. Photocopy apparatus comprising:

a. feed means to feed a sheet of copy paper from a first station;

b. corona charging means spaced downstream of said first-named means and adapted to charge one surface of said sheet;

c. means for immobilizing said sheet in a planar position for exposure to an image;

d. means for feeding said sheet into a toner bath;

e. means for discharging said sheet from said toner bath;

f. drive means;

g. mechanical means interconnecting said drive means and each of the aforesaid means;

h. cam means operatively connected to said drive means to effect a sequential feed of a paper sheet, charging by said corona charge means, immobilizing of said sheet in a planar position, exposing the immobilized sheet to a light image, and driving said exposed sheet through a toner bath to a discharge position;

i. means for engaging and disengaging said drive means from said mechanical means upon respective initiation and completion of a single cycle of operation of said photocopy machine;

j. exposure illuminating means;

k. switching means to actuate said exposure illuminating means;

l. first spiral camming means associated with said mechanical means and adapted to operate said switching means; and

m. second spiral camming means independent of said first said spiral camming means and adjustably prepositioning said second switching means with relation to said first spiral camming means to control exposure time.

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